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Impact of international monetary policy in Uruguay: a FAVAR approach

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[1] *The opinions herein do not affect the institutional position of Banco Central del Uruguay*.

IN A NUTSHELL

- Uruguay is a small and dollarized open emerging economy, with a shallow financial sector.

- The aim of this study is to analyze the vulnerability of the Uruguayan economy to US monetary policy normalization.

- The approach consists of implementing a Factor-Augmented Vector Autoregressive (FAVAR) model on a quarterly balanced panel that span from 1996Q1 to 2014Q4.

- FAVAR models enable the researcher to incorporate more information without adding more variables and allow a better identification of structural shocks.

IN A NUTSHELL

- In this paper, FAVAR models are used in two stages. In the first stage, the impact of foreign monetary policy is assessed on commodity prices, foreign output and regional output. In the second one, the effects on real exchange rate and housing prices (as domestic assets) and on domestic output are analyzed.

- Despite of the uncertainty surrounded the responses, preliminary results indicate that Uruguay may be negatively affected by an increase in the FFR.

- Those effects seem to be mild and short-lived.

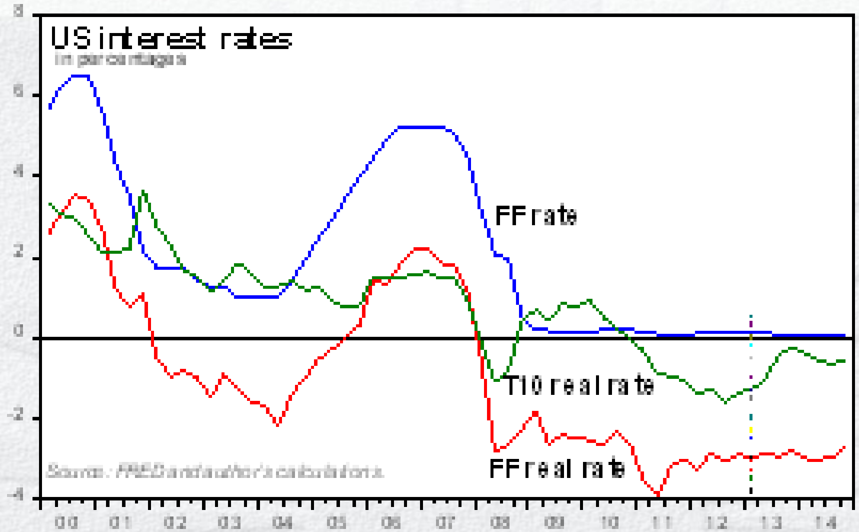
PLAN

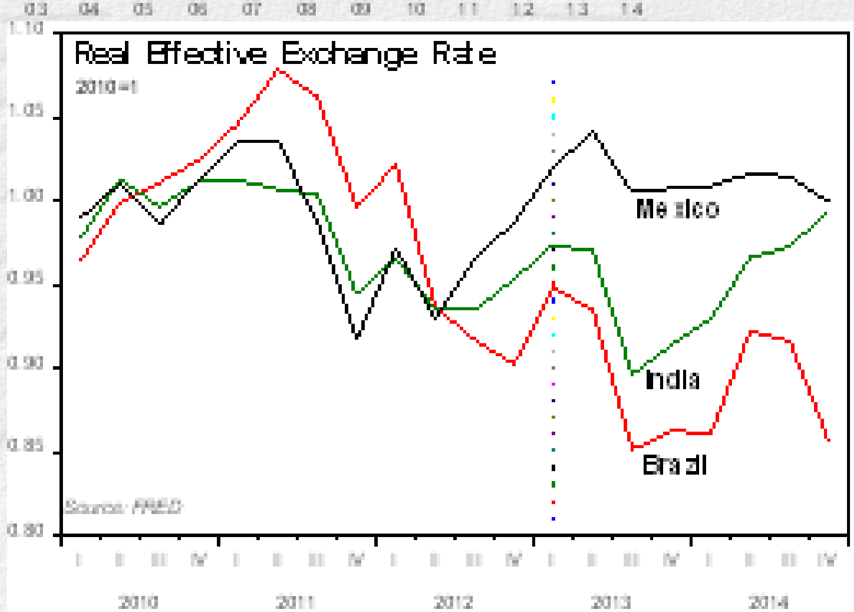
- Motivation
- Methodology
- Data
- Results
- Future agenda

MOTIVATION

- On May 22th, 2013, the chairman of the Federal Reserve (FED) announced the possibility of a decrease in security purchases:
  - This statement re-initiated a debate regarding the impact of US monetary policy in emerging markets (EM).
  - The importance of the issue is reflected in the movements in exchange rates and stock prices observed in EM following the announcements.
- Would it be the same for Uruguay?

MOTIVATION


US interest rates
in percentages
FF rate
T10 real rate
FF real rate
Source: FRED and author's calculations.
8
6
4
2
0
-2
-4
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14


Real Effective Exchange Rate
2010=1
Mexico
India
Brazil
Source: FRED
1.10
1.05
1.00
0.95
0.90
0.85
0.80
2010
2011
2012
2013
2014

MOTIVATION

- A small and dollarized open economy, shallow financial market.

MOTIVATION

- Small open economy: 40% openness ratio
- Dollarization
  - Deposits: almost 80%
  - Credits: more than 50%
  - Mismatches are the true problem: 87% of firms
- Uruguayan public sector debt: around 50% is foreign-currency denominated, dollarization has been declining and time of maturity has been increasing.
- A tighter FED monetary policy = bad news for Uruguay:
  - Debt burden increase, 10-year sustained growth put to a hold
  - Local currency depreciation may fuel inflation
  - Higher inflation may reduce investment projects

MOTIVATION

- Shallow financial market may oneself wonder the very existence of a response:

