DSGE modelling at the European Central Bank

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Banco Central do Brazil

The views expressed are my own and not necessarily those of the ECB.
This presentation is based on work by many ECB colleagues, in particular Kai Christoffel, Günter Coenen, Roberto Motto, Massimo Rostagno and Anders Warne.

Outline

1. Introduction and motivation
2. Structure of Bayesian DSGE models at the ECB
3. Some empirical applications using the NAWM
4. Conclusions and way forward

I. Introduction

Introduction

- **Monetary policy makers need a wide range of macro-econometric models/tools**
  - **for forecasting**
  - **and for policy analysis**
- **More and more institutions (Fed, ECB, IMF, Sveriges Riksbank, …) include Bayesian Dynamic Stochastic General Equilibrium (DSGE) models in their tool kit for monetary policy analysis and forecasting.**

Introduction

- **Bayesian DSGE models combine**
  - **a sound micro-founded DSGE structure, characterised by the derivation of behavioural relationships from the optimising behaviour of agents subject to technological and budget constraints and the specification of a well-defined general equilibrium,**
    - ➢ **which makes it suitable for policy analysis;**
  - **with a full-system Bayesian likelihood estimation,**
    - ➢ **which provides a good probabilistic description of the observed data and a good forecasting performance.**

Introduction

- **Advantages of the DSGE approach:**
  - **The general equilibrium structure lends itself to telling economically coherent stories and structuring forecast-related discussions accordingly.**
  - **Information about "deep" structural parameters can be used to calibrate/estimate the model (e.g. breaks, short time-series) and the model structure (e.g. cross-equation restrictions) helps to identify parameters and the type of shocks and to reduce the risk of over-fitting.**
  - **Less subject to the Lucas critique and more suitable for policy analysis.**
    - **Puts a premium on expectations**
    - **Better feel for which parameters are likely to be policy invariant and which ones are not.**

Introduction

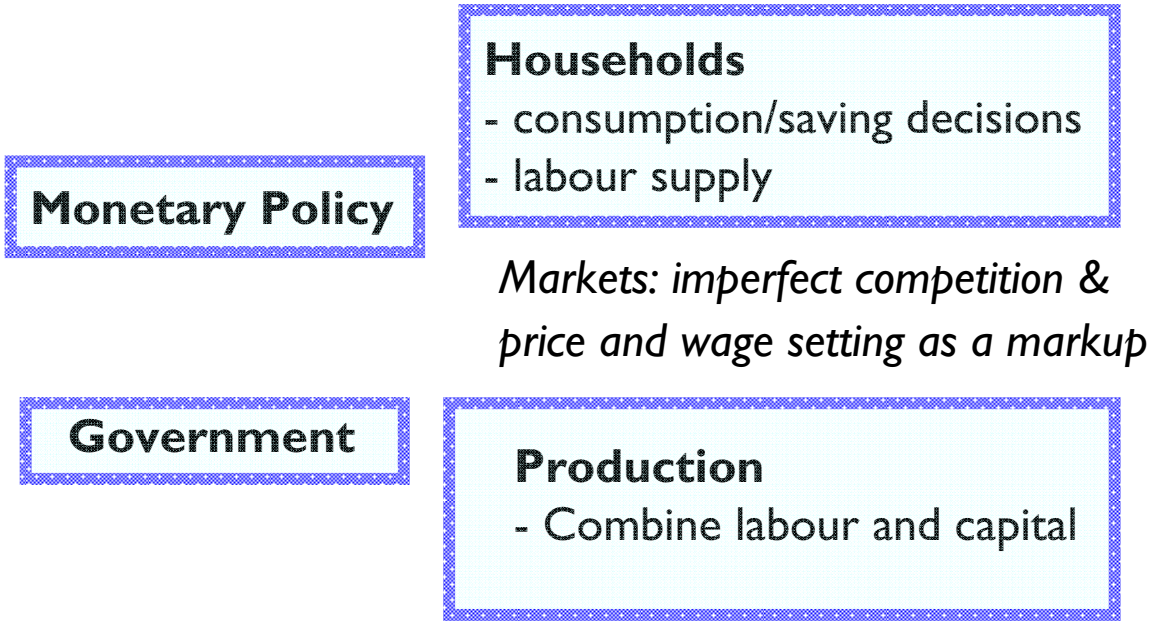
- **Advantages of Bayesian likelihood approach:**
  - **Formalises the use of prior information and helps identification, thereby also making the estimation algorithm of the highly restricted model much more stable.**
  - **Delivers a full characterisation of the parameter and shock uncertainty, allowing to construct probability distributions for unobserved variables (e.g. output gap) and derived functions (e.g. forecasts)**
  - **Very flexible approach to deal with measurement error, unobservable variables, different sources of information.**
  - **Provides a framework for empirically evaluating models and the appropriate input for model averaging and Bayesian decision making under model uncertainty.**

II. Structure of Bayesian DSGE models used at the ECB

Motivation

- **Currently, two Bayesian DSGE models are routinely used at the ECB:**
  - **New Area Wide Model (NAWM) (Christoffel et al, 2008)**
    - **Used for forecasting (in the context of the quarterly ECB Projection Exercises) and policy analysis;**
    - **There is also a calibrated version, relatively richer in detail and open for topic-driven extensions.**
  - **Christiano-Motto-Rostagno (CMR) Model**
    - **Supports the cross checking through monetary/financial scenarios**
- **Both models have a similar core, based on Smets and Wouters (2003, 2007), but**
  - **NAWM includes a detailed international block**
  - **CMR includes a detailed financial block**

