



EUROPEAN CENTRAL BANK

EUROSYSTEM

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# **Modelling International Linkages: The GVAR approach**

## **Book presentation**

“The GVAR Handbook”

Frankfurt-am-Main, 11 November 2013

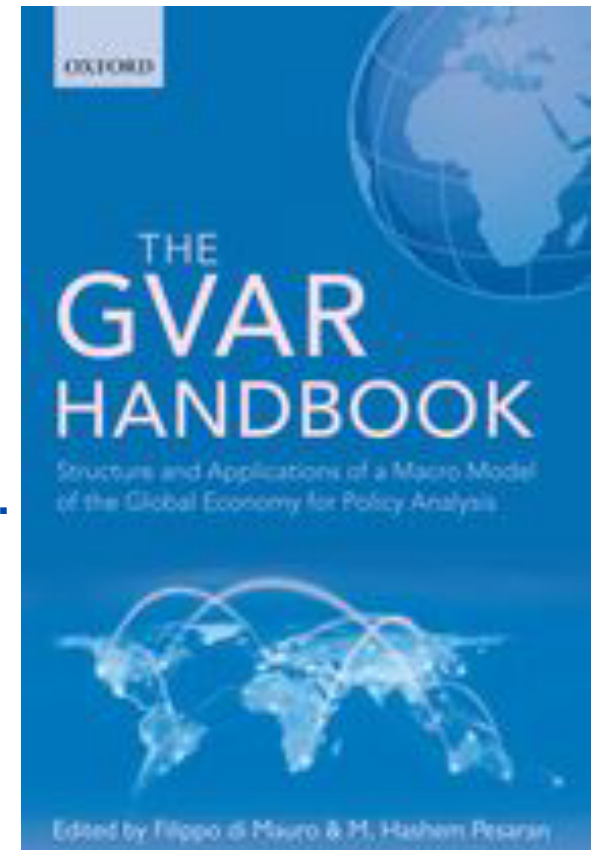
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# Motivation

- **Globalization has greatly increased the degree of interdependence across countries**
- **National economic issues best considered from a global perspective**
- **There are many countries and regions, as well as many channels of transmission to take into account:**
  - **Fundamental trade and financial linkages**
  - **Common shocks (such as oil or food prices)**
  - **Other channels (e.g., technology, uncertainty and complexity)**
- **We need to model complex high-dimensional systems, but there is a severe curse of dimensionality...**

# Motivation (II)

- Today we will show how interdependencies can be handled via the GVAR (Global vector auto-regression) model
  - The GVAR was originally developed by Pesaran, Scheuermann and Weiner (204, PSW), but then developed tremendously thereafter
  - On this we have published a book
  - It includes 23 contributors
  - ...but many more should have been included..
- today's presentation will provide a broad picture of policy relevant applications



# The value added of a GVAR modelling...

- The model is data driven, permitting reliable quantification of linkages
- The model is truly global accounting for the complexity of international linkages...
- ....yet it is parsimonious, thus addressing “curse of dimensionality”
- It can provide important policy relevant input on questions like “What happens if the oil price increases by 10 percent? If China GDP falls by one percent? What has been the impact of globalization on transmission?”
- Admittedly, shock identification is more difficult but possible
- At the ECB we have a long history of handling/developing GVAR starting with the association of some of us with Professor Pesaran since 2004.

- 1 Stylized facts
- 2 The GVAR approach and a benchmark GVAR
- 3 Conclusions

# Stylized Facts

# Stylized facts #1: Pair-wise correlations differ widely across variables and across countries

	First Dif .					
	Output	Inflation	Equity prices	Ex. Rate	ST Int. Rate	LT Int. Rate
China	2%	6%		8%	5%	
EuroArea	14%	12%	50%	32%	15%	45%
Japan	3%	5%	36%	24%	5%	28%
Canada	14%	11%	47%	20%	17%	37%
UK	9%	6%	49%	27%	13%	38%
US	14%	14%	46%		10%	39%
Average	9%	9%	46%	22%	11%	37%

