

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

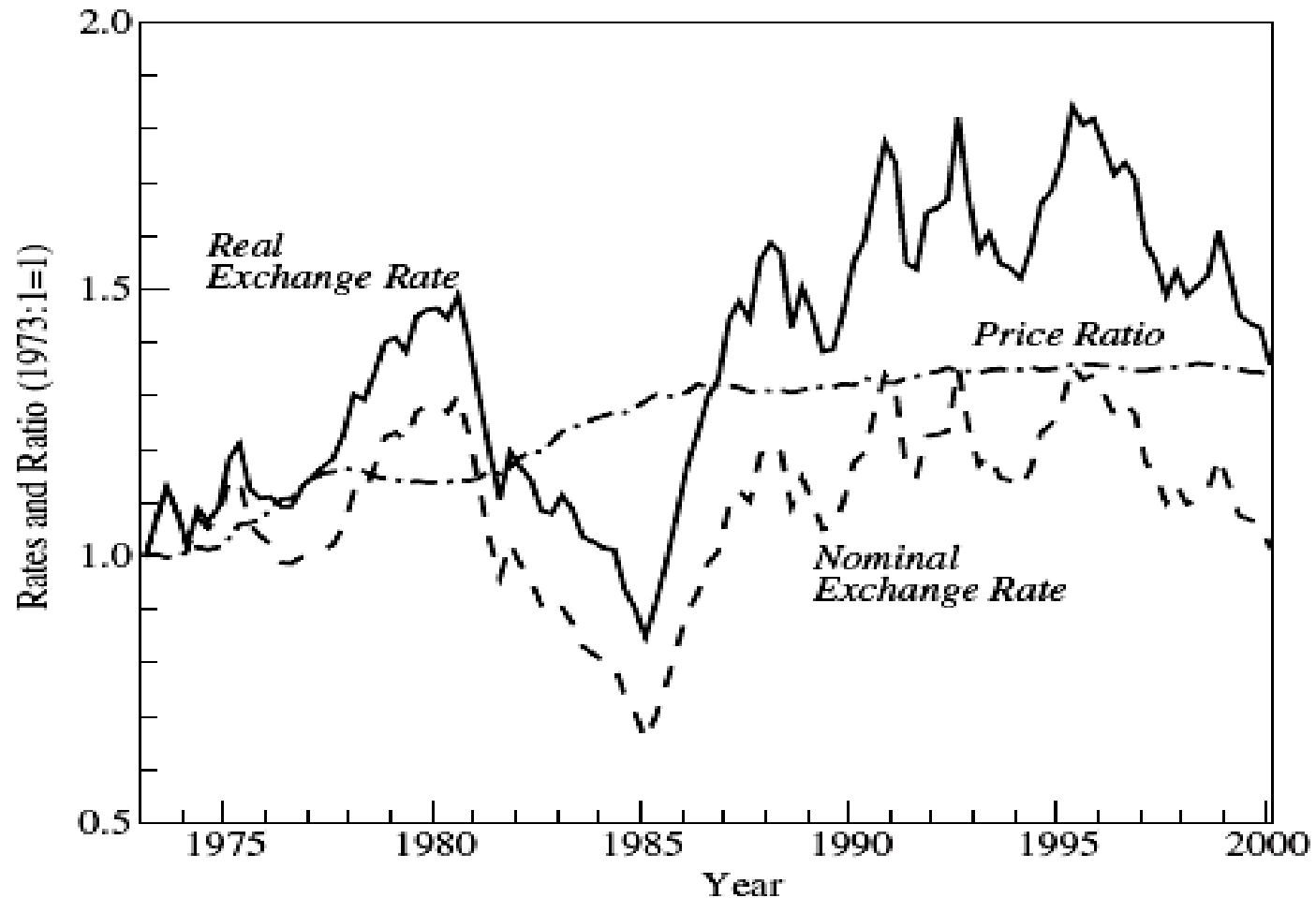
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Focus on the Real Exchange Rate

- Real exchange rate (RER) is a key relative price in international macroeconomics.
- Stylized facts about RER are hard to reconcile with standard theory:
 - **large** and **persistent** fluctuations are evidence of failure of Purchasing Power Parity condition
 - these fluctuations appear “**disconnected**” from the real economy, i.e. they do not translate into import and consumer prices
 - **negative correlation** between the ReR and relative consumption is evidence of substantial **lack of consumption risk sharing** across countries (Backus and Smith, 1993)

Focus on the Real Exchange Rate



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- Volatility of the \$/€real exchange rate: **20.74**
- Volatility relative to real consumption: **11.71**
- Persistence: **0.97**
- Correlation with relative consumption: **-0.48**

Can nontradable (NT) goods help? How?