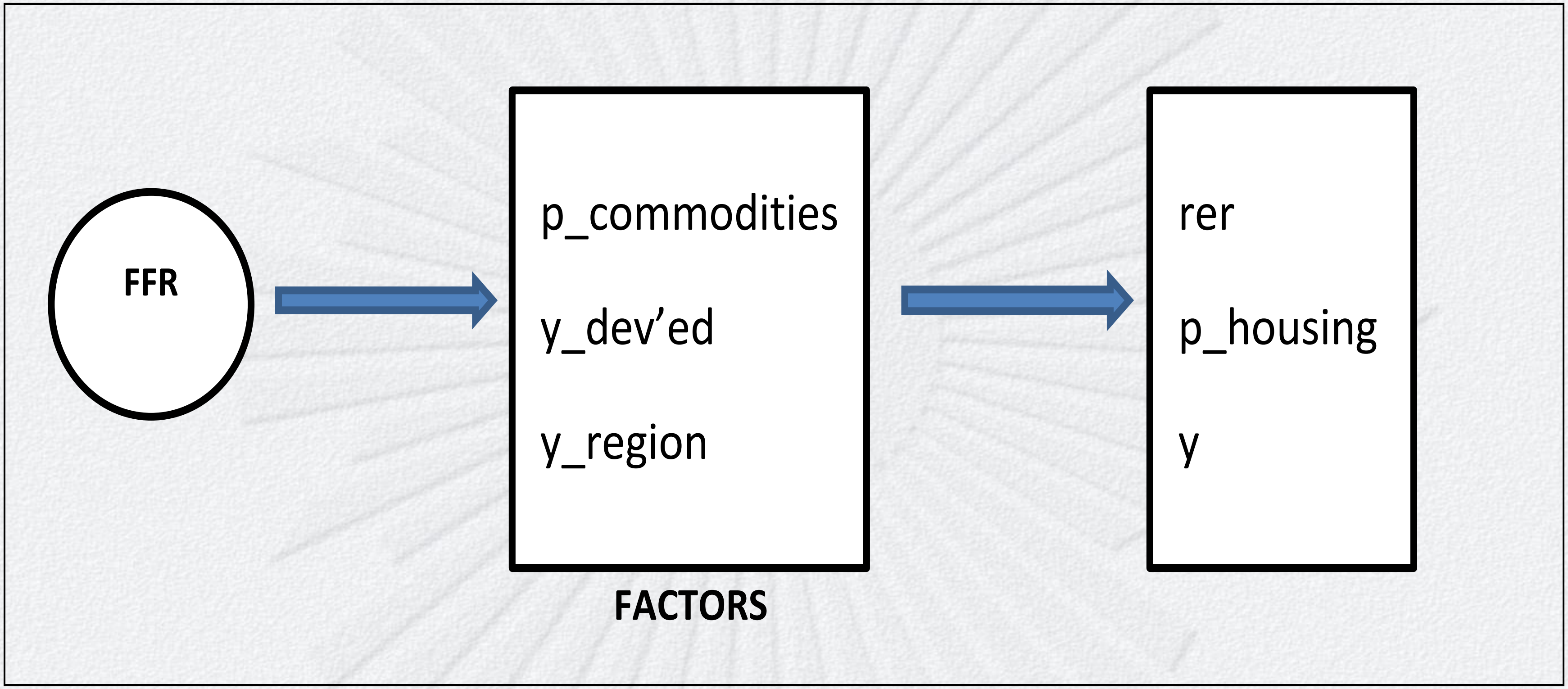
  real assets: the biggest component in households´net wealth

  households: intensive in their use of cash (70%)

  low and stable use of credit (22%) and debit cards (8%)

- A reasonable way to think how shocks reach Uruguay is: *first,* FFR changes; *second*, it affects commodity prices; *then*, the effect hits the external demand from the developed world; *next*, it reaches Uruguayan relevant region and *finally*, Uruguayan economic activity reacts.

MOTIVATION



MOTIVATION

- A Factor-Augmented Vector Autoregressive (FAVAR) model is used in two stages:
  - In the *first stage*, the impact of foreign monetary policy is assessed on commodity prices, foreign output and regional output.
  - In the *second one*, the effects on real exchange rate, domestic assets (as housing prices) and on domestic output are analyzed.

METHODOLOGY

- Structural **factor models** rest on the idea that a large number of observable economic variables can be described by a relatively small number of unobserved factors. These factors, in turn, can be affected by a few shocks which can be understood as macroeconomic disturbances.

- Macroeconomic data set x_{it} is composed of two mutually orthogonal unobservable components: the common component χ_{it} and the idiosyncratic component ξ_{it}

$$x_{it} = \chi_{it} + \xi_{it}$$

METHODOLOGY

- The *idiosyncratic component* ξ_{it} arise from shocks that affect a specific variable or a small group of variables and may reflect sector specific variations, variations to foreign countries, or measurement errors.

METHODOLOGY

- The *common components* are the ones responsible for most of the co-movements between macroeconomic variables and are represented by a linear combination of a relatively small number (r << n) of unobserved factors (these are also called *static factors* in the literature):

$$\chi_{it} = a_{1i}f_{1t} + a_{2i}f_{2t} + \cdots + a_{ri}f_{rt} = a_i f_i$$

- When allowing a VAR model for vector f_t components, dynamic relations among macroeconomic variables show up:

$$f_t = D_1 f_{t-1} + D_2 f_{t-2} + \cdots + D_p f_{t-p} + \varepsilon_t$$
$$\varepsilon_t = R u_t$$

METHODOLOGY

- **Vector autoregressive (VAR) models** are very useful in handling multiequation time-series models because the econometrician not always knows if the time path of a series designated to be the “independent” variable has been unaffected by the time path of the “dependent” variables. The most basic form of a VAR treats all variables symmetrically without analyzing the issue of independence.

$$O_t = \sum_{i=1}^{p} A_i O_{t-i} + u_t^O \qquad (1)$$

- GC, IRFs, VD: can give some light for the understanding of their relationship and guidance into the formulation of more structured models.

METHODOLOGY

- **Factor-augmented VAR (FAVAR) models** combine factor models and VAR models at the same time.

$$\begin{pmatrix} F_t \\ O_t \end{pmatrix} = \begin{bmatrix} \phi_{11}(L) & \phi_{12}(L) \\ \phi_{21}(L) & \phi_{22}(L) \end{bmatrix} \begin{pmatrix} F_{t-1} \\ O_{t-1} \end{pmatrix} + \begin{pmatrix} u_t^F \\ u_t^O \end{pmatrix} \qquad (2)$$

where O_t is the (Mx1) vector of observable variables and F_t is the (kx1) vector of unobserved factors that captures additional economic information relevant to model the dynamics of O_t.

METHODOLOGY

- Let us assume that informational time series X_t are related to the unobservable factors F_t by the following observation equation

$$X_t = \Lambda^f F_t + \Lambda^O O_t + e_t$$

where F_t is a (k x 1) vector of common factors, Λ^f is a (N x k) matrix of factor loadings, Λ^O is (N x M), and e_t are mean zero and normal, and assumed a small cross-correlation, which vanishes as N goes to infinity.

METHODOLOGY

- FAVAR models are a mixture of a factor model and a VAR model.
- Advantages:
  - Factors can alleviate omitted variable problems in empirical analysis using traditional small-scale models. (Bernanke and Boivin (2003)).
  - Factors may help to generate a more general specification (Bernanke, Boivin and Eliasz (2005))
  - Factors help in keeping the number of parameters to estimate under control without losing relevant information (Chudik and Pesaran (2007)).
- Disadvantages:
  - Unobsevable factors do not have an exact meaning but some researchers try to give them a structural interpretation. (Forni and Gambetti (2010)).

