

# What is Driving Exchange Rates? New Evidence from a Panel of U.S. Dollar Bilateral Exchange Rates

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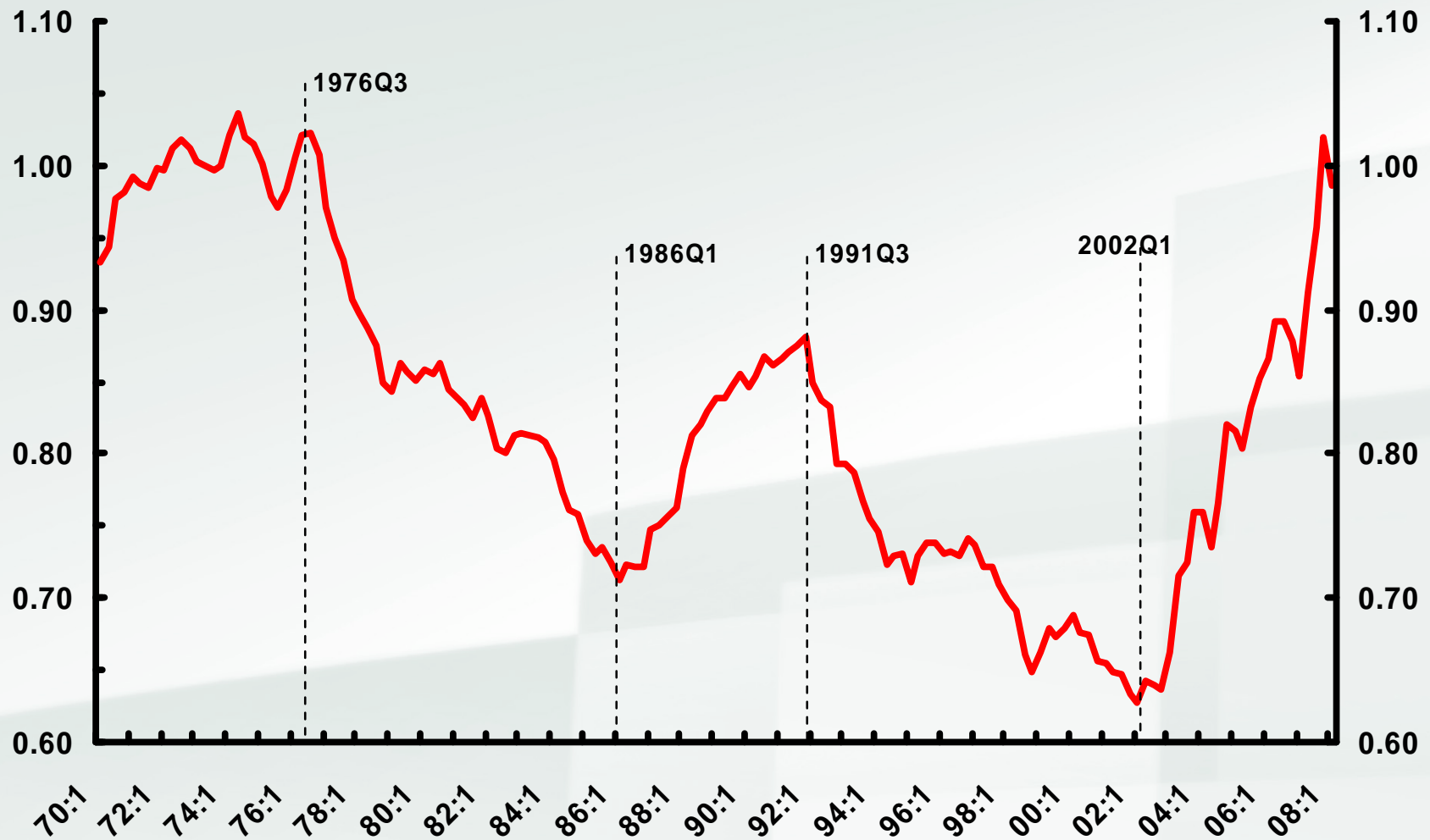
Bank of Canada

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# Roadmap

1. Motivation
2. Related Literature
3. Empirical methodology
  - Dynamic factor model
  - Cointegration tests
  - State space model
  - Historical decomposition
  - Robustness checks
4. Conclusion

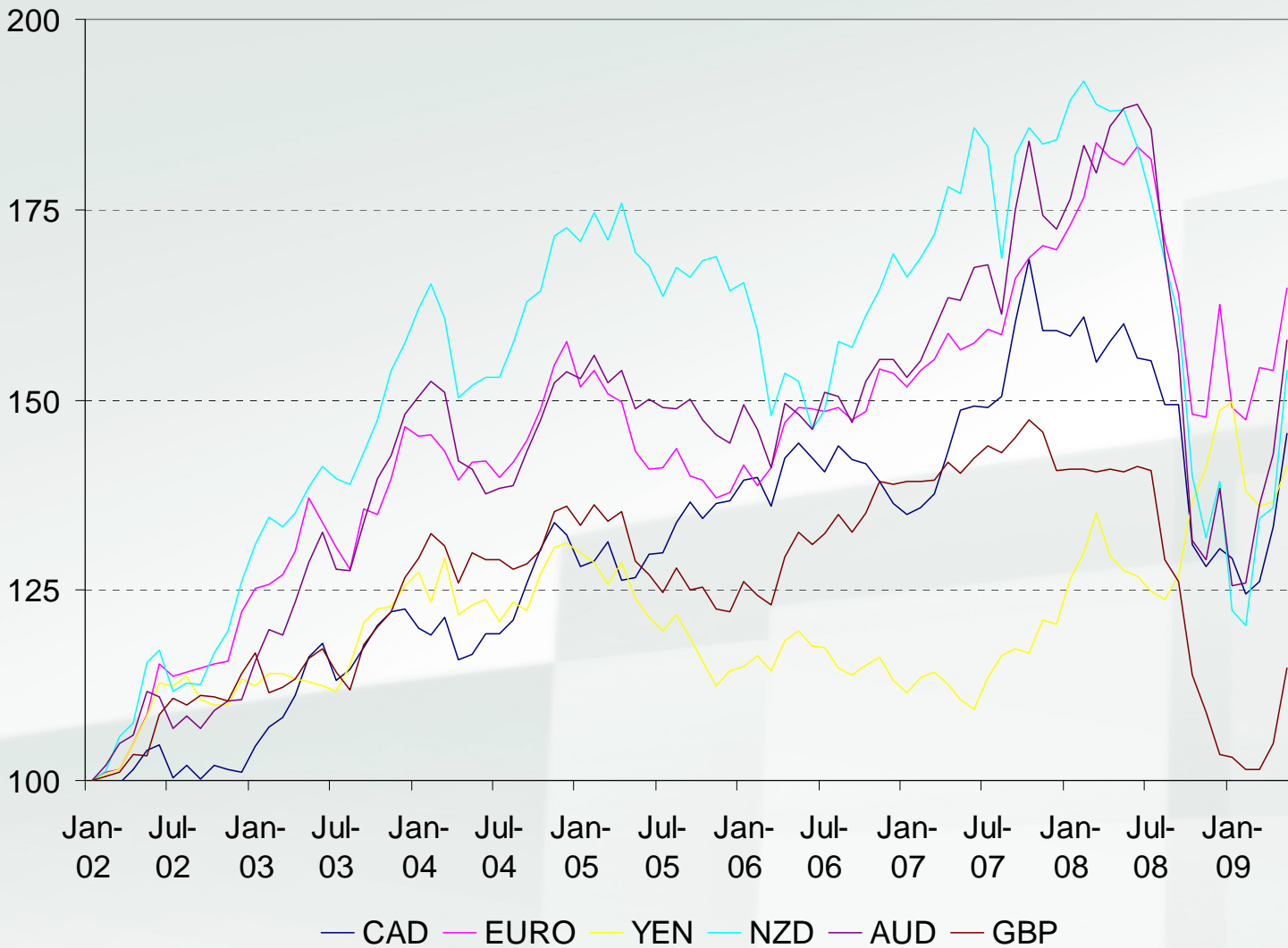
# US\$/CDN\$ since 1970 (quarterly)



# Why did the Canadian dollar appreciate so rapidly?

- Real oil prices and non-energy commodity prices increased by 150% and 70%, respectively, between 2002 and 2008.
  - Large appreciations of commodity exporters (Australia, Canada, New Zealand) against the U.S. dollar likely linked to commodity prices;
  - If this is true, why did commodity importers (euro area and U.K.) appreciate, too, against the U.S. dollar?