- **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.
- **Corsetti *et al.* (2005)**: A standard international business cycle model with *incomplete asset markets* augmented with *distribution services* **can account quantitatively** for the main features of real exchange rates. (also: Benigno & Thoenissen, 2006)

Our Objective

- Estimate a model (of the EUR-USD real exchange rate) to **evaluate its ability** to match stylized facts regarding the RER and **understand which features/parameters and which shocks** are important
- Lubik and Schorfheide (2005), Rabanal and Tuesta (2005), deWalque, Smets and Wouters (2006) all estimate 2-country NOEM models. **None of them consider nontraded goods**

Structure of the talk

1. Brief description of the model

- Role of NT goods & distribution costs in RER
- Decomposition of the real exchange rate dynamics

2. Estimation results

- Posterior densities
- RER: matching stylized facts (moments)

3. The dynamics of the real exchange rate

- With respect to economic features
- With respect to exogenous shocks

4. Conclusions

The Model

- The model is based on Corsetti, Dedola and Leduc (2006)
- Basic features:
 - ✓ 2 sectors producing **tradable** and **non-tradable** goods
 - ✓ Exporting firms engage in **international price discrimination**
 - ✓ A third sector **distributes** tradable goods using local non-tradables
 - ✓ **sticky** prices and wages (but w/o indexation)
 - ✓ **home bias** in consumption preferences
 - ✓ **incomplete financial markets** at the international level
 - ✓ **systematic** monetary policy

The RER in the model

The real exchange rate of the home country is defined as:

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

The consumption price index 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 for tradables as:

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

where a_H is the weight of the domestic traded goods

Moreover, bringing one unit of traded goods to consumers in the each country requires local NT goods (Corsetti and Dedola, 2004):

$$P_H = \bar{P}_H + \eta P_N$$

Where the dynamics of the RER come from (1)

- In our model the law of one price does not hold because of **three** assumptions: the presence of NT goods and distribution costs, international price discrimination from exporting firms and the presence of home bias in consumption.
- In turn, international price discrimination can be the result of either different degree of nominal rigidities or different price for NT goods in the two countries

Where the dynamics of the RER come from (2)

Formally, we can decompose the changes in the RER into 3 main economic components:

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

- First two terms capture **international price discrimination**:

$$\bar{P}_F \neq S\bar{P}_F^* \quad \bar{P}_H \neq S\bar{P}_H^*$$

- The third captures the **home bias** effect
- The last two terms represent, respectively, the home and foreign **internal real exchange rate** (traded - nontraded relative price)

The Model: alternative specifications

- We estimate a “complete” model (with all the features above) and two “alternative” specifications:

- LCP w/o distribution costs

- PCP w/o “ “ and w/o IPD

... to be able to study the differential contribution of NT goods in different specifications

The Model: Structural shocks

There are **eleven shocks** in the model:

- home and foreign **technology shocks**, in both the traded and nontraded goods sectors (AR1)
- shock to the **uncovered interest parity** (AR1)
- home and foreign **monetary policy** shocks (i.i.d.)
- home and foreign **preference** shocks (AR1)
- home and foreign **markup** shocks in labor mkt (i.i.d.)

The data

- Nine observables:
 - *Real exchange rate*
 - *Real private consumption* (euro area & USA)
 - *Non tradable inflation* (euro area & USA)
 - *CPI inflation* (euro area & USA)
 - *Short-term interest rate* (euro area & USA)
- Sample period: **1983:1 - 2005:2**
- All inflation rates are computed as Q-on-Q changes in the corresponding price indexes and de-meanned; the short-term interest rates are de-meanned, consumption is linearly detrended and the real exchange rate is de-meanned

Results: posterior distributions

Table 6. Marginal densities

Model	Marginal density
Complete	2977
LCP	2970
PCP	2974

Notes: The marginal density is computed using the harmonic mean estimator (Geweke, 1999).