METHODOLOGY

- Estimation strategy for a FAVAR model: a two-step procedure.

- In the ***first step***, factors are estimated. Some authors suggest to extract them by the first of principal components (**PCA**) of the series involved (Bernanke et al. (2005), Boivin (2009)); others, suggest to apply a ML method following a factor analysis (**FA**).

- In the ***second step***, the FAVAR equation is estimated by OLS, replacing F_t by $\widehat{F}_t$.

METHODOLOGY

Factor Analysis vs. Principal Components

- Common factors are extracted from a large group of variables. Both approaches create variables that are linear combination of original series.
- On the **Principal Component** approach (PCA) these common factors account a maximal amount of variance in the variables.
- On the **Factor Analysis** (FA) approach these common factors capture common variance in the variables.
- FA is generally used when the research purpose is to detect data structure (i.e. latent construct or factors).
- PCA is generally preferred for purposes of data reduction (i.e. translating variable space into optimal factor space) but not when the goal is to detect latent factors.

DATA

- A balanced set of 36 quarterly macroeconomic TS.
- Expressed in real terms and in log levels (except ratios and interest rates) and whenever necessary, series are transformed in order to leave them stationary.
- 1996Q1-2014Q4, 76 observations after adjustments
- **Observable variables Y**: Federal funds rate (*FFR*), 10-year bond rate (*T10*), real exchange rate (*rer*), country risk (*UBI*), domestic passive real interest rate (*i_p)*, housing prices (*p_h*), domestic output (y), and primary fiscal result (*pb*).
- **Other informational variables:** several commodity prices (wheat, soybean, food, oil), foreign output (from Argentina, Brazil, USA, China, UK, Italy, Spain, Germany, Mexico), US debt to GDP ratio, Uruguayan country risk indicator, domestic investment ratio (total, public and private), trade (exports and imports), real domestic wages, unemployment, public debt to gdp ratio (total, foreign, domestic, in foreign currency, in domestic currency), public assets to GDP ratio.

DATA – policy rate

p_wheat
p_soybean
p_food
p_oil

Factor 1

→

y_USA
y_UK
y_Italy
y_Spain
y_Germany
y_Mexico

Factor 2

→

y_Argentina
y_Brazil
y_China

Factor 3

DATA – policy rate

- **FFR:** has been the measure for the Fed's monetary policy stance in the economic literature and has been used as the link between monetary policy and the economy.

- Since the end of 2008 the FFR has been at the zero lower bound (ZLB), damping its historical correlation with economic variables like real gross domestic product (GDP), the unemployment rate, and inflation.

- Federal Open Market Committee (FOMC): Unconventional forms of monetary policy (a mix of forward guidance and large-scale asset purchases), to boost the economy.

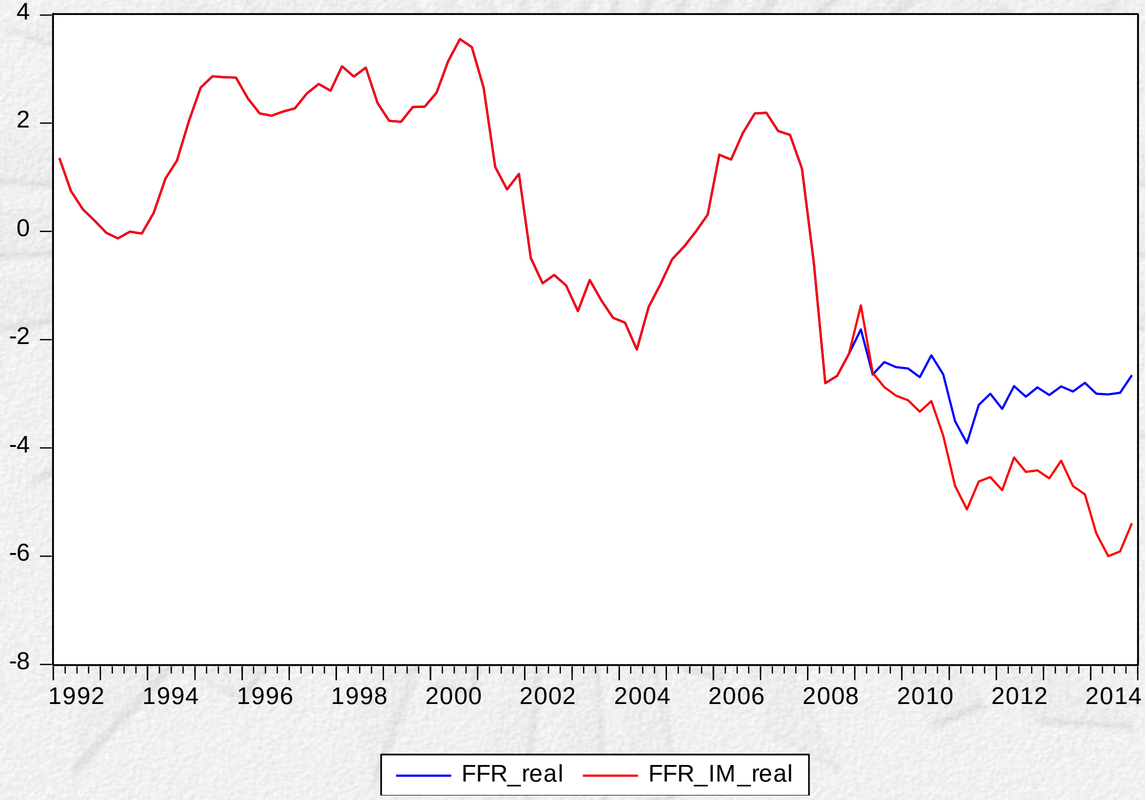
- Attempts to summarize current policy have led some researchers to create a "***virtual***" **fed funds rate.**

DATA – policy rate

- **Wu and Xia** (2014) construct a new policy rate “by splicing together the effective federal funds rate before 2009 and the estimated (*by them*) shadow rate since 2009.
- **Bauer and Rudebusch** (2015): “*the sensitivity of estimated shadow short rates raises a warning flag about their use as a measure of monetary policy. Our findings show that such estimates are not robust and strongly suggest that their use as indicators of monetary policy at the ZLB is problematic.”*
- **Lombardi and Zhu** (2014), infer a shadow short rate that is consistent with other observed indicators of monetary policy and financial conditions.
- **Krippner** (2015), *considers the area between shadow rates and their long-term level.*