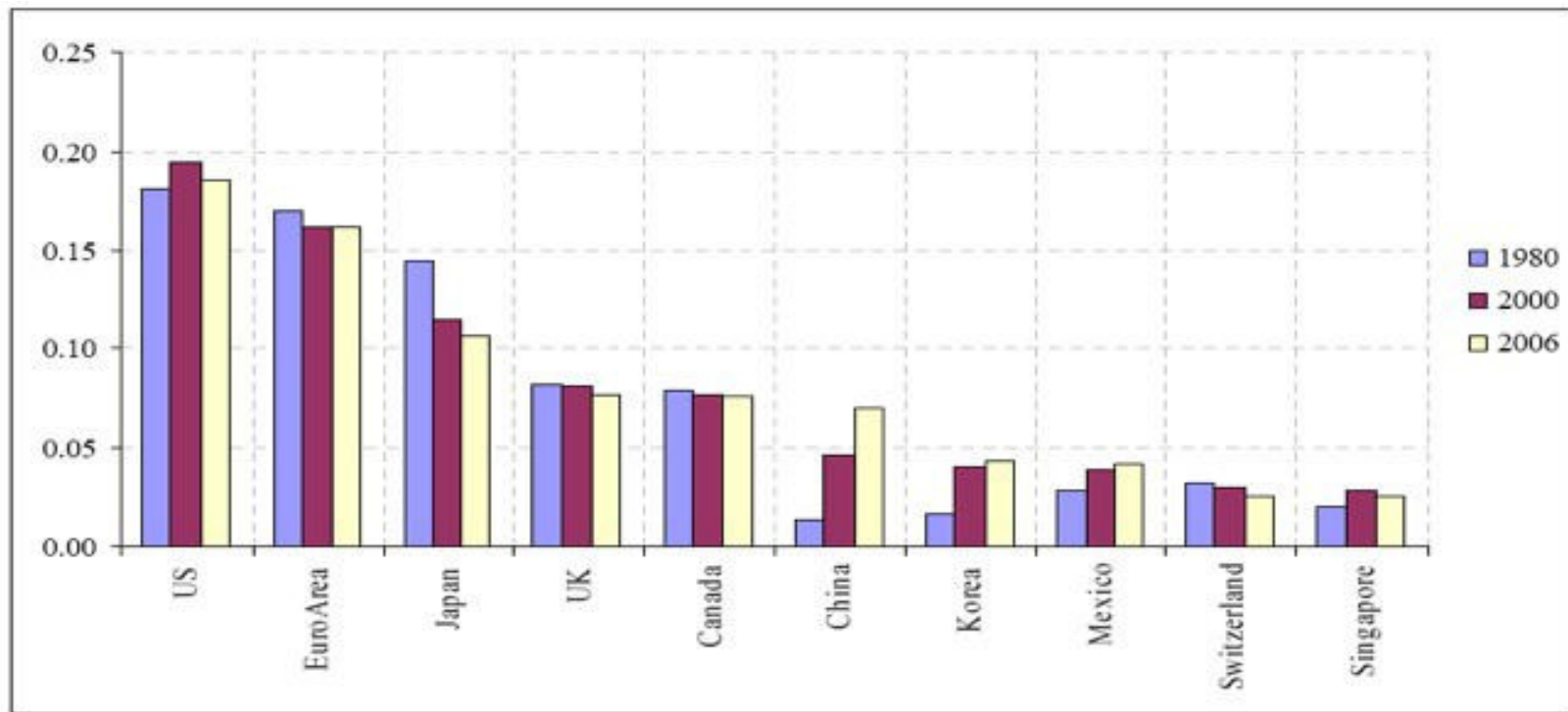
*Source: JAE, 2007 data base, updated to 2008 Q2*

→ Two-country models have limited applicability

→ We need a factor structure (including common factor) and analysis to deal with macro- finance linkages

## Stylized facts #2: US remains dominant

...as shown by ranking of selected economies according to their average weight in partners' trade



Source: IMF Direction of Trade Statistics.