Table 5. Comparison of median values of parameters

parameter	Complete	LCP	PCP
ρ	1.2247	1.1715	1.2241
σ	2.3470	2.2697	2.1661
η	1.0816
a_H	0.8960	0.9470	0.9738
a_T	0.6149	0.5383	0.6336

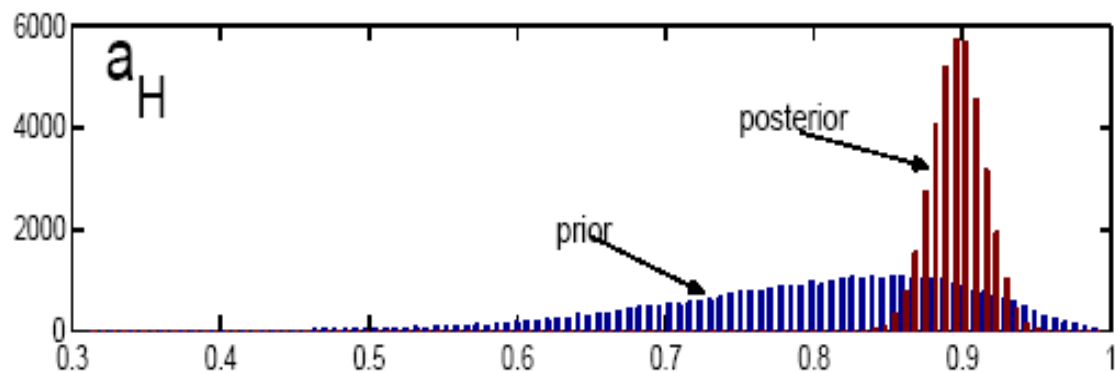
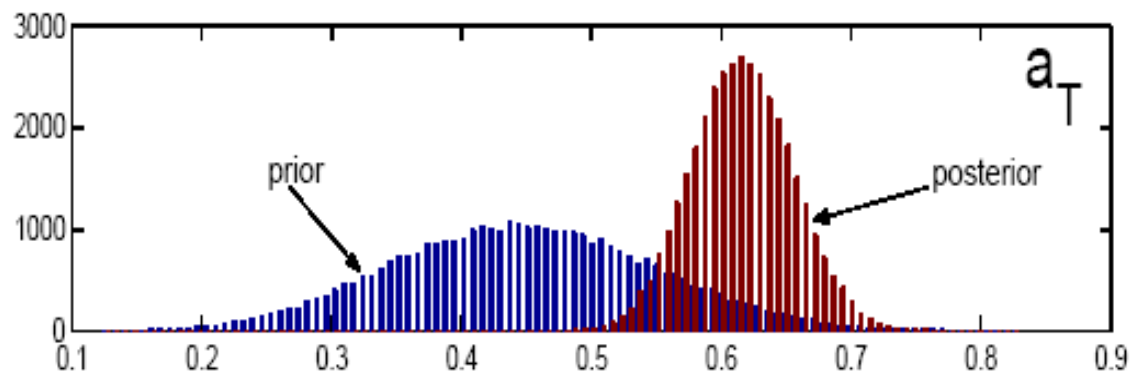
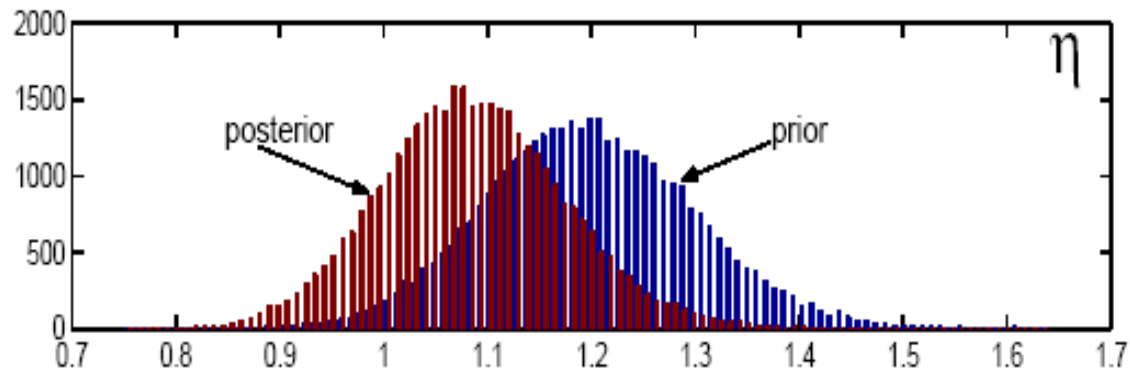
$$\rho \left(1 - \eta \frac{P_N}{P_H} \right) = 0.58.$$