DATA

- Federal funds rate and Wu-Xia virtual effective federal funds rate



RESULTS – Baseline VAR

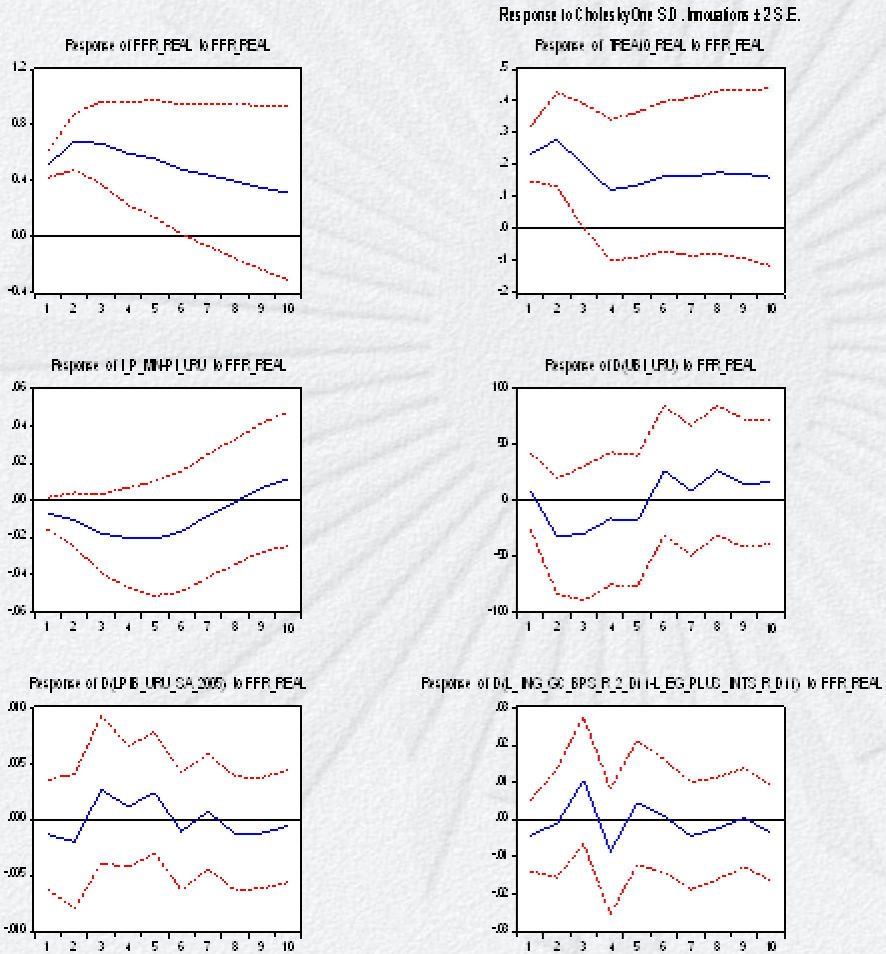
- Baseline VAR

$$O_t = \sum_{i=1}^{p} A_i O_{t-i} + u_t^O$$

Six variables of interest, where $O_t = \left(FFR_t, T10_t, rer_t, UBI_t,\right.$

RESULTS – Baseline VAR

- The results show that a contractionary foreign monetary policy (a one-time rise of FFR) has no clear effects on Uruguayan real output.



RESULTS - FAVAR

- Then, I explore that other unobserved variables may influence the behavior of the observable variables:

$$\begin{bmatrix} O_t^* \\ F_t \\ O_t^d \end{bmatrix} = B(L) \begin{bmatrix} O_{t-1}^* \\ F_{t-1} \\ O_{t-1}^d \end{bmatrix} + u_t$$

where

$$O_t^* = (FFR_t^*, T10_t); \quad O_t^d = \left(rer_t, UBI_t, i_{p_t}, p_{h_t}, y_t, pb_t\right)$$

$\mathrm{F_t} = (\mathrm{F_{1t}}, \mathrm{F_{2t}}, \mathrm{F_{3t}})$, are the factors estimated in the first part by ML

- The whole data set available is used in order to estimate the factors, although several time series are dropped out (measures of sampling adequacy and goodness of fit criteria).
- Velicer's MAP method has retained three factors, labeled "F1", "F2" and "F3".

RESULTS - FAVAR

- F1: commodity prices (food, wheat and soybean) and real wages.

  It can be labelled as a measure of commodity prices.

- F2: foreign real output (from US, Germany, Spain, United Kingdom, Italy and probably Mexico) and American debt. It can be labelled as an indicator of foreign demand from developed countries.

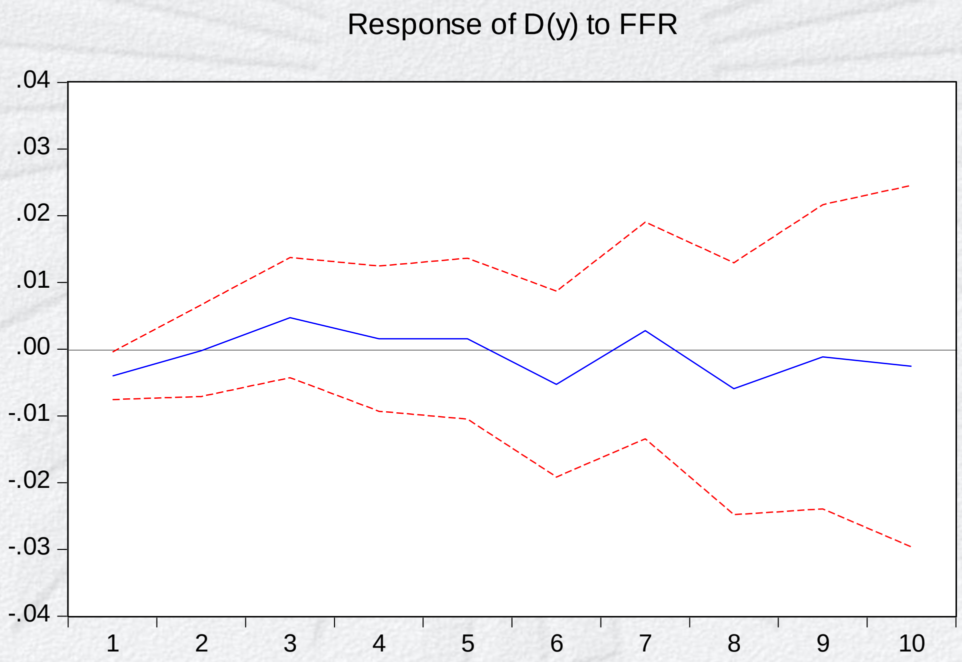
- F3: oil price and a relevant regional foreign real output (Argentina, Brazil and China). It can be labelled as an aggregate variable for the regional demand.