# Changes in exchange rates 2000-2008



## 2 Related literature

Models linking exchange rates to macro fundamentals	Overall limited success	Meese and Rogoff 1983, Obstfeld and Rogoff 2000, Cheung et al. 2005, Engel and West 2006
Models linking exchange rates to commodities	Empirical results somewhat better	Amano and van Norden 1995, Gruen and Kortian 1996, Djoudad et al. 2001, Chen and Rogoff 2003, Issa et al. 2006
Latent factor models (empirical finance)	Good results, but economic interpretation not always clear	Diebold and Nerlove 1989, Mahieu and Schotman 1994, Dungey 1999

### 3 Empirical methodology

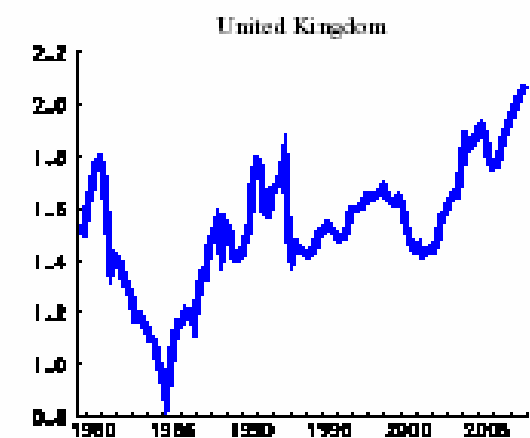
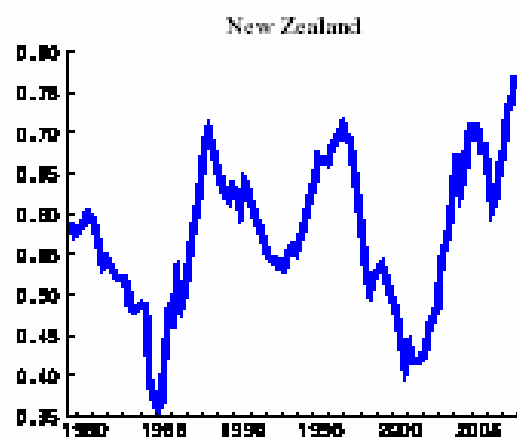
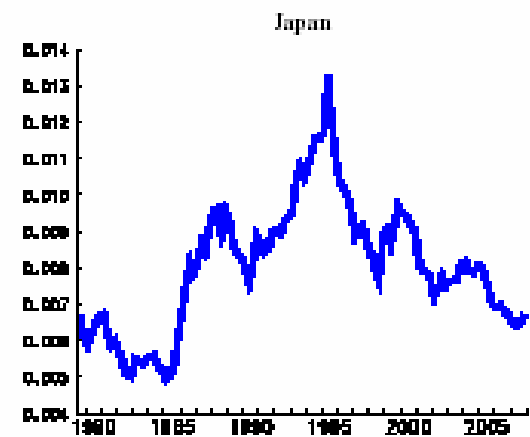
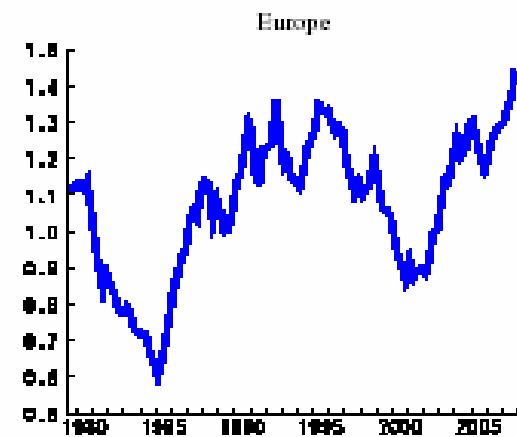
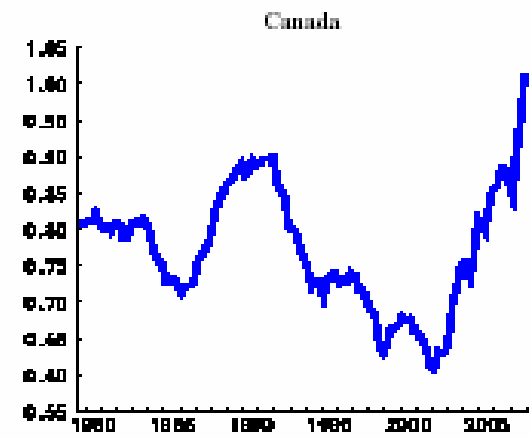
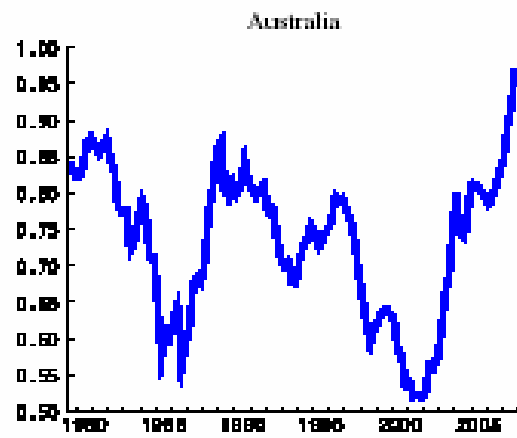
- Extract common movements in the panel of exchange rates using:
  - Dynamic principal factor analysis
  - State-space model
- Each has relative advantages and disadvantages.

# Models

- The principal factor model:
  - Purely statistical technique, relies on a minimum of restrictions and assumptions
- The state-space model
  - Imposes more structure on the data
  - Facilitates statistical inference
  - Allows for explicit links between common/specific components and an economic variable
  - Can be sensitive to the assumptions regarding the processes of the unobservable variables

# Data

- We use real U.S. bilateral exchange rates for Australia, Canada, the euro area, Japan, U.K. and New Zealand.
- Sample: 1981Q1-2007Q4 (currencies floated freely against the U.S. dollar).
- Most exchange rates  $I(1)$ ; small first-order autoregressive term (0.3), so we use the data in first differences



## 3.1 Dynamic principal factor model

- We start by estimating a dynamic factor model.
- We normalize each exchange rate by its standard deviation to ensure equal contribution to the total variance of the model.
- Panel of  $p$  real U.S. dollar exchange rates ( $X=(x_1, \dots, x_p)'$ ) with mean  $\mu$  can be expressed as linear functions of  $m$  ( $m < p$ ) hypothetical common factors ( $f_1, \dots, f_m$ ), plus an error term.