Results: posterior distributions

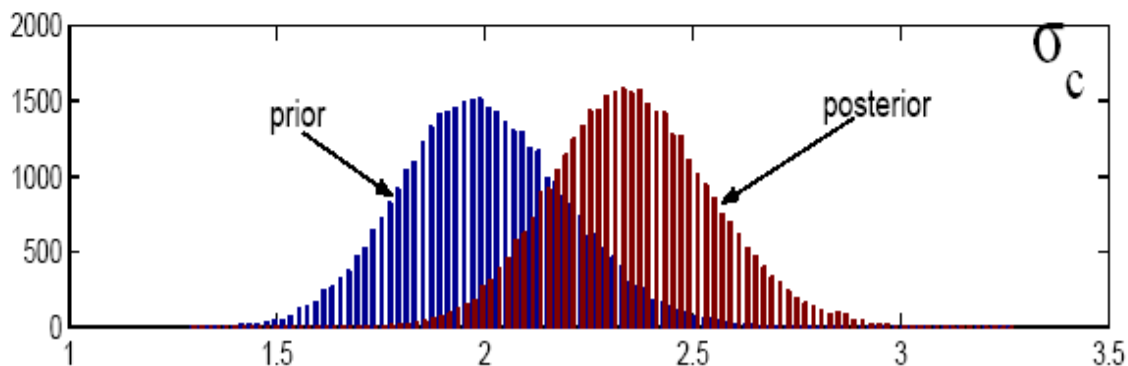
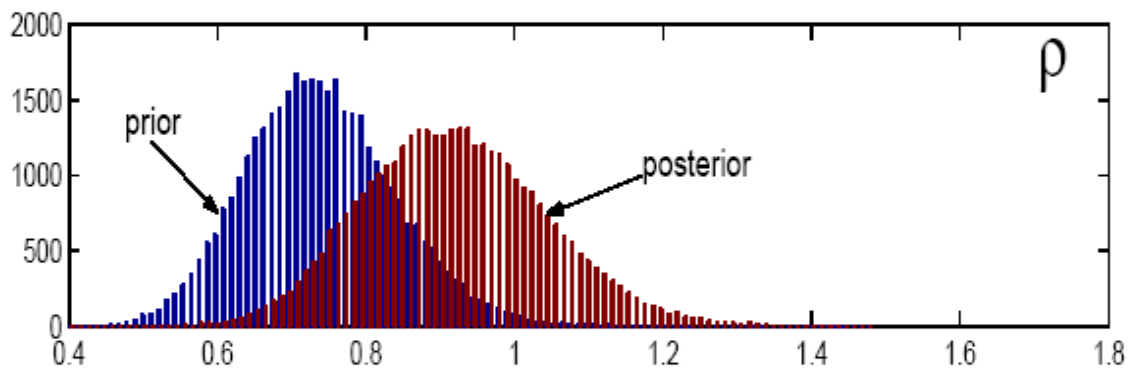
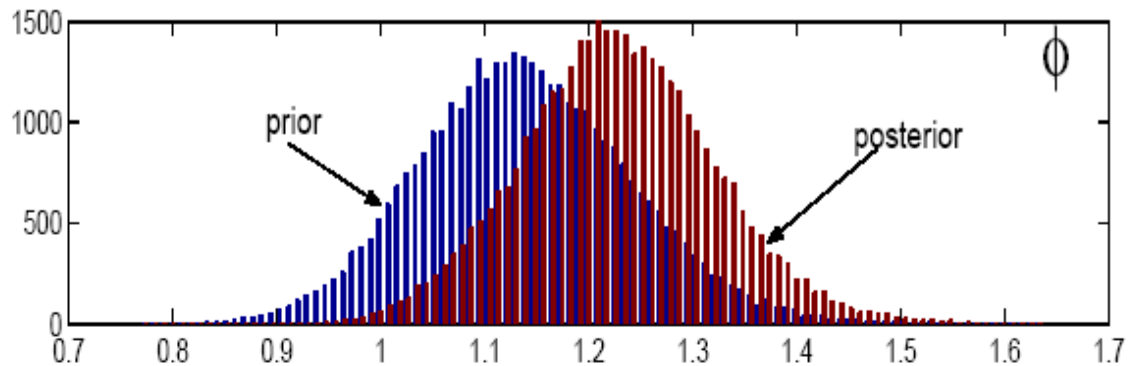
Statistics for the posterior distribution: Benchmark model