- Once the baseline model is expanded into a FAVAR one, dynamics seem more plausible because an undoubtedly response of all the observed variables is reached, especially for domestic output.

RESULTS – FAVAR

- There is a clear and statistically significant impact effect but the following results are uncertain: an increase of one standard deviation of FFR (230 basis points) reduces quarterly output growth by 0.40% on impact but as confidence intervals grow rather fast as time goes by, it is not possible to have credible forecasts.

Response to Cholesky One S.D. Innovations ± 2 S.E.



RESULTS – FAVAR

- The dynamics of the variables in the system depends on the structure imposed on the factor loadings.

- In the *recursive scheme*, the impact matrix A_0 is lower triangular:

  - foreign variables do not respond to Uruguayan performance

  - Uruguayan economy reacts in the same period to changes occurred in the rest of the world, in the relevant Region and in the variables that act as linkages between them.

RESULTS – FAVAR

- In the *non-recursive scheme*, the impact matrix A_0 implies

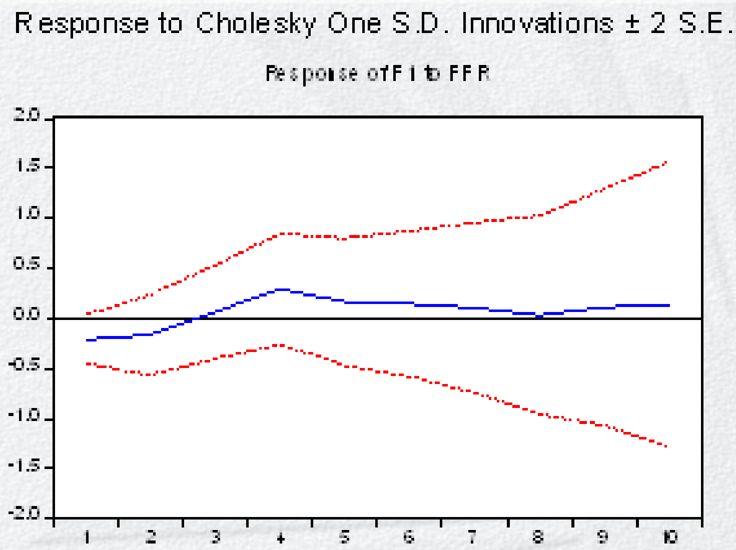
  - different reactions of unobserved factors to foreign interest rates changes.

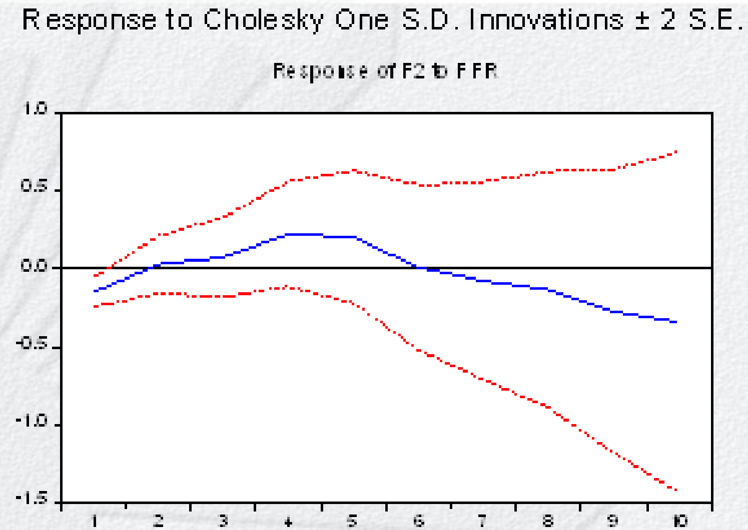
  - no contemporaneous response of domestic output to a FFR_t^* change because real activity seems to react through a specific pattern: those three unobserved factors canalize the initial change in US monetary policy instrument affecting domestic interest rate directly and through real exchange rate and country-risk, and finally reaching domestic output.

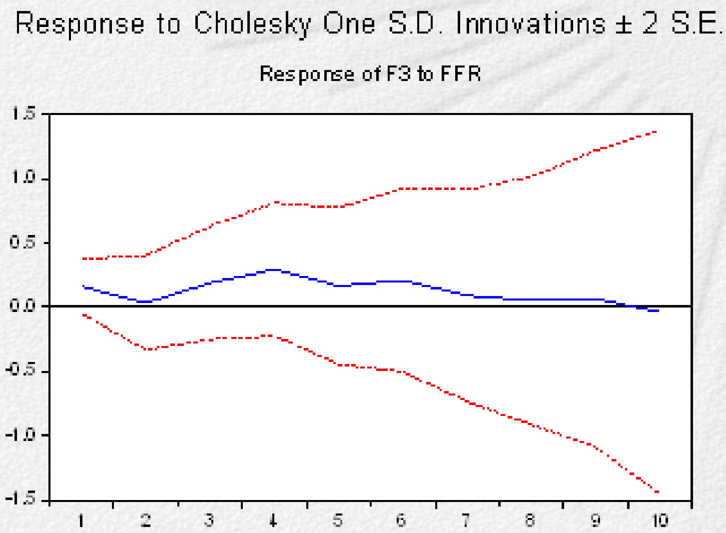
RESULTS – FAVAR

- There seems to be four **channels** through which a one-time rise in **FFR have real effects in Uruguay:**
  - the commodity price channel
  - the aggregate demand channel
    - OCDE countries
    - relevant region
  - the assets channel (exchange rate and housing prices).