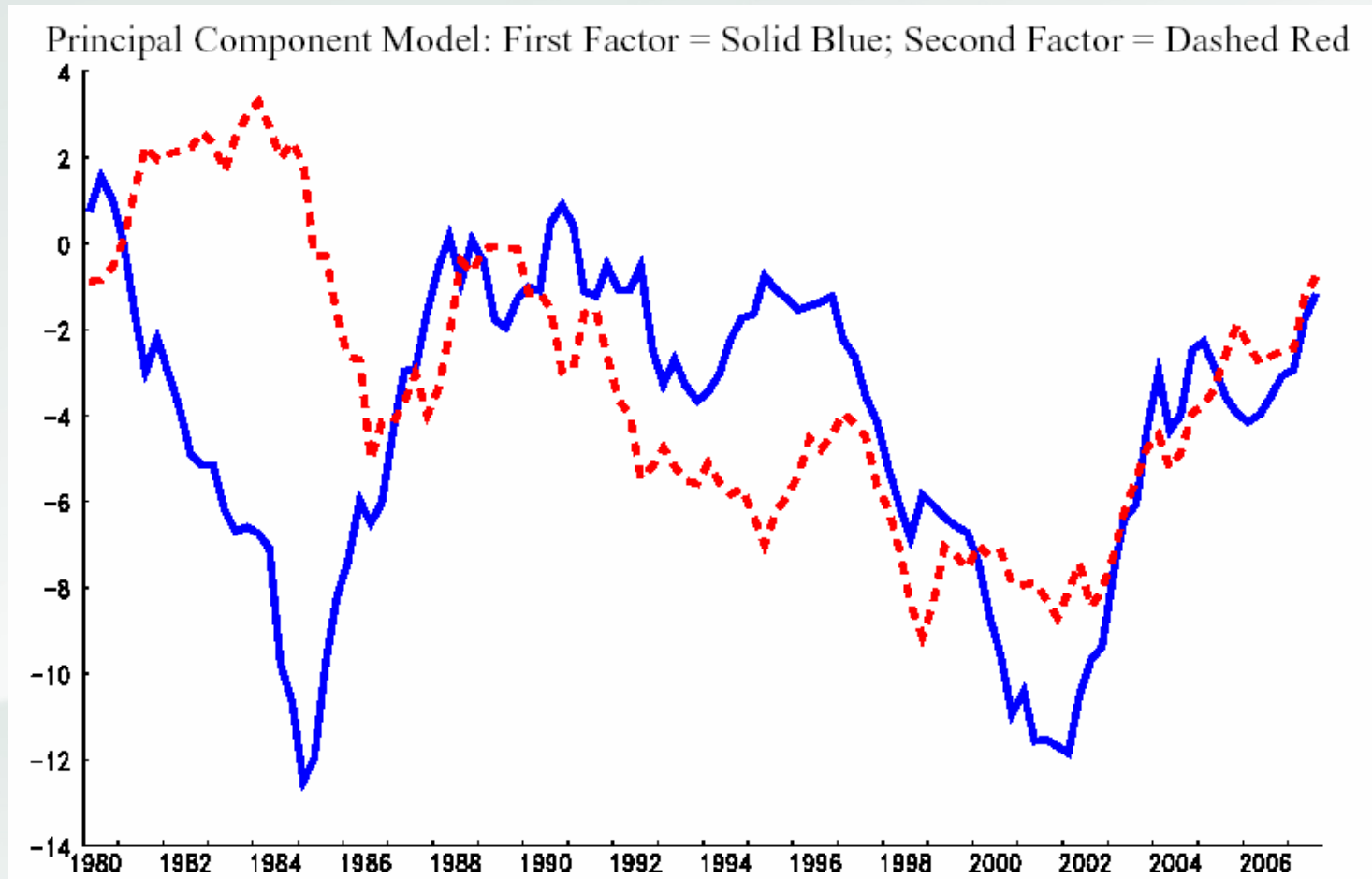
$$X_t - \mu = LF_t + \varepsilon_t$$

$$f_t = l_1 f_{t-1} + l_2 f_{t-2} + \dots + l_p f_{t-p} + v_t$$

$$\varepsilon_t = \alpha_1 \varepsilon_{t-1} + \alpha_2 \varepsilon_{t-2} + \dots + \alpha_q \varepsilon_{t-q} + \zeta_t$$

# Results from the dynamic factor model

We find two factors (eigenvalue of the third factor 0.3)



## Loading factors dynamic factor model

	<b>Factor 1</b>	<b>Factor 2</b>
AU	0.61	0.45
CA	0.43	0.37
EU	0.79	-0.34
JA	0.52	-0.25
NZ	0.74	0.21
UK	0.74	-0.26

- Results robust to estimation of a static or dynamic factor model

## 3.2 What drives the factors?

- Factor models useful to detect patterns in the data, but more evidence needed for economic interpretation.
- Strategy:
  1. Cointegration tests
    - Relative fiscal position
    - Short-term interest rates
    - Commodity prices
    - No evidence for productivity differentials
  2. Building a state space model that incorporates the factors directly.

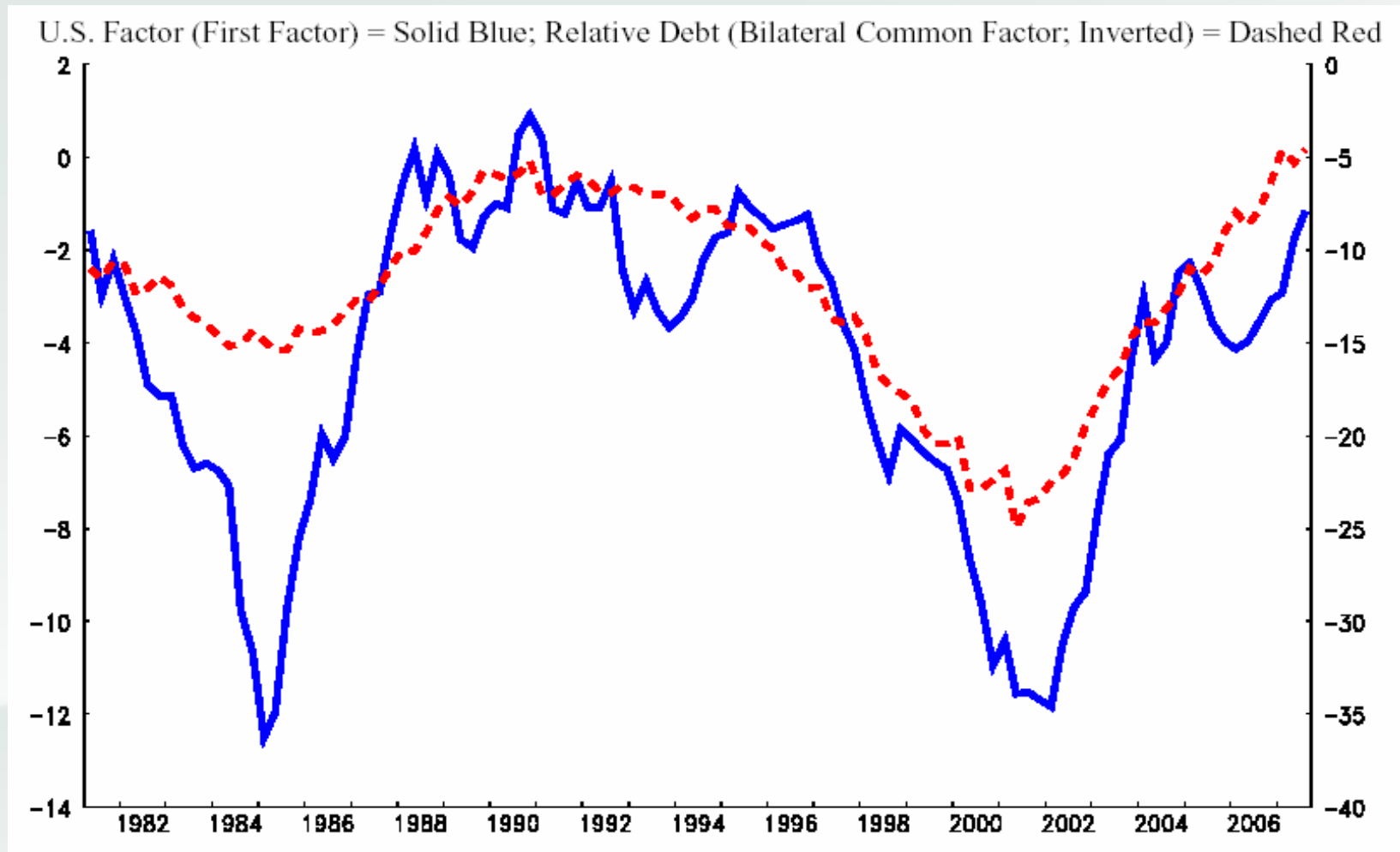
# What drives the factors? Insights from the literature

1. Productivity shocks (Balassa/Samuelson effect)
2. Fiscal policy: Rising government debt leads to fall in savings and lowers net foreign assets-to-GDP ratio; leading to a depreciation to facilitate build-up of current account surpluses (Blanchard, 1985; Weil, 1989).
3. Commodity prices, which proxy exogenous terms-of-trade shocks (Chen and Rogoff, 2003).

## What drives the first factor (“U.S. factor”)?

- We estimate dynamic factor models for government debt-to-GDP ratios (relative to US) and productivity differentials. In both cases, the first factor moves in the same direction for all country pairs.
- First factor of our exchange rate panel is cointegrated with the first factor of government debt, but not with productivity differentials.
  - A deterioration in the U.S. fiscal position - relative to all other countries - leads to a long-run, multilateral U.S. dollar depreciation.
  - This is in line with overlapping generations models (Ganelli, 2005; and Kumhoff and Laxton, 2007).