parameter	symbol	2.5	50	97.5	mean	st. dev.
risk premium	κ_0	0.00	0.01	0.02	0.01	0.00
intratemp. elast. subst. T/NT	ϕ	1.05	1.22	1.41	1.23	0.09
intratemp. elast. subst. H/F	ρ	0.69	0.91	1.17	0.92	0.12
intertemp. elast. subst. C	σ_C	1.99	2.35	2.75	2.35	0.19
Home trad. rigidity	κ_H	3.39	10.13	27.16	11.49	6.19
Home imports rigidity	κ_F	1.61	3.27	6.98	3.53	1.41
Home nontrad. rigidity	κ_N	22.52	53.63	113.58	57.35	23.63
Foreign imports rigidities	κ_H^*	7.99	22.65	60.44	25.72	13.64
Foreign trad. rigidity	κ_F^*	1.91	2.83	4.47	2.93	0.69
Foreign nontrad. rigidity	κ_N^*	8.44	26.79	73.63	30.63	17.28
Home wage rigidity	κ_W	162.11	283.88	491.34	295.89	84.55
Foreign wage rigidity	κ_W^*	197.62	348.96	550.35	355.65	90.60
Distribution costs	η	0.92	1.08	1.27	1.08	0.09
Home bias	a_H	0.86	0.90	0.93	0.90	0.02
Tradable goods bias	a_T	0.54	0.61	0.69	0.62	0.04

Prior & posterior marginal densities (1)



Prior & posterior marginal densities (2)



Results: matching the moments (1)

Moment	Data	Benchmark			LCP			PCP		
		2.5	50	97.5	2.5	50	97.5	2.5	50	97.5
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

1. Complete model is able to generate more volatility
2. All models are basically equal in terms of persistence
3. Negative correlation ok, but
 - (i) none actually matches it except PCP
 - (ii) channels through which is achieved are different

Results: matching the moments (2)

Selected second moments of the observables: 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

Results: matching the moments (3)

How do the model get to the Backus-Smith puzzle ?

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

- With a combination of **UIP**, **preference shocks** and the **incomplete financial markets** assumption.
- With incomplete markets, the simple static relationship between the real exchange rate and the ratio of the marginal utilities is replaced by a relationship that holds only in expected first differences.

$$E_t \left[\bar{RS}_{t+1} - \bar{RS}_t \right] = E_t \left[\sigma_C(\hat{C}_{t+1} - \hat{C}_t) - (Z_{P,t+1} - Z_{P,t}) \right] - \left[\sigma_C(\hat{C}_{t+1}^* - \hat{C}_t^*) - (Z_{P,t+1}^* - Z_{P,t}^*) \right] + \phi(\hat{b}_t) + Z_{UIP}$$

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

The dynamics of the real exchange rate (2)