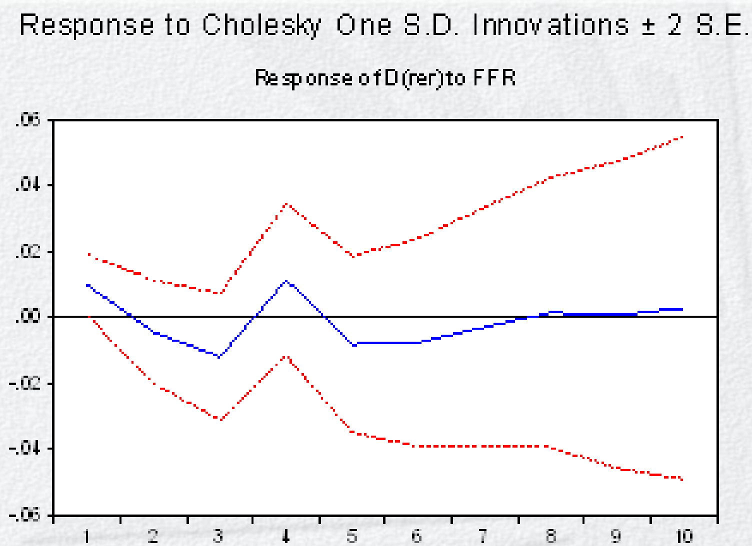
RESULTS – FAVAR

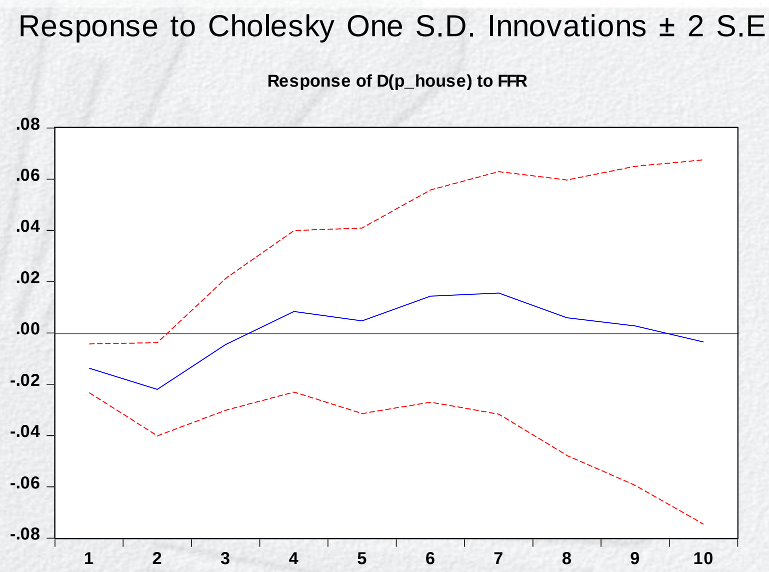


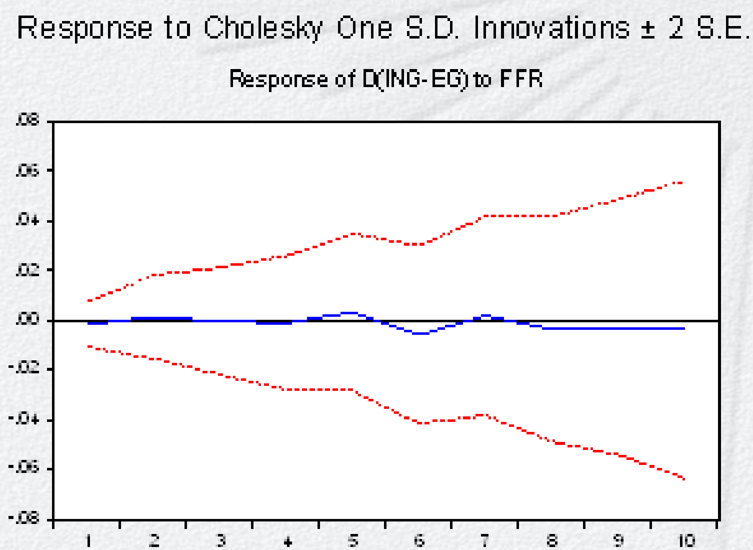




RESULTS - FAVAR







Liz Bucacos (2019)

A FAVAR approach

RESULTS - FAVAR

Robustness

- The previous results are robust to different orderings of the shocks, beginning always by FFR.
- There is a slight change in the results, however, when country-specific risk (measured by UBI) is handled either as an exogenous or an endogenous variable (0.47% decrease on impact).
- I proceed to substitute the effective federal funds rate (FFR) by the **Wu-Xia virtual effective federal funds rate** (FFR_im) in the FAVAR estimation:

  FIR : same dynamic responses are found but more uncertainty

RESULTS - FAVAR

- I also applied **block restrictions** on the FAVAR equation in order to prevent feedbacks from the observed domestic variables to the foreign interest rate and the unobserved factors blocks:
- $$\begin{pmatrix} O_t^* \\ F_t \\ \mathrm{O_t} \end{pmatrix} = \begin{bmatrix} \phi_{11}(\mathrm{L}) & 0 & 0 \\ \phi_{21}(\mathrm{L}) & \phi_{22}(\mathrm{L}) & 0 \\ \Phi_{31}(\mathrm{L}) & \Phi_{32}(\mathrm{L}) & \Phi_{33}(\mathrm{L}) \end{bmatrix} \begin{pmatrix} O_{t-1}^* \\ F_{t-1} \\ \mathrm{O_{t-1}} \end{pmatrix} + \begin{pmatrix} \mathrm{u_t}^{O^*} \\ u_t^F \\ \mathrm{u_t^O} \end{pmatrix}$$

FIR: unanticipated MP shock affects the real economy by the same channels found in previous exercises in this study regardless of the foreign interest rate used.

RESULTS – CONCLUDING REMARKS

- The aim of this study is to analyze the vulnerability of the Uruguayan economy to US monetary policy.

- A Factor-Augmented Vector Autoregressive (FAVAR) model is implemented on a quarterly balanced panel that span from 1996Q1 to 2014Q4, for the first time.

- FAVAR models enable the researcher to incorporate more information without adding more variables and allow a better identification of structural shocks.

- In this paper, FAVAR models are used in two stages. In the first stage, the impact of foreign monetary policy is assessed on commodity prices, foreign output and regional output. In the second one, the effects on real exchange rate, domestic assets (as housing prices) and on domestic output are analyzed.

RESULTS – CONCLUDING REMARKS

- According to the exercise done, Uruguay seems to be reachable.

  A rise of 230 basis points in the Federal funds rate (in real terms) drops Uruguayan output growth rate by 0.40% at once; nevertheless, what happens afterwards is uncertain. These results only suggest the need to deep into the transmission mechanism of a particular shock.

- No formal test for structural breaks were perfomed despite of the presence of breaks in individual TS. Stationarity of the estimated FAVAR model, may suggest co-breaking.

- An important limitation of this study is the time span of the sample.

- Future research on this topic should include a broader data set, analyze possible breaks and apply a dynamic factor model approach.

Thank you!