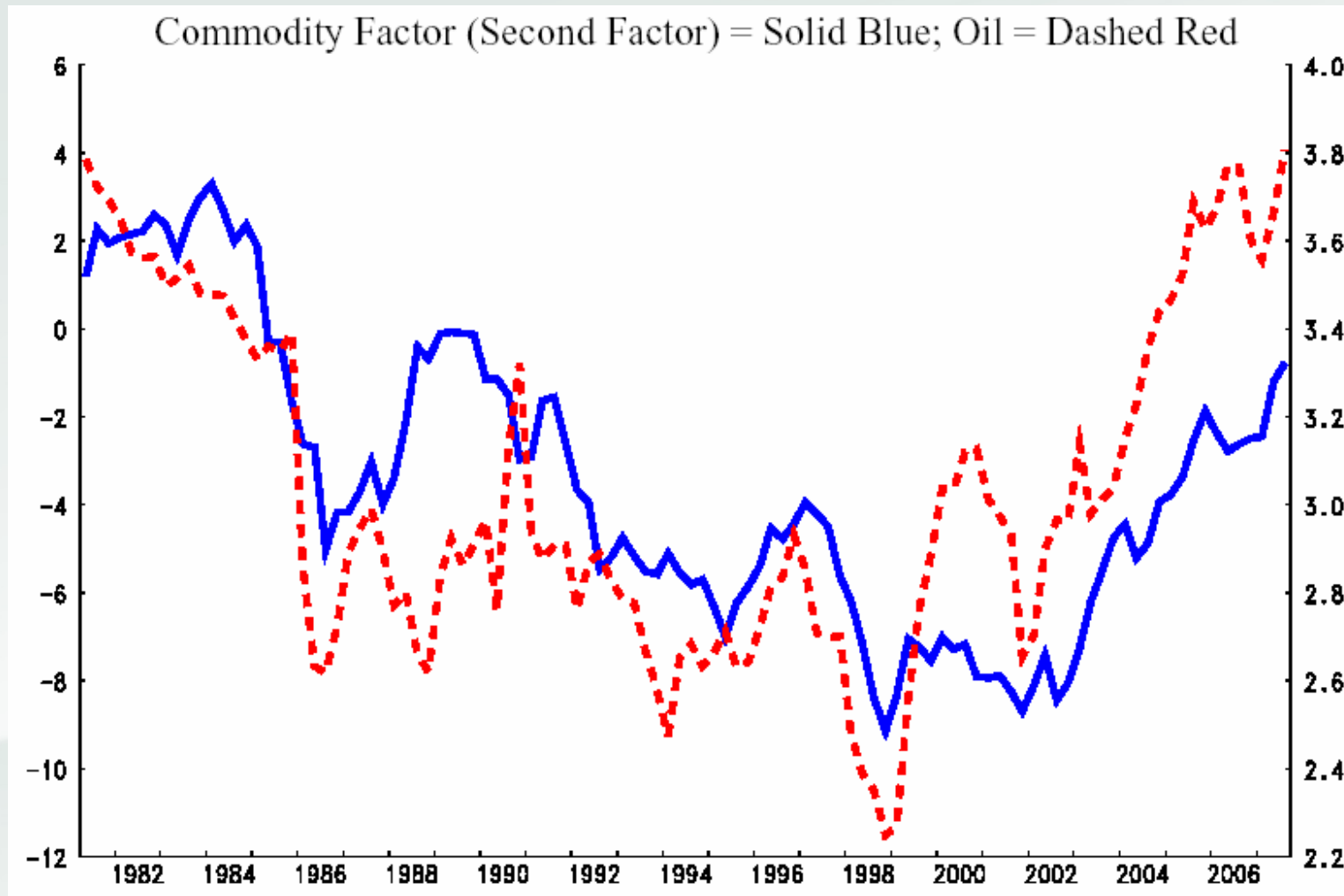
# First factor: relative U.S. fiscal position



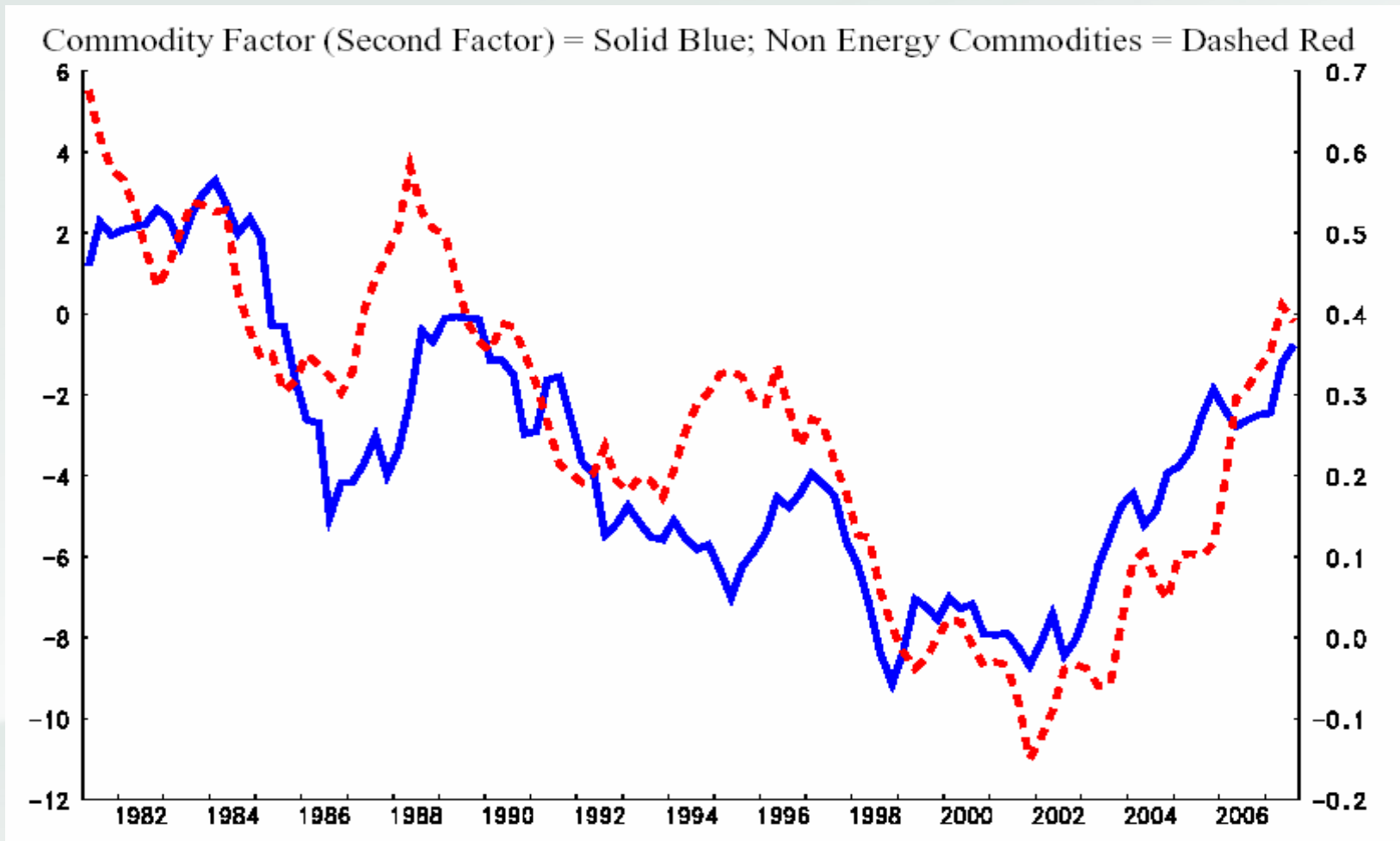
# What drives the second factor?

- Pattern of the loading factor suggests that commodity prices might play a role.
- Indeed, second factor cointegrated with real energy and non-energy commodity prices.