Models Overview: Core Structure

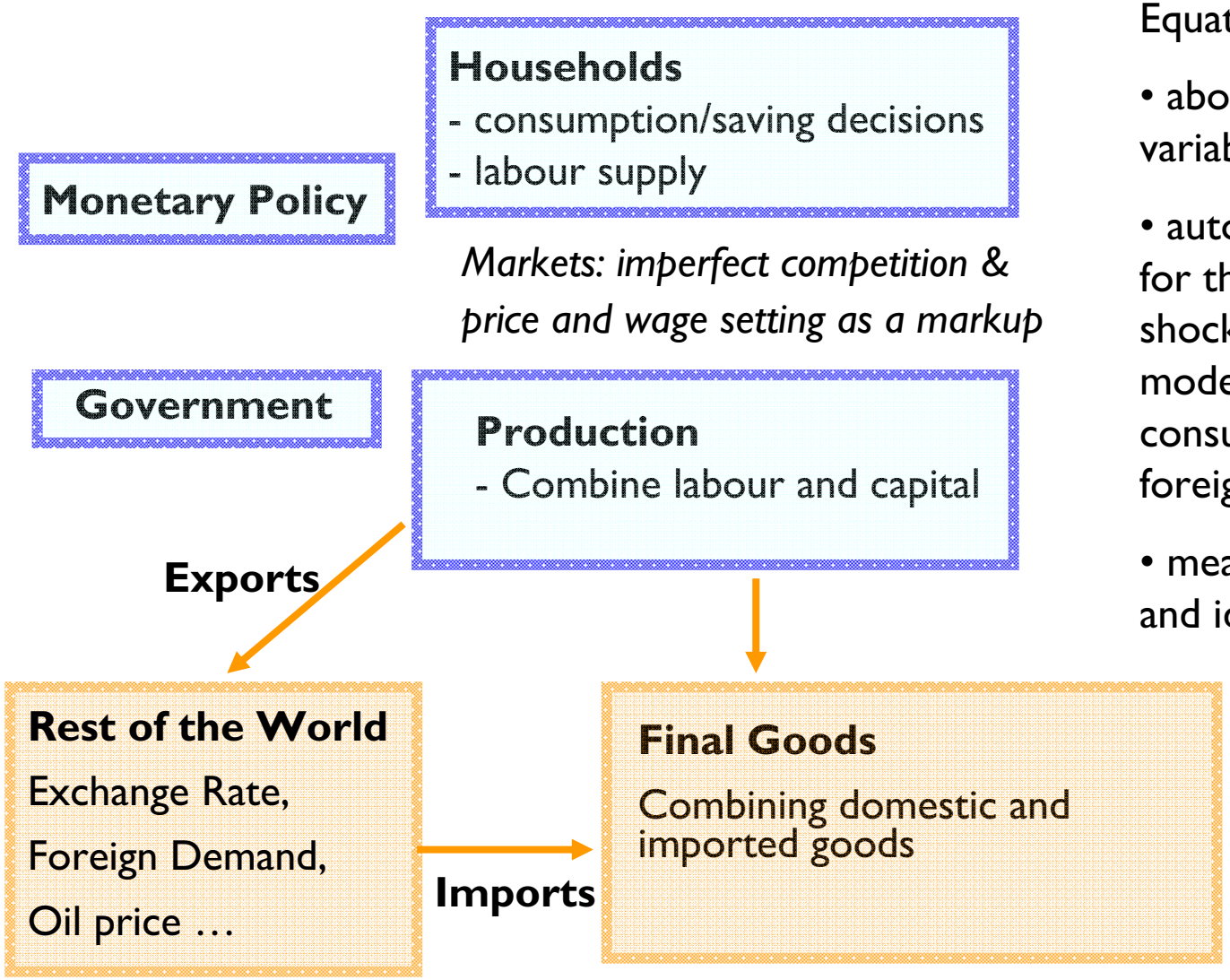


Core structure of both models Smets-Wouters (2003, 2007)

Models overview: NAWM

- **Important considerations guiding the development of the estimated version of the NAWM:**
  - **"to provide a comprehensive set of core projection variables"**
  - **"to allow conditioning the projections on exogenous assumptions regarding monetary, fiscal and external developments"**

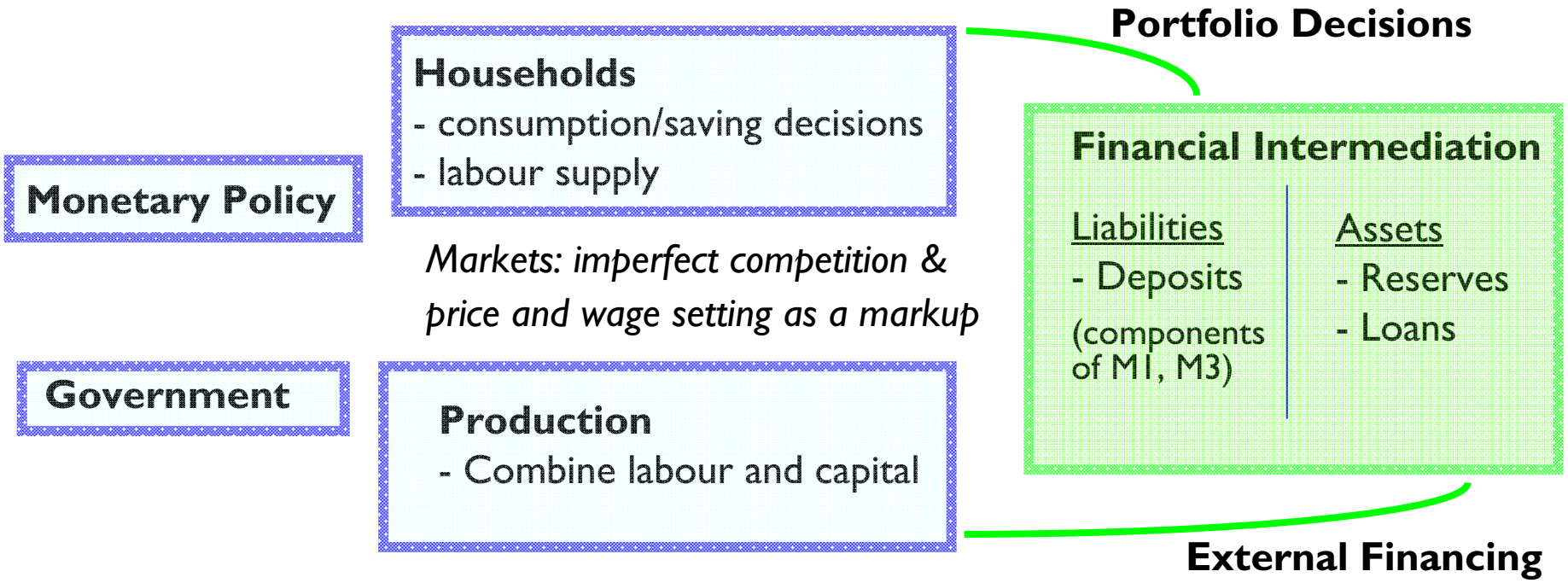
Models Overview: NAWM



Equations:

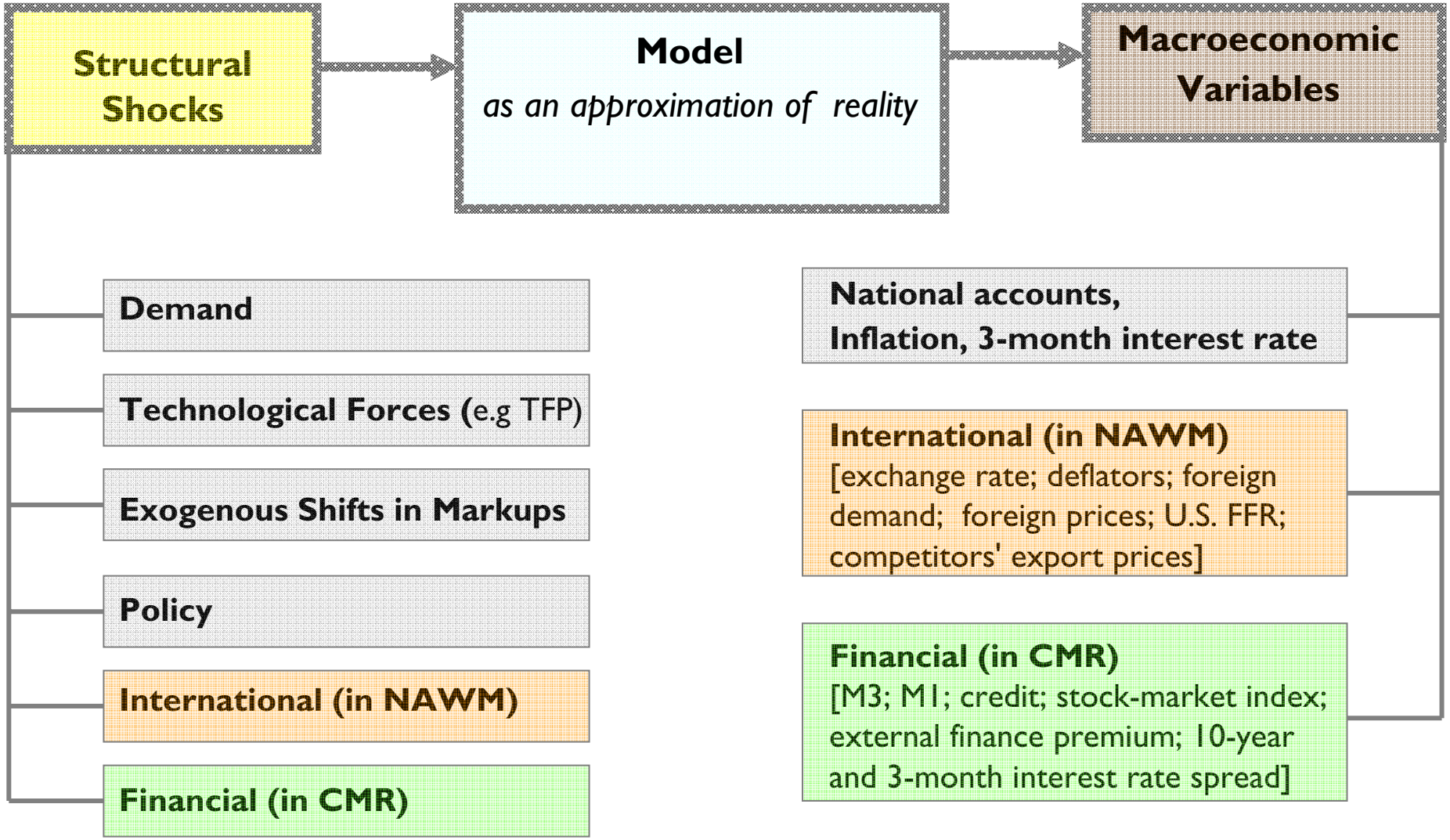
- about 50 endogenous variables
- autoregressive processes for the model's structural shocks and the AR/VAR models for government consumption and the foreign variables
- measurement equations and identities

Models Overview: CMR



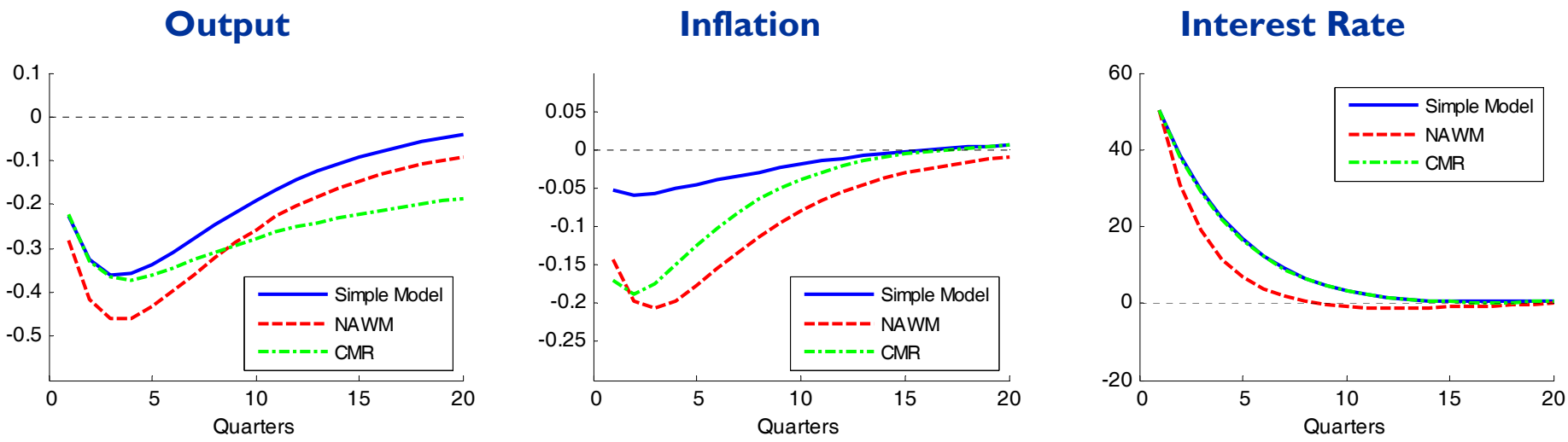
- The CMR expands on the core structure with a monetary and financial block which interacts directly with consumption, investment and price setting.
- The different focus of the two models (international dimension in NAWM and monetary/financial in CMR) make them usable for complementary purposes

Data, Model and Shocks



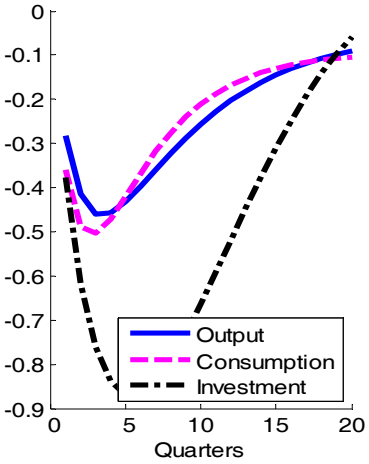
Monetary Policy Transmission

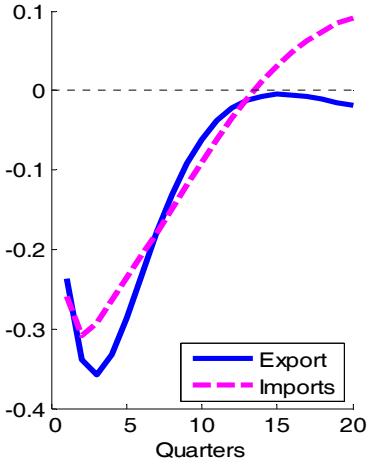
Unanticipated Increase in Interest Rate by 50 bp

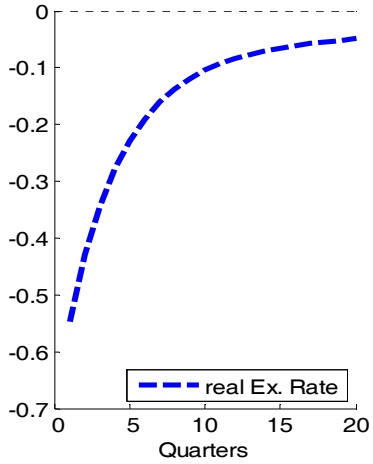


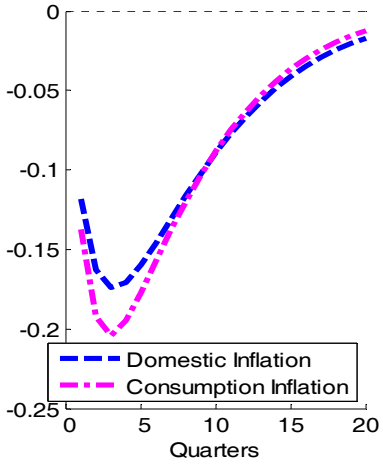
- Response is qualitative same across models
- Considering uncertainty, quantitative differences small