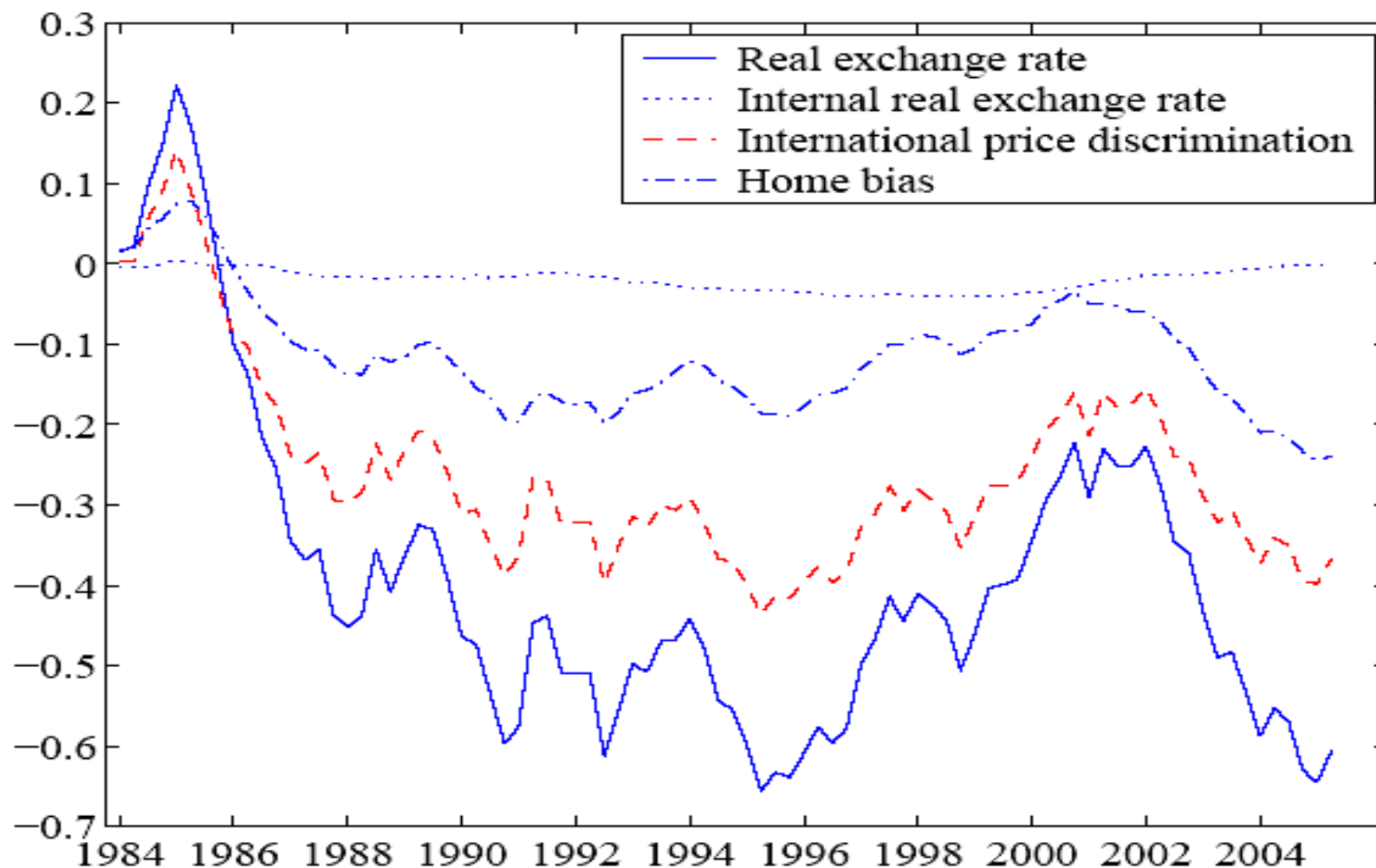
Recall the decomposition of the RER changes into its components:

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

- Variance decomposition suggests that:
 - **international price discrimination** accounts for 56% of total variance
 - 34% is explained by covariance terms involving **prices of traded goods**
 - the **home bias** contributes for around 8%
 - the **internal real exchange rates** almost nothing