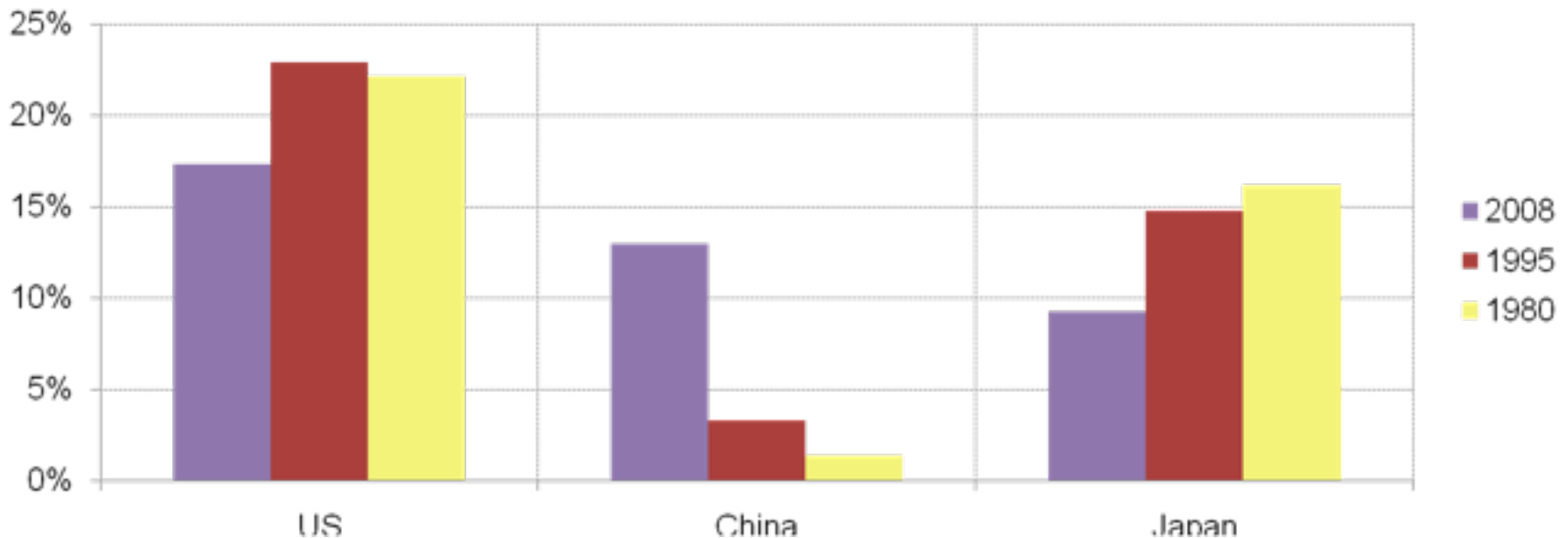
➔ Symmetric country modeling may not be adequate

➔ It makes sense to model the US as somewhat “special”



### Stylized facts #3: China is catching up though ...

Ranking of selected economies according to their average weight in US, euro area, China and Japan trade



Source: Cesa-Bianchi, Pesaran, Rebucci, Tamayo, and Xu (2010)

➔ We need a model that allows for structural asymmetries/changes

# **The GVAR Approach**

# GVAR approach in a nutshell

- The GVAR model is a collection of country-specific VARs, including domestic and foreign variables (with an asterisk)
- Country  $i$  is modelled as the following VARX\*:

$$\Phi_i(L, p_i)x_{it} = a_{i0} + a_{i1}t + \Lambda_i(L, q_i)x_{it}^* + \Psi_i(L, q_i)d_t + u_{it}$$

- There are multiple channels of international transmission:
  - Impact of rest of the world variables:  $x_{it}^*$
  - Common variables such as oil prices and common trends:  $d_t$
  - Correlation of shocks across variables within countries and across countries ( $u_{it}$ )

# GVAR approach in a nutshell

- Foreign variables ( $x_t^*$ ) are assumed weakly exogenous and defined as:

$$x_{it}^* = \sum_{j=0}^N w_{ij} x_{jt},$$

- With weights ( $w_{ij}$ ) based (generally) on bilateral trade shares
- Weak exogeneity (to be tested) implies that individual countries – with the notable exception of the US – are a small economy
- Due to weak exogeneity, country models can be estimated individually and the number of parameters decrease substantially
- GVAR links and aggregates the country VARX\* models based on trade weights
- The model is solved recursively and used for forecasting or Impulse response analysis

# **GVAR in practice: How to build a GVAR step-by- step?**

- 1. Select variables and construct trade-weighted rest of the world variables**
- 2. Find cointegration rank (variables can cointegrate within countries and between domestic and foreign variables)**
- 3. Estimate country models (with or without identified cointegrating relations)**
- 4. Test for exogeneity of the foreign variables**
- 5. Stack country models together and solve the GVAR system**
- 6. Simulate and forecast**

# **A Benchmark GVAR (Dees et al. JAE, 2007)**

## Countries and Regions in the GVAR Model

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<b>USA</b>	<b>Euro area</b>	<b>Latin America</b>
<b>China</b>	Germany	Brazil
<b>Japan</b>	France	Mexico
<b>UK</b>	Italy	Argentina
	Spain	Chile
<b>Other developed economies</b>	Netherlands	Peru
Canada	Belgium	
Australia	Austria	
New Zealand	Finland	
<b>Rest of Asia</b>	<b>Rest of W. Europe</b>	<b>Rest of the world</b>
Korea	Sweden	India
Indonesia	Switzerland	South Africa
Thailand	Norway	Turkey
Philippines		Saudi Arabia
Malaysia		
Singapore		

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## Variables Included in Country- Specific Models