# Second factor: Commodity prices



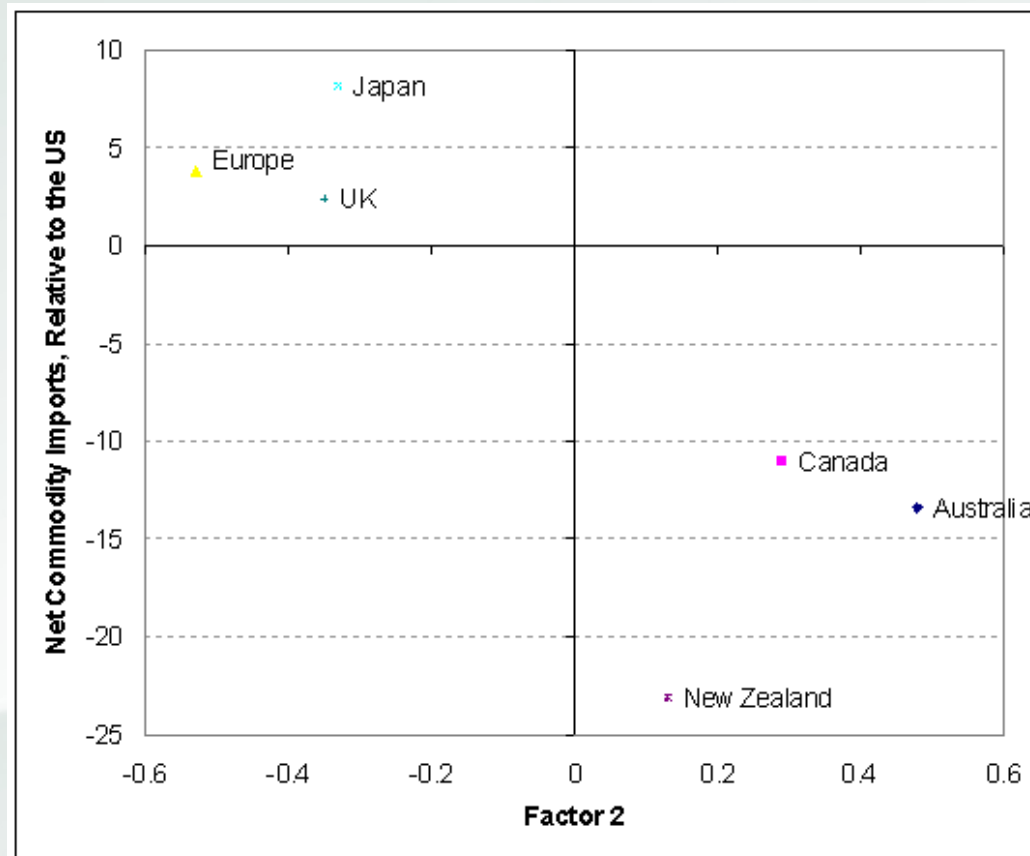
# Second factor: Commodity prices



# Cointegration tests

	First factor	Second factor
Test statistic (Saikkonen)	-4.11	-4.80
Test statistic (Engle-Granger)	-4.07	-4.22
Critical values	1% -4.44	-4.44
	5 % -3.83	-3.38
	10% -3.52	-3.52

# Loading factor 2 vs. net commodity imports, relative to the US



## 3.3 State space model

- We build a state-space model which incorporates:
  - A direct link between the first factor and the first factor of the relative debt-to-GDP ratio
  - A direct link between the second factor and energy- and non-energy commodity prices
  - The factor in the short-term interest rate differential drives the short-term dynamics of the exchange rate

# State-space model

$$X_t^i = \gamma_1^i C_t^1 + (\gamma_2^i + D^{93} \gamma^{CAN}) C_t^2 + v_t^i$$

$$\Delta C_t^1 = \phi_1 C_{t-1}^1 + \beta_1 rdiff_{t-1} - \lambda_1 (C_{t-1}^1 - \beta_2 Debt_{t-1}) + \eta_t^1$$

$$\Delta C_t^2 = \phi_2 C_{t-1}^2 - \lambda_2 (C_{t-1}^2 - \beta_3 p_{t-1}^{NE} - \beta_4 p_{t-1}^{Oil}) + \eta_t^2$$

$$D(L)v_t^i = \varepsilon_t^i \text{ for all } i$$

- $p^{oil}$ : real WTI oil price,
- $p^{NE}$ : real IMF non-energy commodity prices
- $Debt_t$ : symmetrical common component of the debt/GDP ratio, relative to the U.S. debt/GDP
- $rdiff_t$ : Symmetrical common component of the short-run real interest rate differential with the U.S.
- $D93$ : dummy for energy liberalization in Canada

# Estimation of the structural state space

US Factor

Parameter	Coefficient	T-Stat
$\gamma_1^{AU}$	0.48	8.87
$\gamma_1^{CAN}$	0.33	4.81
$\gamma_1^{EU}$	0.77	17.74
$\gamma_1^{JA}$	0.51	7.05
$\gamma_1^{NZ}$	0.60	9.86
$\gamma_1^{UK}$	0.66	10.84

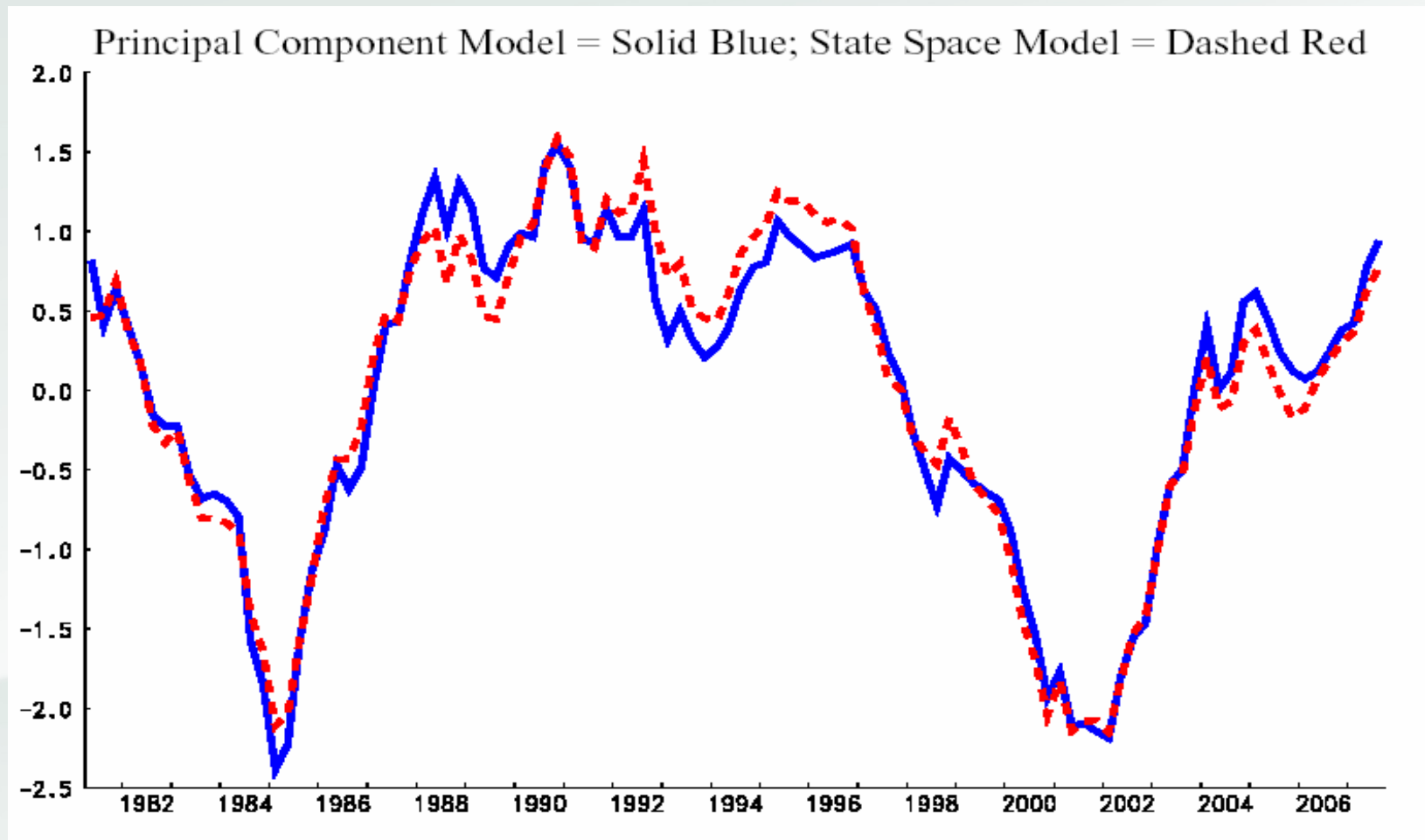
Commodity factor

Parameter	Coefficient	T-Stat
$\gamma_2^{AU}$	0.56	11.05
$\gamma_2^{CAN}$	0.21	2.89
$\gamma_2^{EU}$	-0.31	-6.61
$\gamma_2^{JA}$	-0.20	-2.50
$\gamma_2^{NZ}$	0.23	3.65
$\gamma_2^{UK}$	-0.18	-2.64
$\gamma^{CAN}$	0.41	3.20