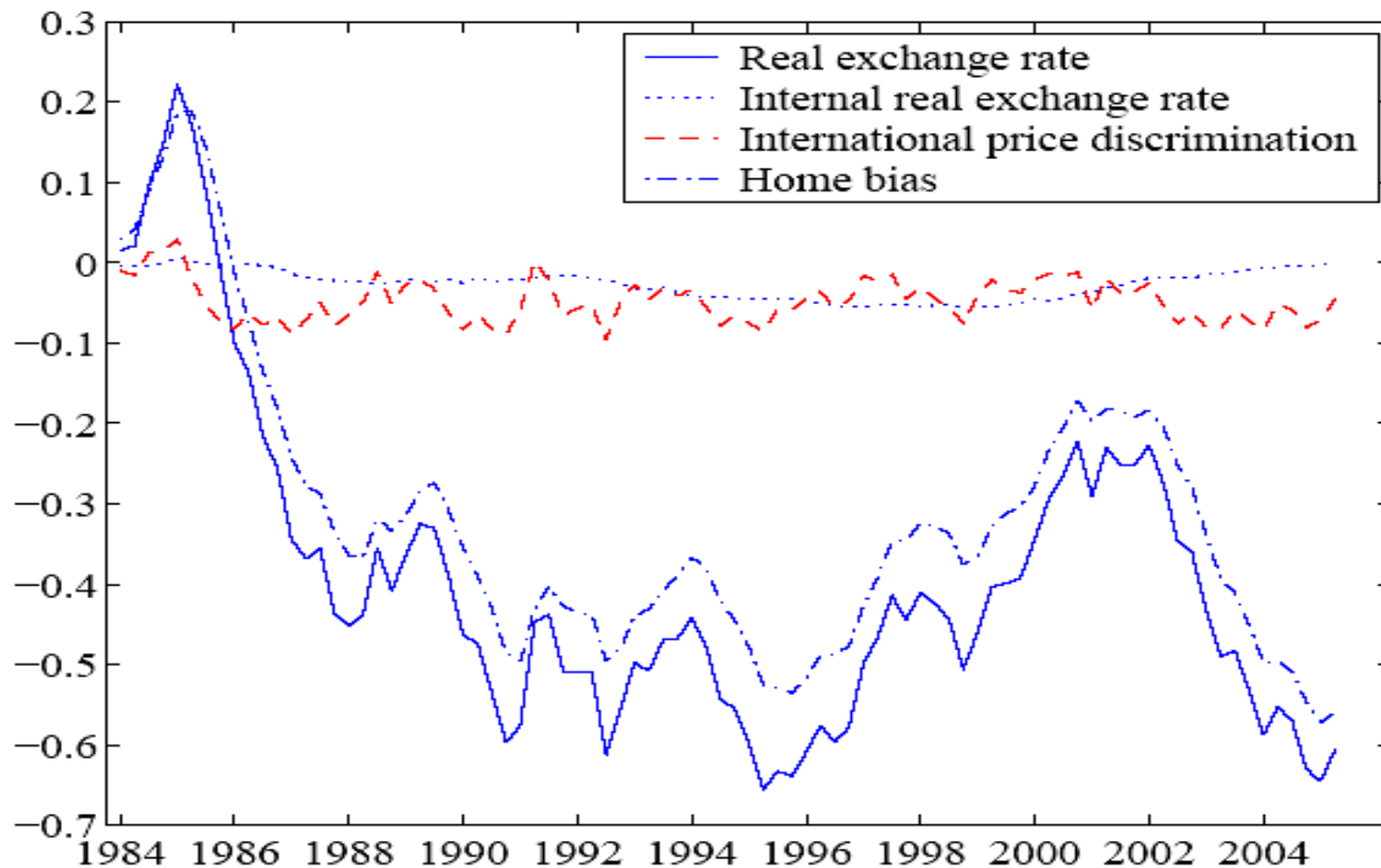
The real exchange rate decomposition

(benchmark model)