Variables	All Countries Excluding US		US	
	Endogenous	Foreign	Endogenous	Foreign
Real Output	$y_{it}$	$y_{it}^*$	$y_{us,t}$	$y_{us,t}^*$
Inflation	$\pi_{it}$	$\pi_{it}^*$	$\pi_{us,t}$	$\pi_{us,t}^*$
Real Exchange Rate	$e_{it} - p_{it}$	-	-	$e_{us,t}^* - p_{us,t}^*$
Real Equity Price	$q_{it}$	$q_{it}^*$	$q_{us,t}$	-
Short-Term Interest Rate	$r_{it}^S$	$r_{it}^{*S}$	$r_{us,t}^S$	-
Long-Term Interest Rate	$r_{it}^L$	$r_{it}^{*L}$	$r_{us,t}^L$	-
Oil Price	-	$p_t^o$	$p_t^o$	-



## The estimated GVAR

- The model has 175 endogenous variables, 99 stochastic trends and 76 long-run (cointegrating) relations
- It is dynamically stable: all its roots either lie on or inside the unit circle
- Because it implicitly allows for co-breaking, the model parameters are remarkably stable over time
- The residuals from the GVAR are much less correlated across countries, except for exchange rates

## Cross-country GVAR residual correlations drop

Data						
	Output	Inflation	Equity	Exch Rate ST	Int. Rate LT	Rate
China	2%	6%		8%	5%	
EuroArea	14%	12%	50%	32%	15%	45%
Japan	3%	5%	36%	24%	5%	28%
Canada	14%	11%	47%	20%	17%	37%
UK	9%	6%	49%	27%	13%	38%
US	14%	14%	46%		10%	39%
Average	9%	9%	46%	22%	11%	37%
Residuals						
	Output	Inflation	Equity	Exch Rate	ST Int.	LT Int.
China	-1%	4%		1%	0%	
EuroArea	-5%	7%	-11%	30%	5%	-4%
Japan	-3%	1%	-14%	18%	-1%	-3%
Canada	0%	4%	2%	14%	10%	-4%
UK	1%	6%	-2%	22%	2%	-5%
US	-2%	3%	-1%		3%	-3%
Average	-2%	4%	-5%	17%	3%	-4%

# **A FIRST FLAVOUR OF APPLICATIONS AND ONE SIMULATION**

# GVAR applications for policy analysis

## – Quantifying spillover effects from external shocks

- *Dées, di Mauro, Pesaran and Smith (2007), J. of Applied Econom.*
- *IMF WEO (2006), Chapter II “Oil Prices and Global Imbalances”.*
- *Galesi and Lombardi (2013), GVAR Handbook (Ch.5)*

## – Forecasting:

- *Pesaran, Schuermann and Smith (2009), Int. J. of Forecasting*
- *Lui and Mitchell (2013), GVAR Handbook (Ch.9)*
- *Assenmacher (2013), GVAR Handbook (Ch. 16)*

## – Assessing real-financial linkages:

- *Castren, Dees and Zaher (2010), J. of Financial Stability*
- *Chen et al. (2010), IMF Working Paper.*
- *Chudik and Fratzscher (2011), Eur. Eco. Review.*
- *Al-Hashimi, Dees (2013), Macro-prudential applications, GVAR Handbook (Ch. 10)*