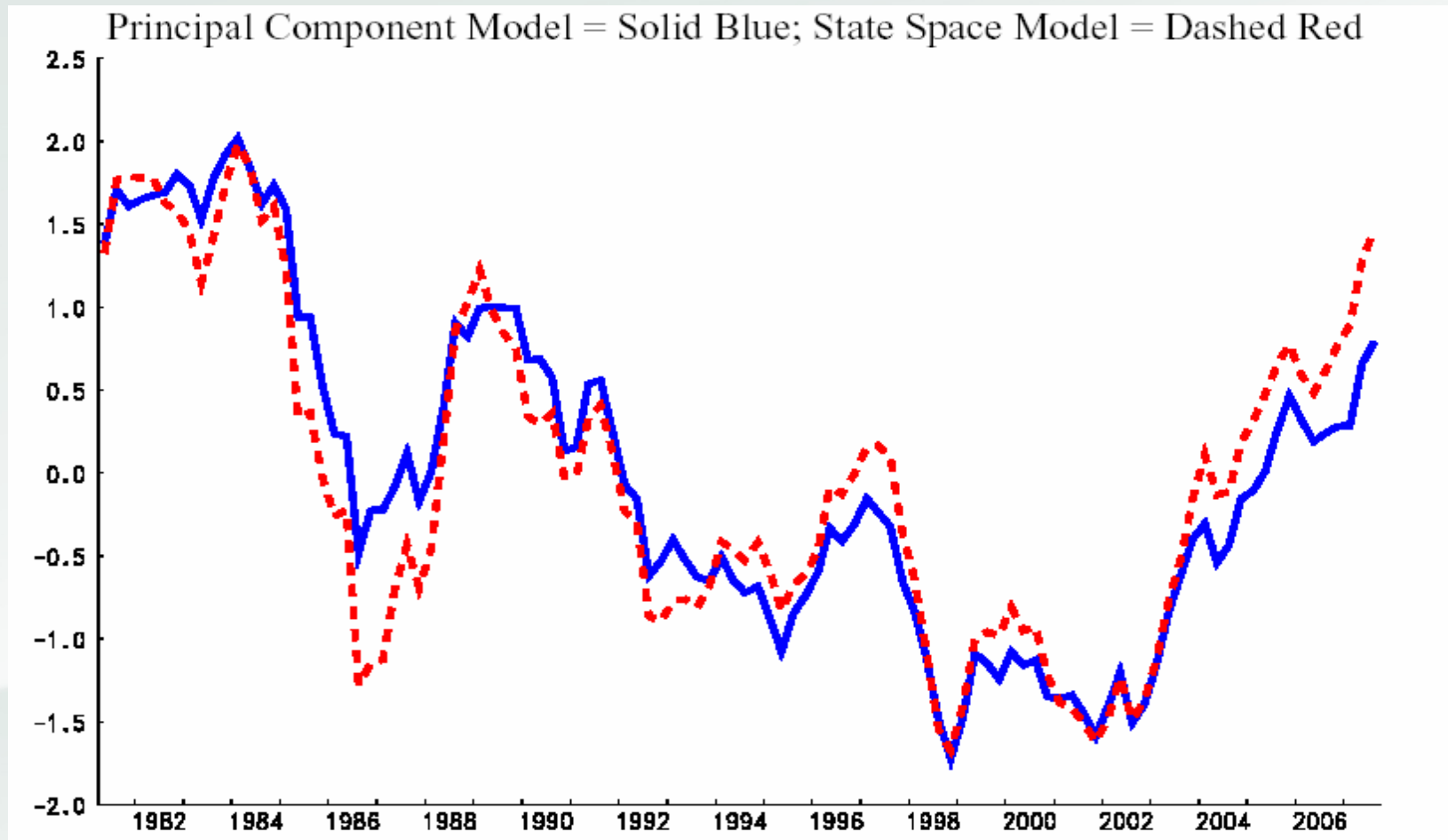
## Estimation of the structural state space: Cointegration relationships

Cointegration Parameters	Coefficient	T-Stat
$\lambda_1$	-0.20	-4.07
$\beta_1$	-0.55	-6.56
$\beta_2$	0.94	4.85
$\lambda_2$	-0.18	-4.54
$\beta_3$	0.73	4.71
$\beta_4$	0.59	3.61

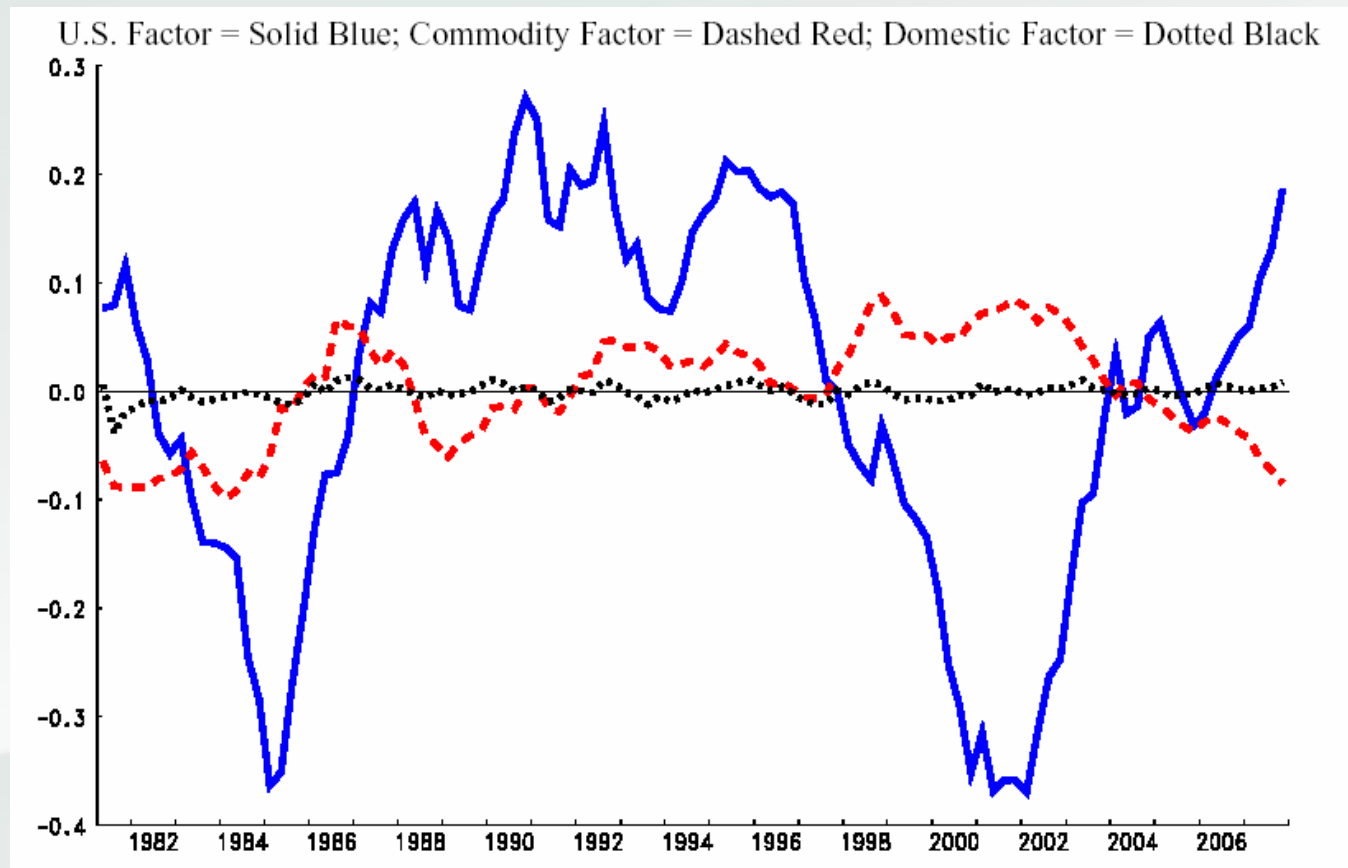
# U.S. factor: Factor model vs. state-space model