Annex

It is common that several variables are dropped out of the data set, according to measures of sampling adequacy (MSA) and goodness-of-fit criteria. Only TS whose MSA value are greater or very close to Kaiser's MSA (Kaiser and Rice (1974)), remain:

MSA value > 0.90 :	marvelous
MSA value in the 80s:	meritorious
MSA value in the 70s:	middling
MSA value in the 60s:	mediocre
MSA value in the 50s:	miserable
MSA value < 0.50:	unacceptable

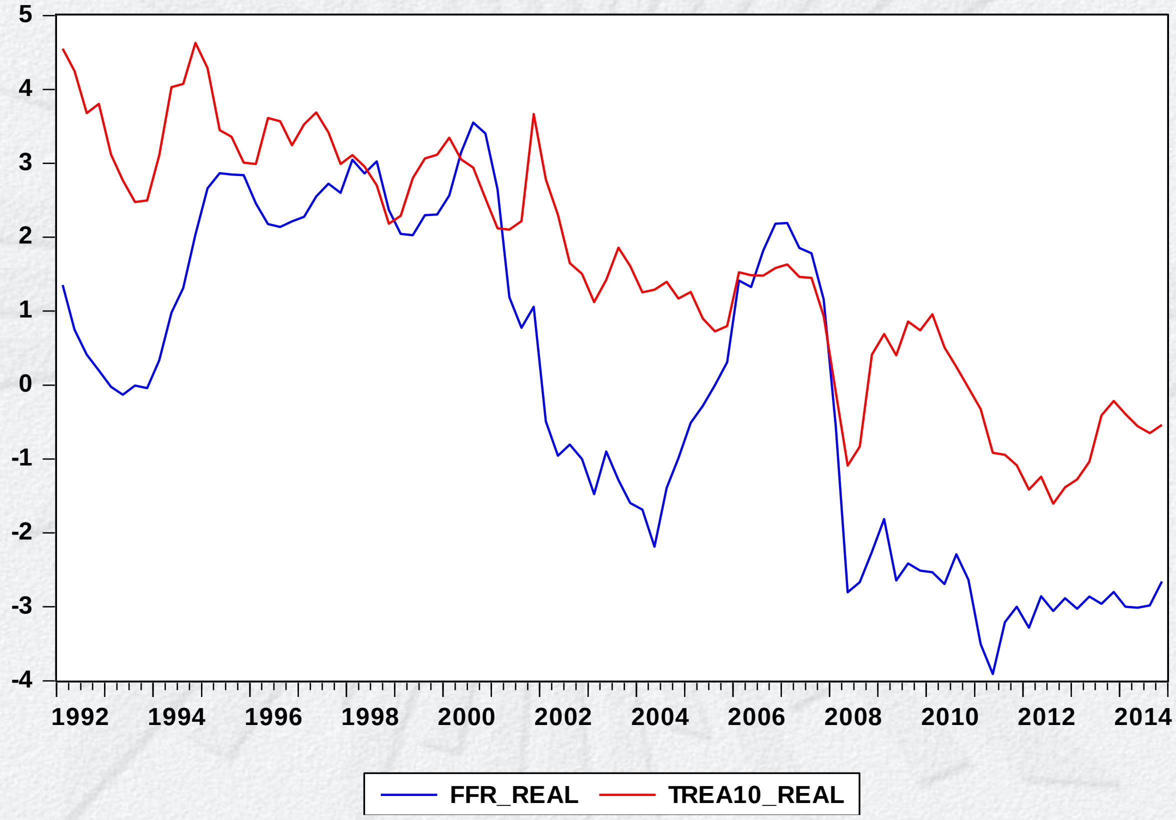
- There are various methods to determine the number of factors.

- **Velicer's** (1976) minimum partial map (MAP) method computes the average of the squared partial correlations after m components have been partialized out (for m=o, …, p-1). The number of factors retained is the number that minimizes this average. The intuition here is that the average squared partial correlation is minimized where the residual matrix is closest to being the identity matrix.

- There is evidence that the MAP method outperforms a number of other methods under a variety of conditions.