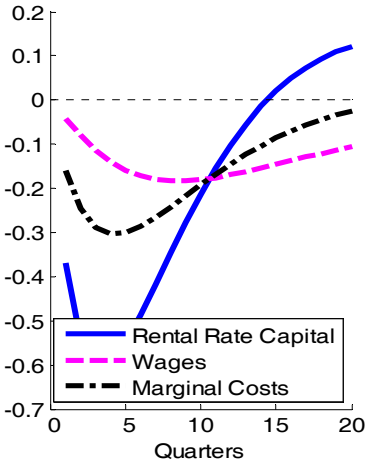
Monetary Policy Transmission: NAWM









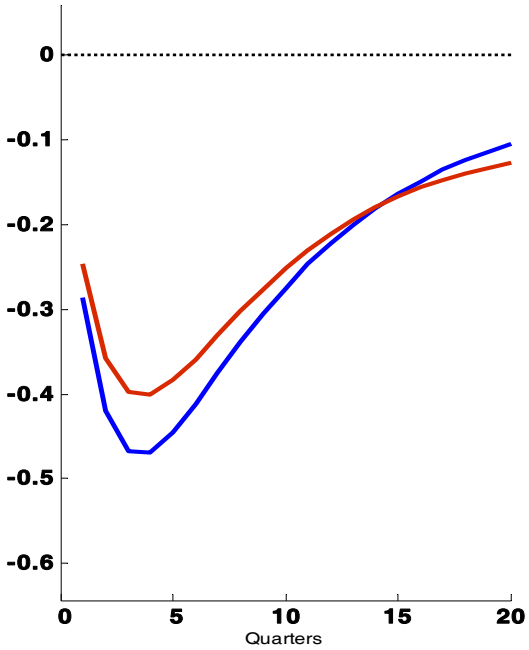


Additional channels in open economy:

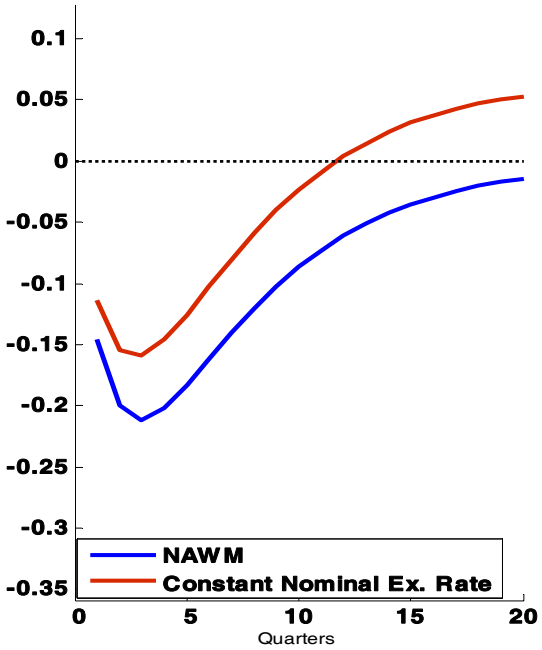
- Appreciation of currency
- Drop in exports amplifies output reaction
- Reduction in import prices implies stronger inflation response

Monetary Policy Transmission: NAWM

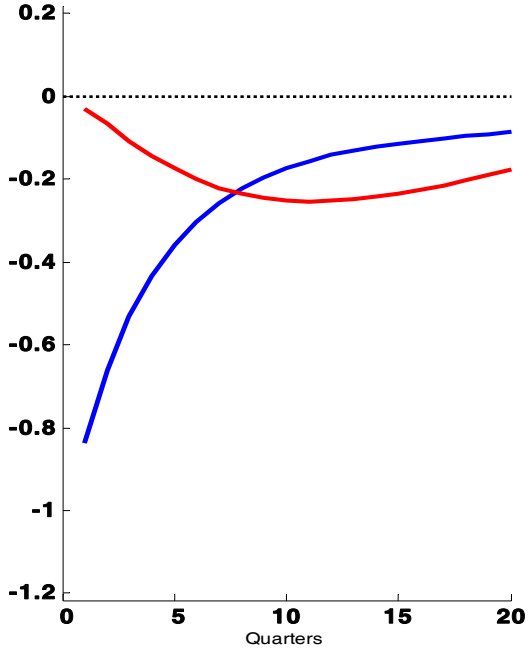
Output



Inflation



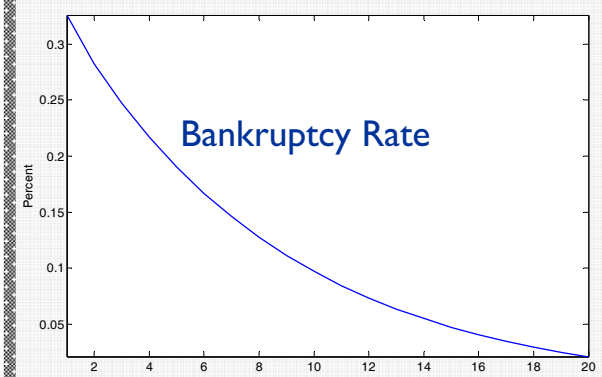
Real Effective Exchange Rate



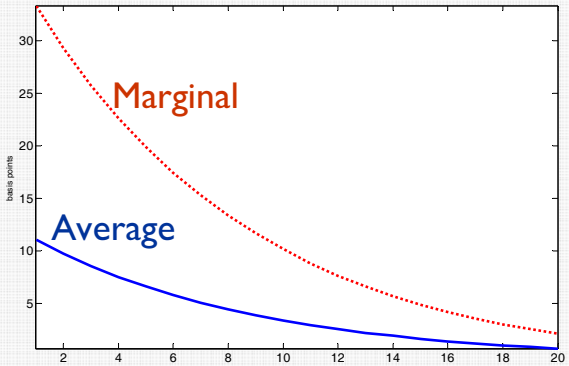
Monetary Policy Transmission: CMR

Deterioration in Economic Activity and Profit Prospects

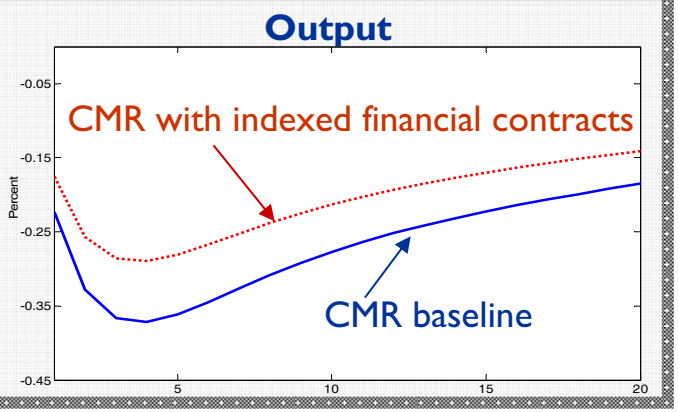
Balance Sheet Deterioration and Rise in Bankruptcy Rate