# Commodity factor: Factor model vs. state-space model

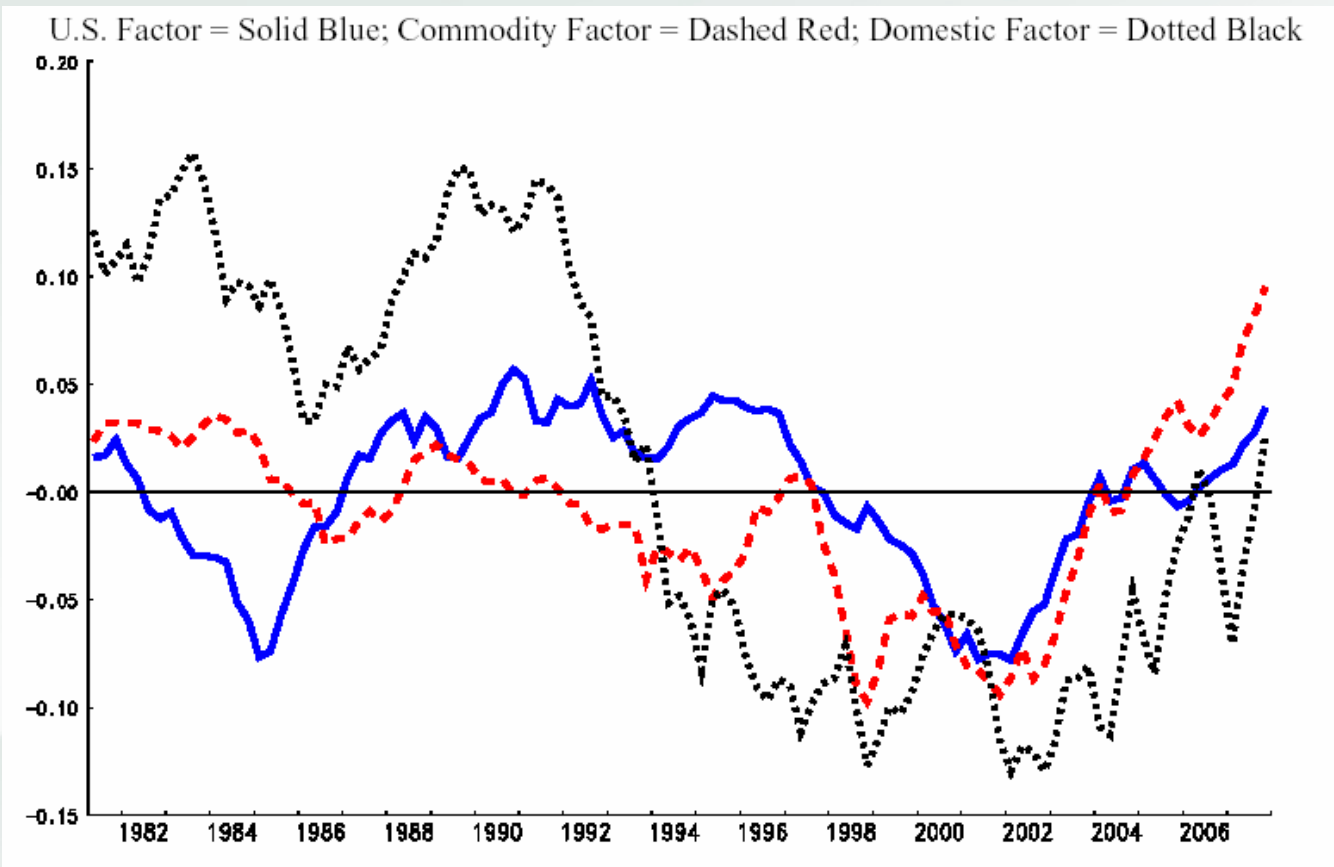


## 3.4 Historical decomposition: Euro area

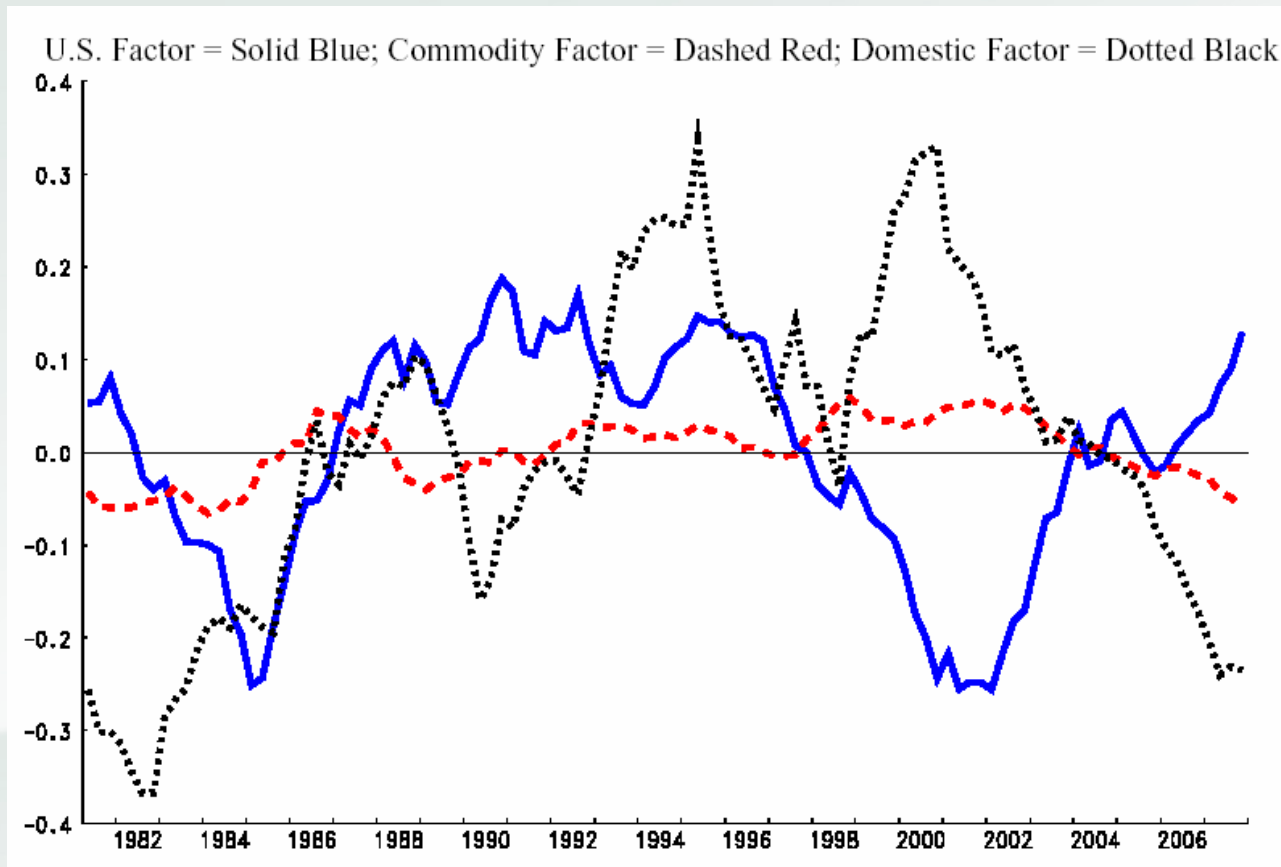


Fratzscher (2007): Europe has borne the bulk of the adjustment of the U.S. dollar effective exchange rate over the past 25 years.