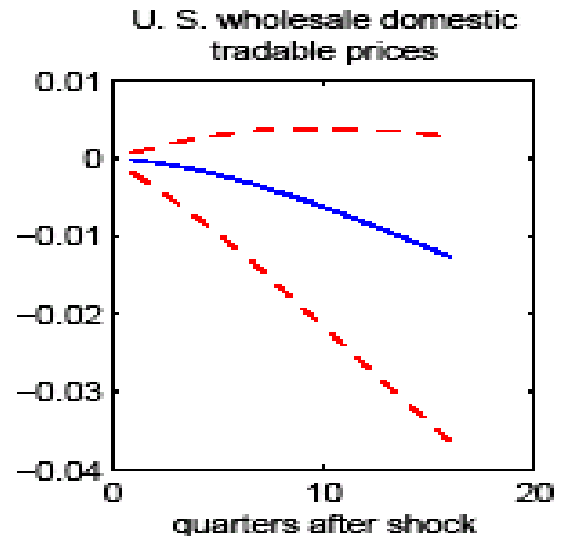
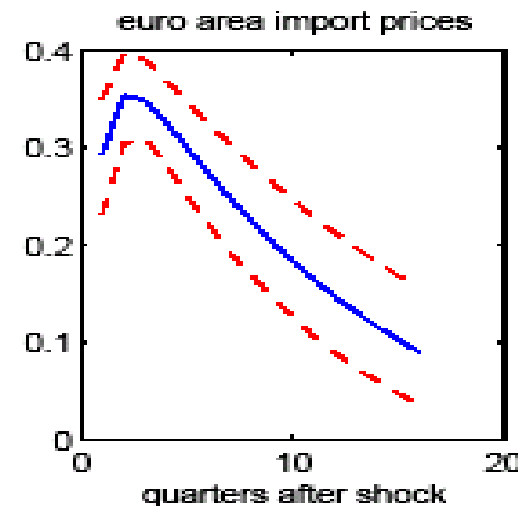
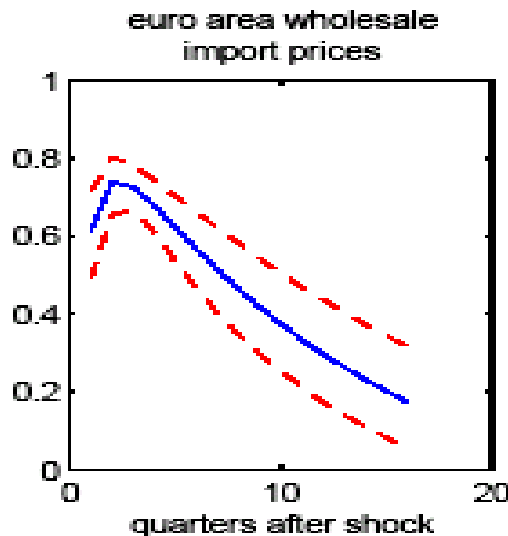
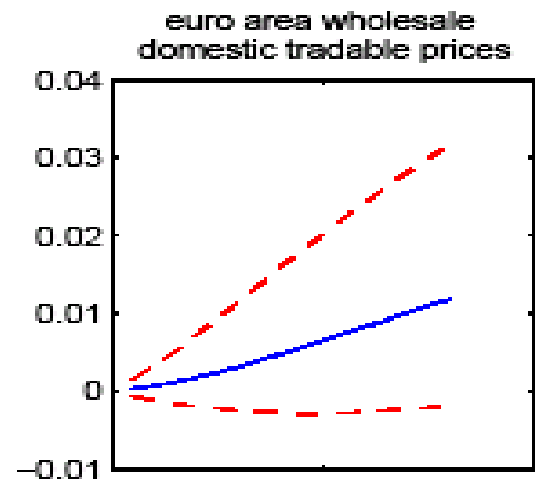
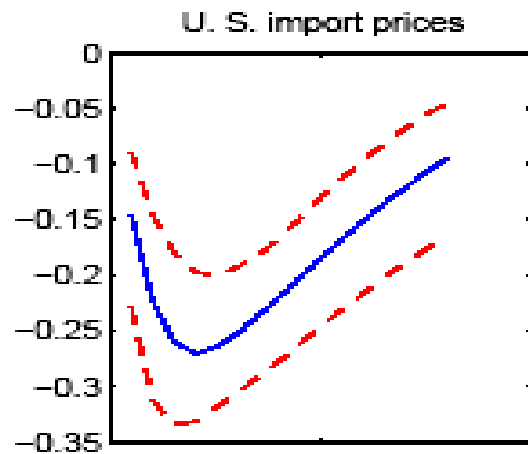
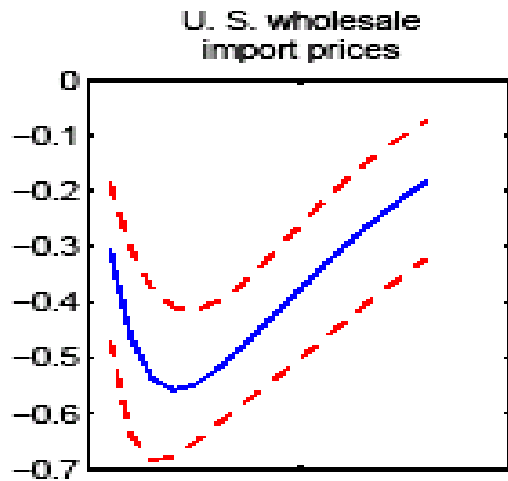


The real exchange rate decomposition

(LCP model w/o distribution costs)



The dynamics of the real exchange rate (4): incomplete pass-through



The importance of different shocks

Decomposition of the asymptotic forecast error variance: benchmark model

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 different shocks

- Around 75% of the real exchange variance is explained by the **UIP shock** (Rabanal and Tuesta, 2005). The remaining is **home and foreign preference shocks**
- Consumption and the short-term interest rates are mainly explained by **home 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

- Having **NT** is crucial to get the dynamics of the RER
- The ‘complete’ model, where **NT are also used in distribution**, is overall preferred to LCP and PCP models
- **International price discrimination**, due to a combination of LCP and distribution costs, is also key to account for the dynamics of the real exchange rate
- **UIP & pref. shocks** are the main sources of RER volatility
- The **pass-through of nominal exchange rate** into import prices is rather low at the border, and even lower at consumer level, given the presence of distribution costs

The End