Rise in External Finance Premium (over and above risk-free rate). Countercyclical

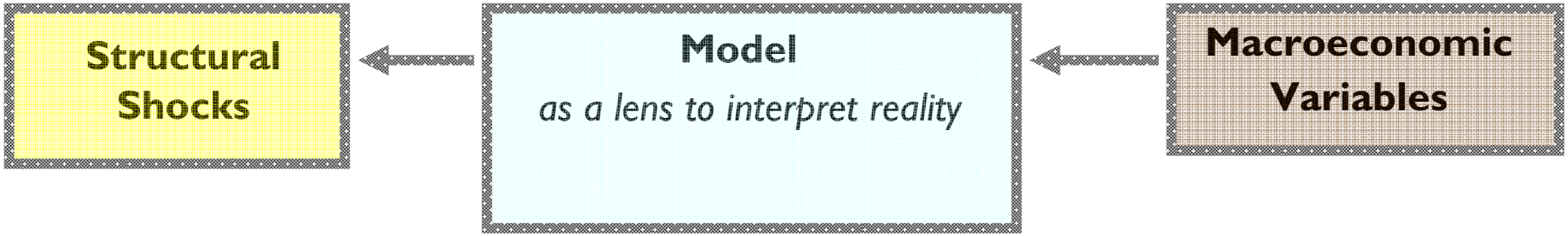


Price Developments Originally Unforeseen Can Affect Financial Position and Real Economy



3. Some applications using the estimated NAWM (Christoffel, Coenen and Warne, 2008)

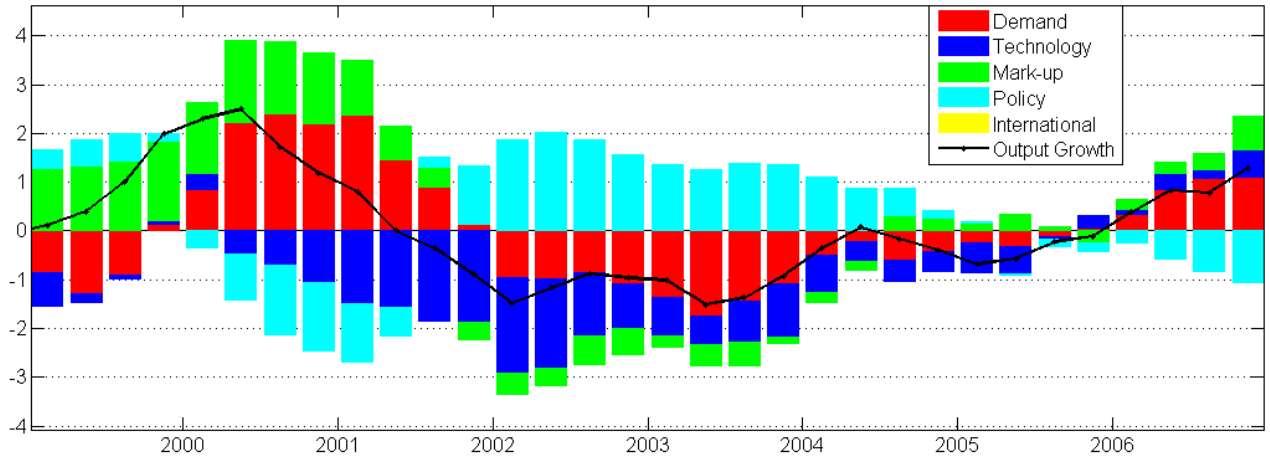
1. Historical analysis



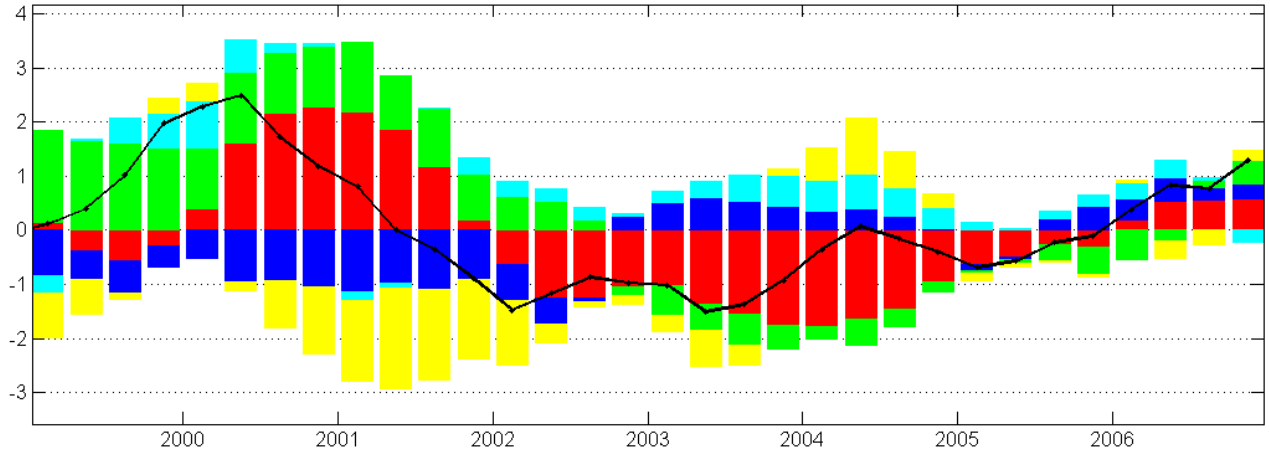
- Model as lens to interpret reality
- Identifying structural shocks
- Decompose variables into contributions from shocks: Historical decomposition
- Example: what is the contribution of external developments to euro area GDP growth