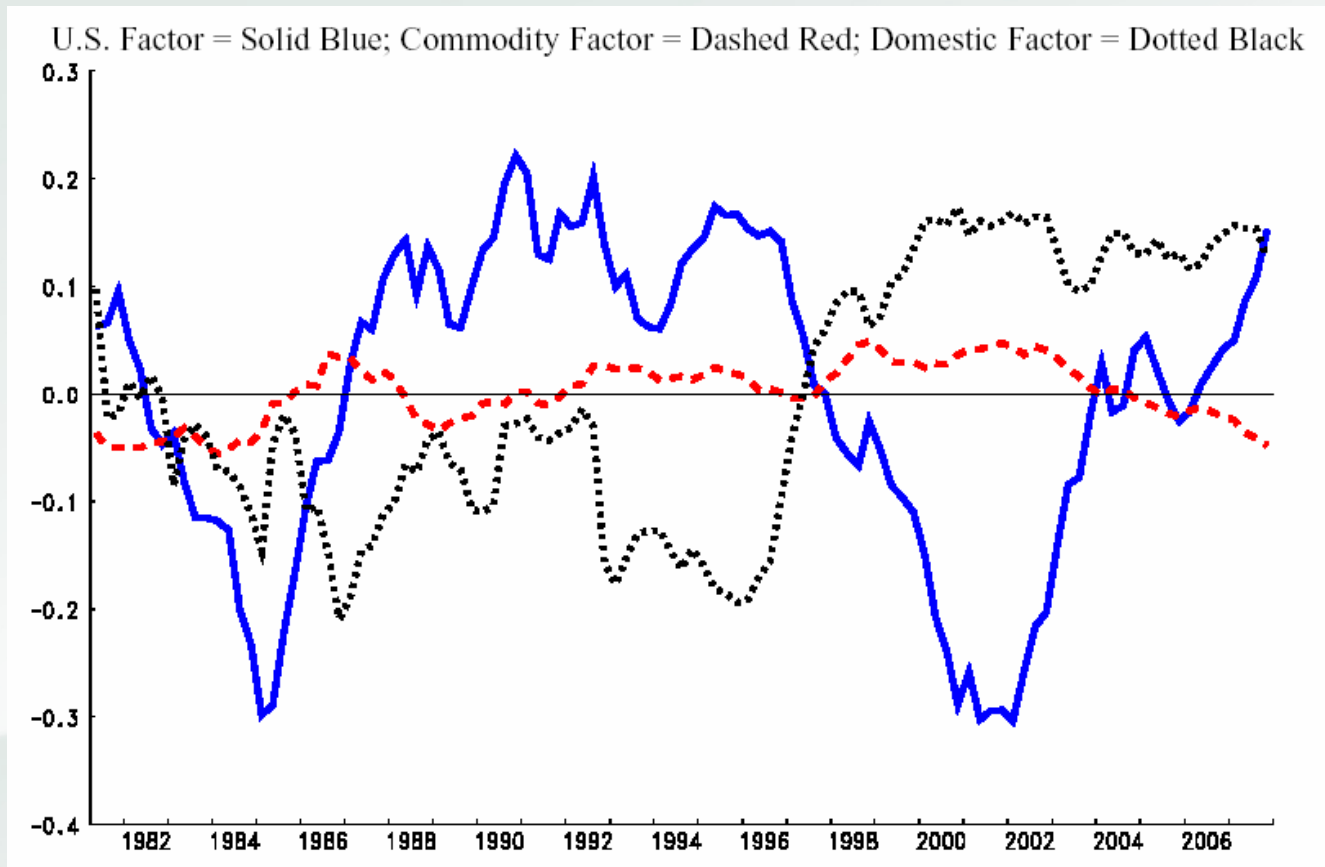
# Historical decomposition: Canada



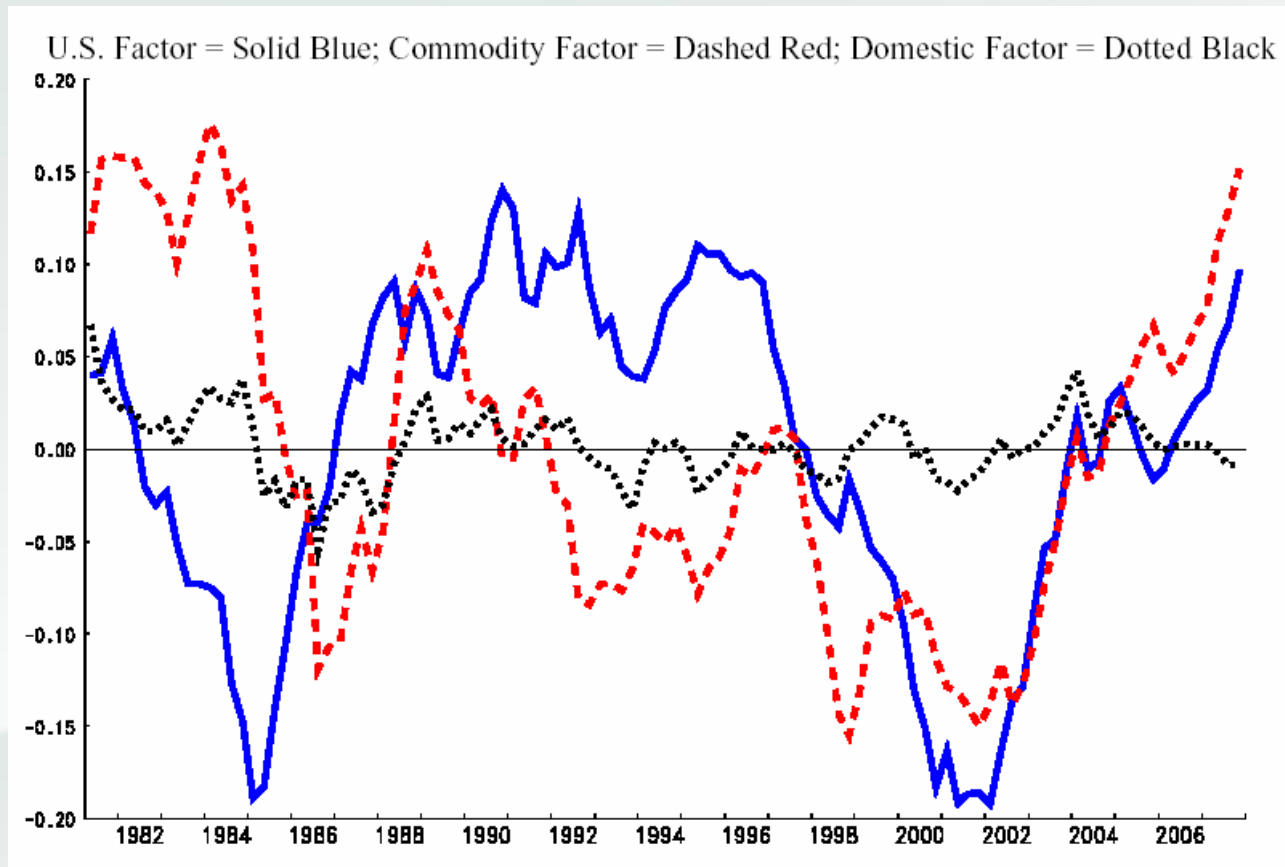
# Historical decomposition: Japan



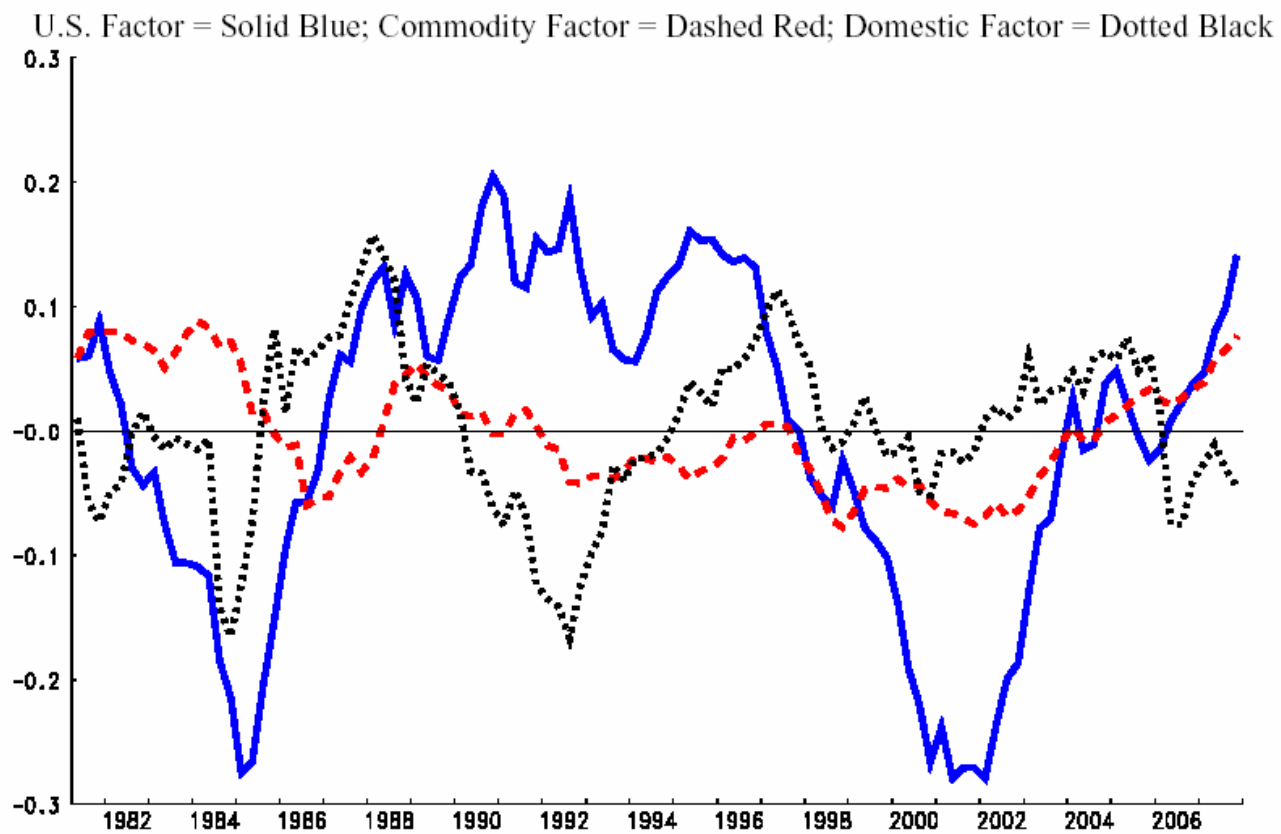
# Historical decomposition: UK



# Historical decomposition: Australia



# Historical decomposition: New Zealand



## 3.5 Robustness checks

Key results are robust to;

- Estimation sample (post-Bretton Woods or 1980-2007)
- Methodology to extract the common components (principal factor model or state-space model)
- Changing the numeraire currency (USD or euro)
- Modelling the link between the factor and economic variables explicitly, or estimating these links ex-post (like in the factor model).

## 4. Conclusion

- We study a panel of six bilateral U.S. dollar real exchange rates using a principal factor and a state-space model.
- Key insights:
  1. U.S. shocks are important role in explaining exchange rates over the 2002-2007 period.
  2. U.S. fiscal shocks seem to have played an important role in the recent (2002-2007) generalized depreciation of the U.S. dollar.
  3. Commodity prices help explain the behaviour of commodity currencies, including Canada