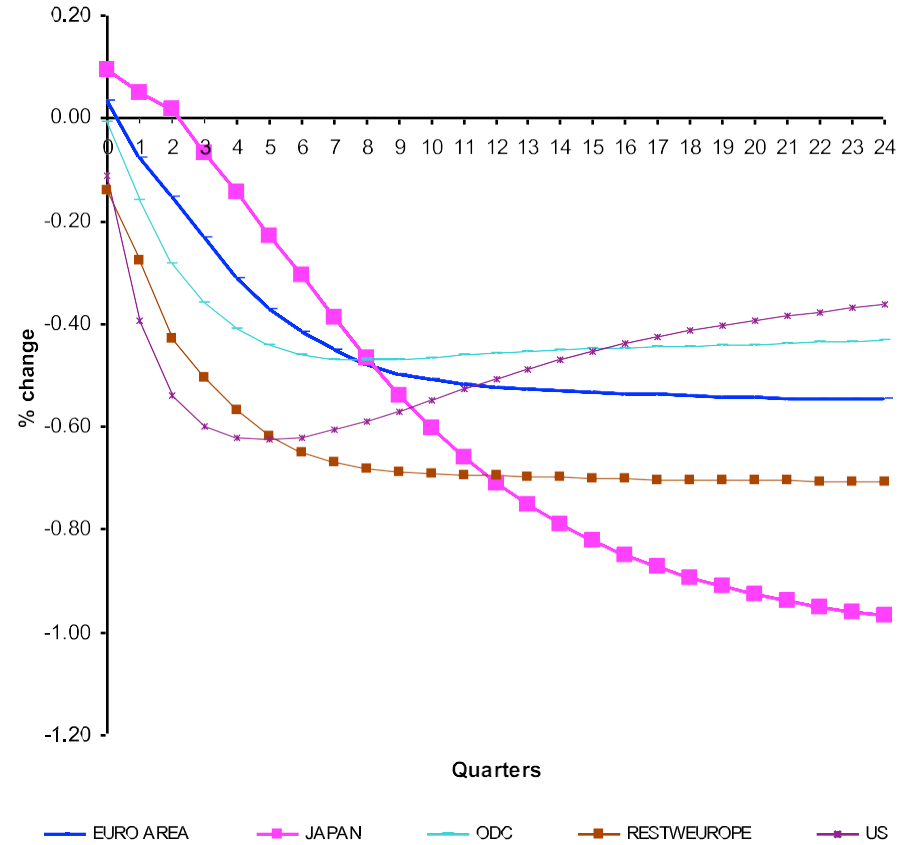
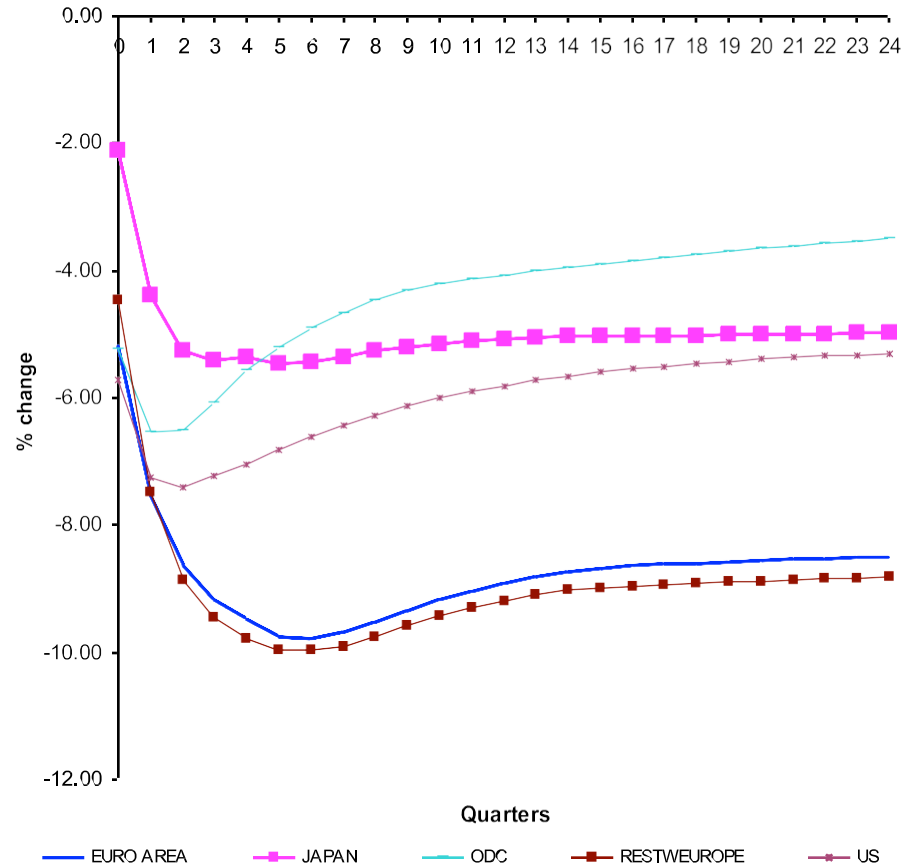
## - Regional applications:

- *Dees (2013), Competitiveness in the Euro area, GVAR Handbook (Ch. 15)*
- *Galesi, Sgherri (2013), Regional spillovers across Europe, GVAR Handbook (Ch.17)*

## 1 - Negative shock to US equity prices

Equity Prices

Real Output



- ➔ Equity prices shocks tend to be transmitted fast, but real impacts are lower in the EA than in the US
- ➔ Equities are very important for the global recovery

# Conclusions

- **GVAR provides a theoretically coherent (and empirically implementable) framework for modeling global interactions.**
- **It is an useful tool to analyze the recent crisis and recovery:**
  - **It provides a comprehensive modeling of international linkages;**
  - **It includes key financial variables (stocks/ government bonds prices/oil price).**
- **The empirical analysis permits to quantify role of equity prices, oil price, etc.**
- **Today we will give you a sense of its main applications**