GDP: Role of international developments

Simple Model

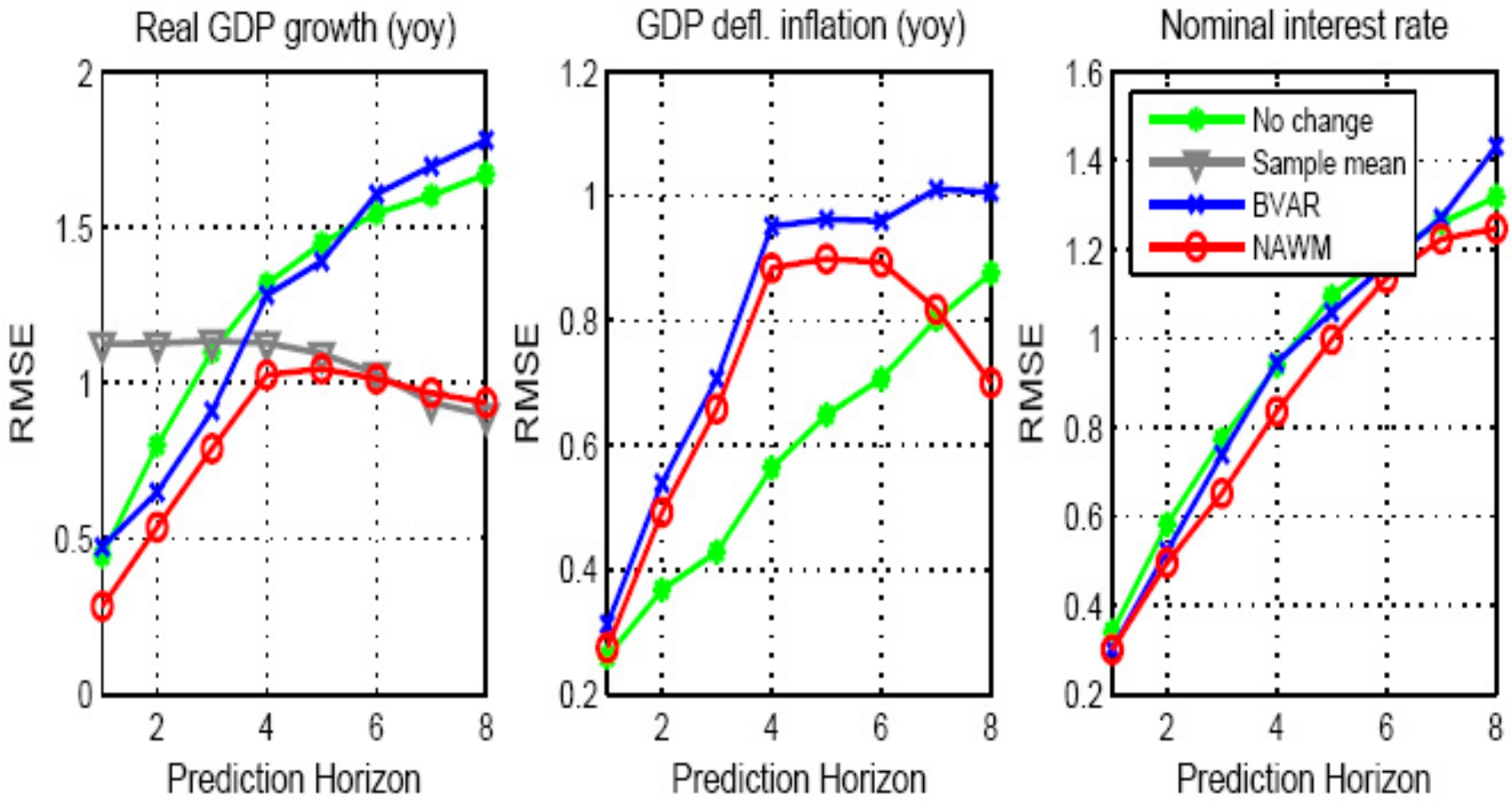


NAWM

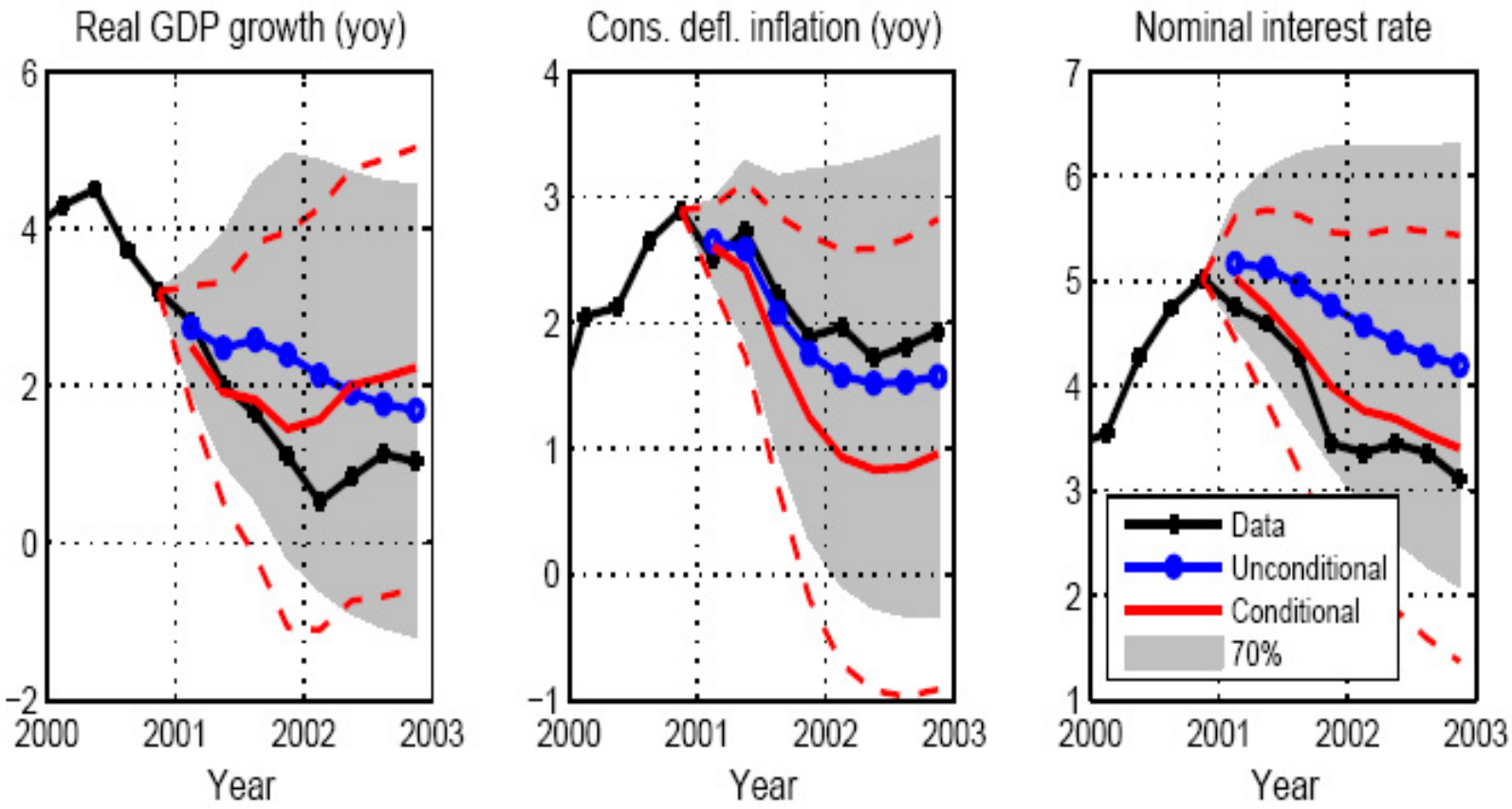


Note: GDP growth, year-on-year % change, in deviation from mean. The sample spans 1999Q1-2006Q4

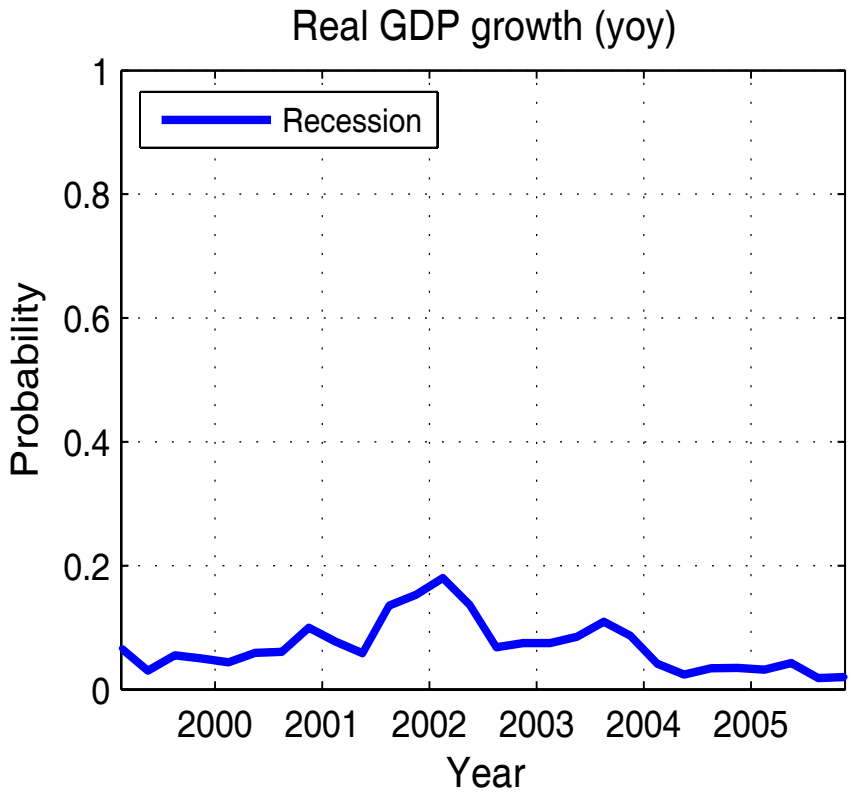
2. Forecasting: Out-of-sample evaluation



2. Forecasting: Mean and interval predictions

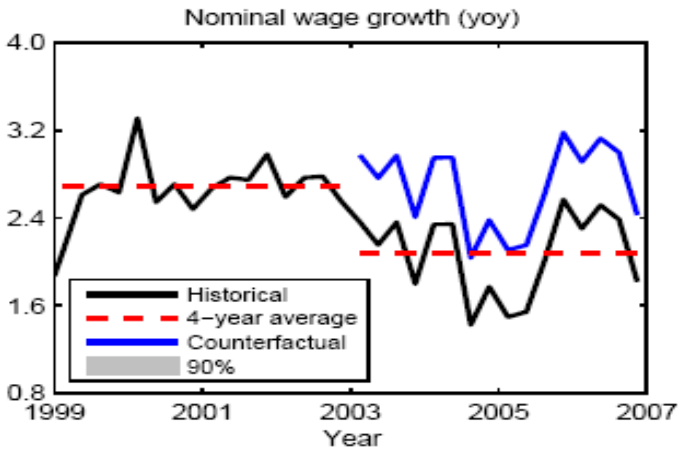


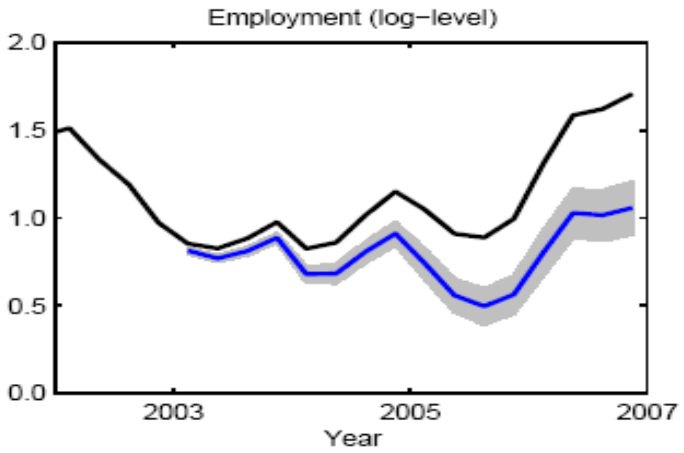
2. Forecasting: Prediction events

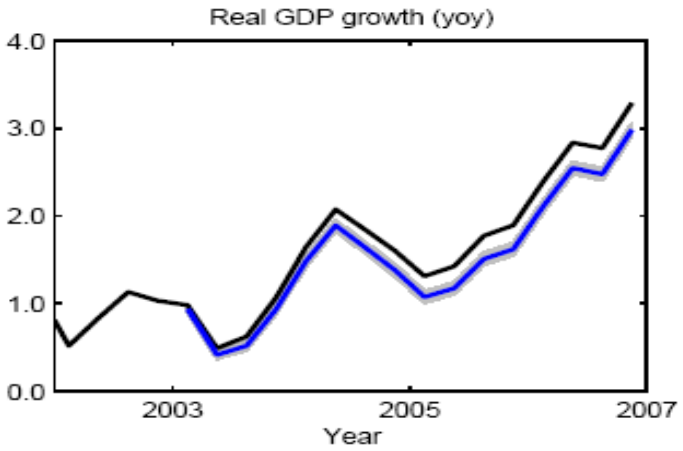


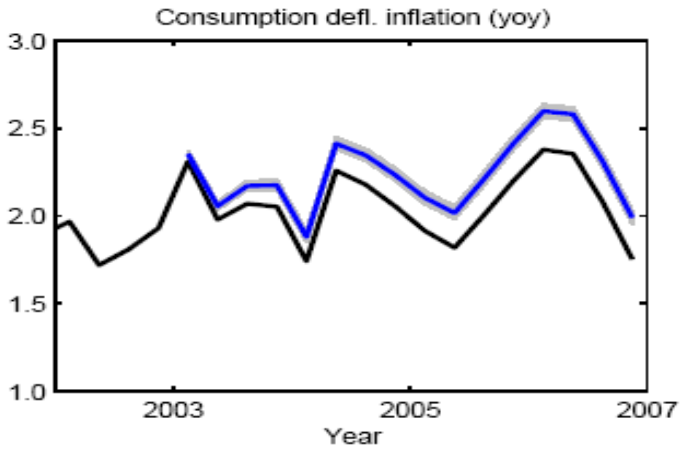
3. Scenario analysis

Reversing wage moderation





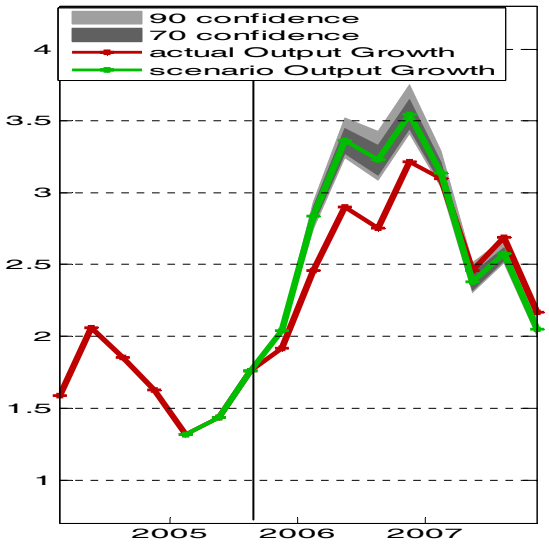




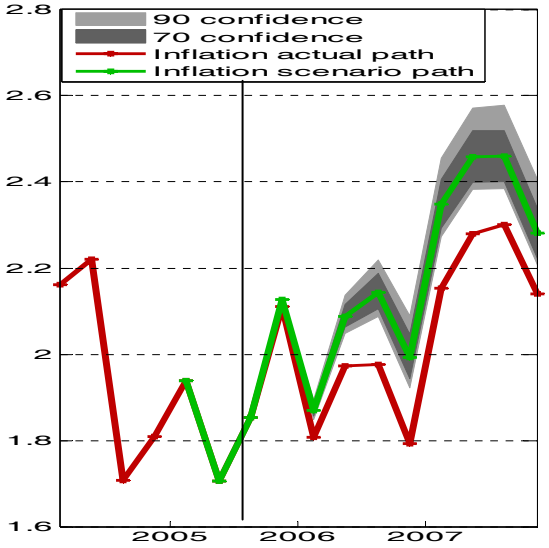
3. Scenario analysis

Delay interest rate increase actually started in December 2005 by two quarters and return gradually to actual interest path

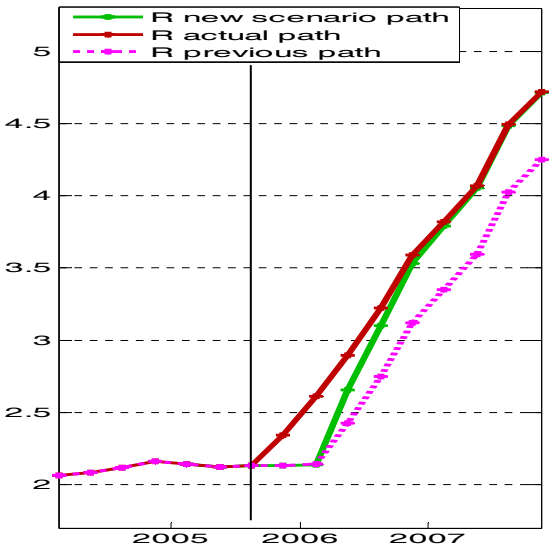
Output



Inflation



Interest Rate



Implication of delayed increase:

- **Higher GDP growth for 6 quarters**
- **Inflation path above actual/projected path for 14 quarters**

Conclusions

Conclusions

- **Bayesian DSGE models provide an empirically and theoretically coherent picture useful for monetary policy analysis.**
- **Like most policy models, they are still very much work in progress:**
  - **Need for richer specification of labour market, asset markets, fiscal policy, sectoral and input/output structure, international interactions, …**
  - **Rational expectations? Allow for learning and imperfect information.**
  - **Strategic interactions between different agents and different actions are often minimised in order to maintain tractability.**

Conclusions

- But there is a risk of creating new monsters:
  - A single large model may be more difficult to understand, more difficult to handle and lead to a lack of robustness.
- General trend:
  - One model in forecasting process
  - ➢ Ensures consistency across projection rounds
  - Suite of models for policy/scenario analysis
  - ➢ Ensures robustness and flexibility in addressing the multitude of questions.
- Question: How large should the benchmark model be?

Background Slides

Comparison of model characteristics

	Country Details	Size	Regular forecast	Micro-founded	Financial sector	Forward-looking	Open
AWM	No	119	Yes	No	No	Limited	Yes
MCM	Yes	~ 500	Yes	No	No	Limited	Yes
NAWM	No	50	Yes	Yes	No	Yes	Yes
CMR	No	29	No	Yes	Yes	Yes	No

Data Coverage

- **CMR and NAWM share common core set of variables**
- **Additional variables according to model focus**

Common Block					
	National Accounts		Prices, Wages and Interest Rates		
NAWM	Output, Investment, Consumption, Government Consumption,	Employment, Extra Euro Area Exports and Imports	GDP deflator, Consumption Deflator, Extra Euro Area Import Deflator	Compensation per employee	Nominal interest rate
CMR		Hours worked	GDP deflator, Investment deflator	Compensation	3-month Interest Rate

Data Coverage (continued)

- **Model Specific Variables**

Specific Blocks		
	International Block	**Financial Block**
NAWM	Nominal effective exchange rate, Foreign demand, Foreign Prices (weighted GDP deflator) U.S. federal funds rate Competitors' export prices Oil Prices	
CMR		M1, M3, Credit, Stock Market Index External Finance Premium, 10-year and 3-month interest rate spread

Key Parameter Estimates

- **Price and Wage Nominal Rigidities Are Important:**
  - **Price Adjustment: Higher Rigidity in NAWM**
  - **Price Indexation: Higher in NAWM**
  - **Wage Adjustment: Similar Across Models**
  - **Wage Indexation: Higher in NAMW**

Price and Wage Setting					
	Price-Setting		Wage-Setting		
	Price Adjustment Probability	Indexation in Prices	Wage Adjustment Probability	Indexation in Wage	Indexation to Productivity
NAWM	0.08	0.41	0.24	0.63	1
CMR	0.27	0.10	0.23	0.25	0.89
Simple Model	0.08	0.17	0.28	0.30	1

Note: Figures in the first and third columns indicate the estimated price/wage adjustment probability. The indexation parameter in price and wage setting (second and fourth columns), is a measure of second-round effects and corresponds to the estimated weight placed on past inflation in the estimated price-inflation and wage-inflation equations, respectively. The complements to 1 of those coefficients provide some indication of the "anchoring" of inflation expectations.

Key Parameter Estimates (cont.)

Main Features of Monetary Policy Reaction:

- Response to Inflation Developments
- Restrain from Reacting to Each Twist and Turn in Data
- In CMR, Attempt to Capture Monetary Pillar Features

Estimated Monetary Policy Reaction Functions

	Reaction to Inflation	Reaction to Economic Activity	"Gradualism"	Additional Terms
NAWM	1.90 [lagged inflation] 0.19 [inflation acceleration]	0.15 [speed of economic activity]	0.87	
CMR	1.86 [expected inflation] 0.26 [inflation acceleration]	0.30 [speed of economic activity]	0.86	0.1 [credit development]
Simple Model	1.75 [lagged inflation] 0.40 [inflation acceleration]	0.08 [speed of economic activity]	0.81	

Note: The coefficient on inflation, output and credit indicate the increase in the policy instrument in response to an increase in those indicators.

Model Overview