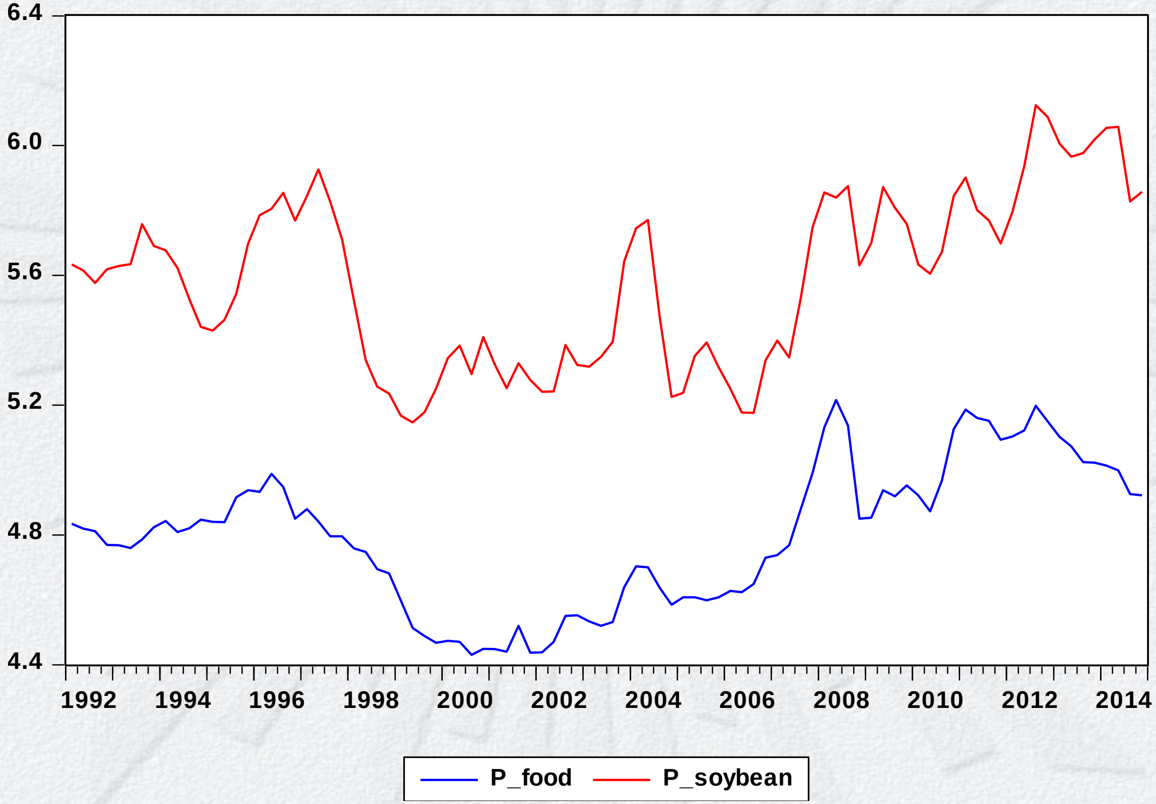
DATA

- Federal funds rate and 10-year Treasury interest rate



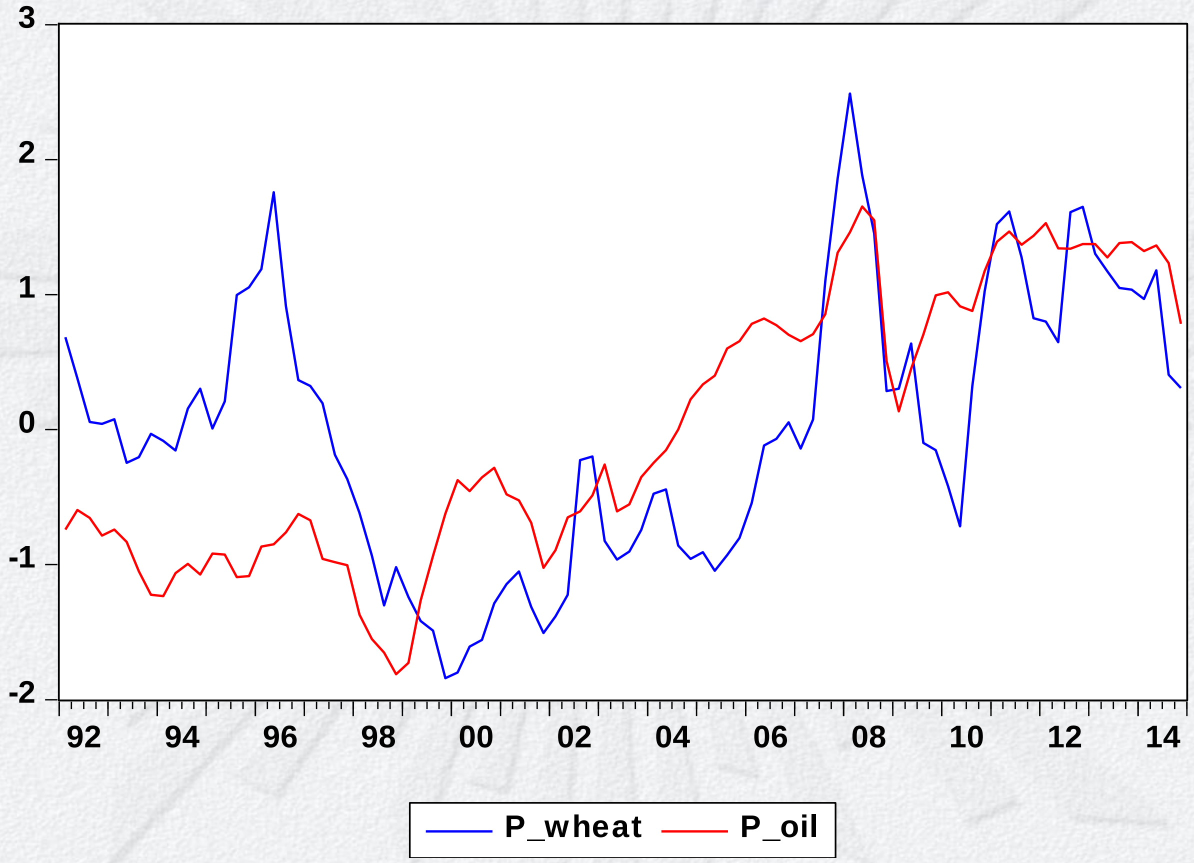
DATA

- Commodity prices



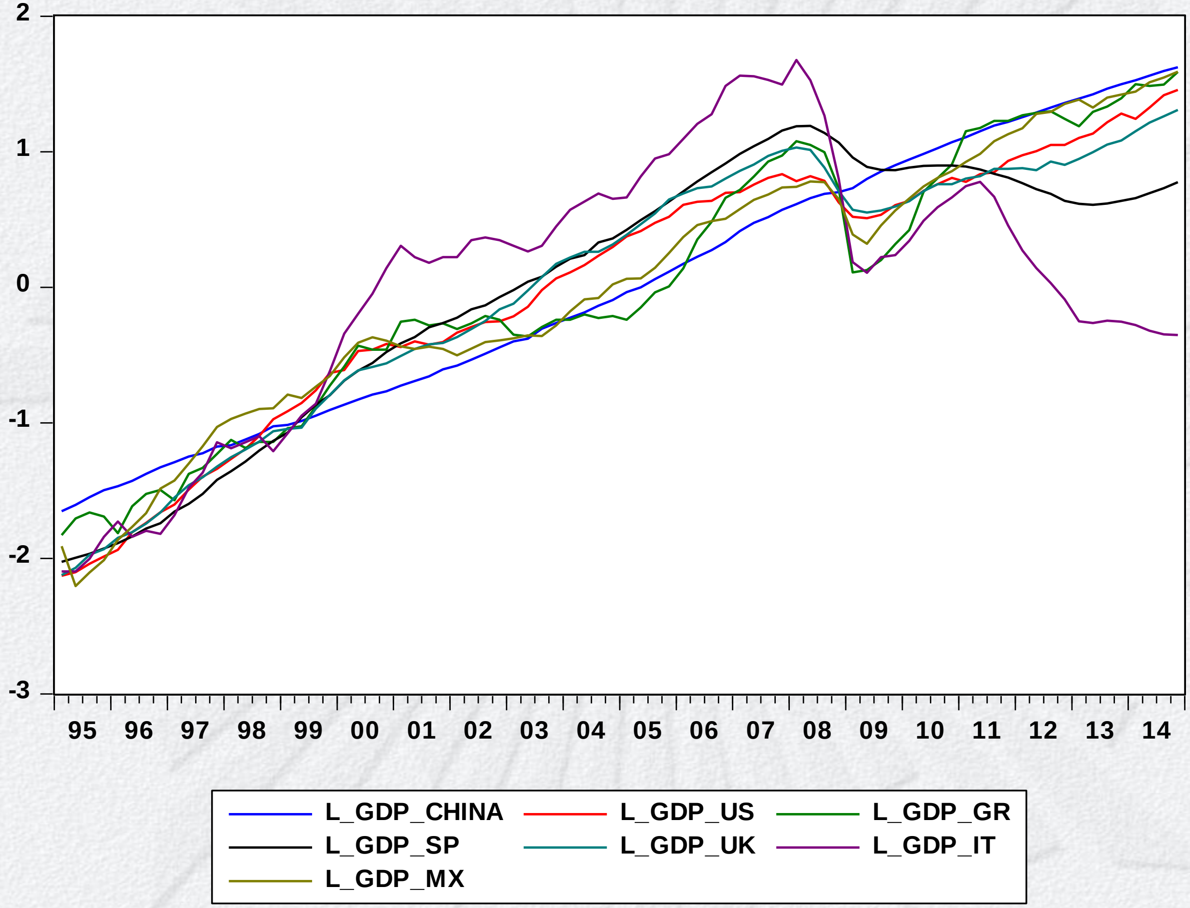
DATA

- Commodity prices



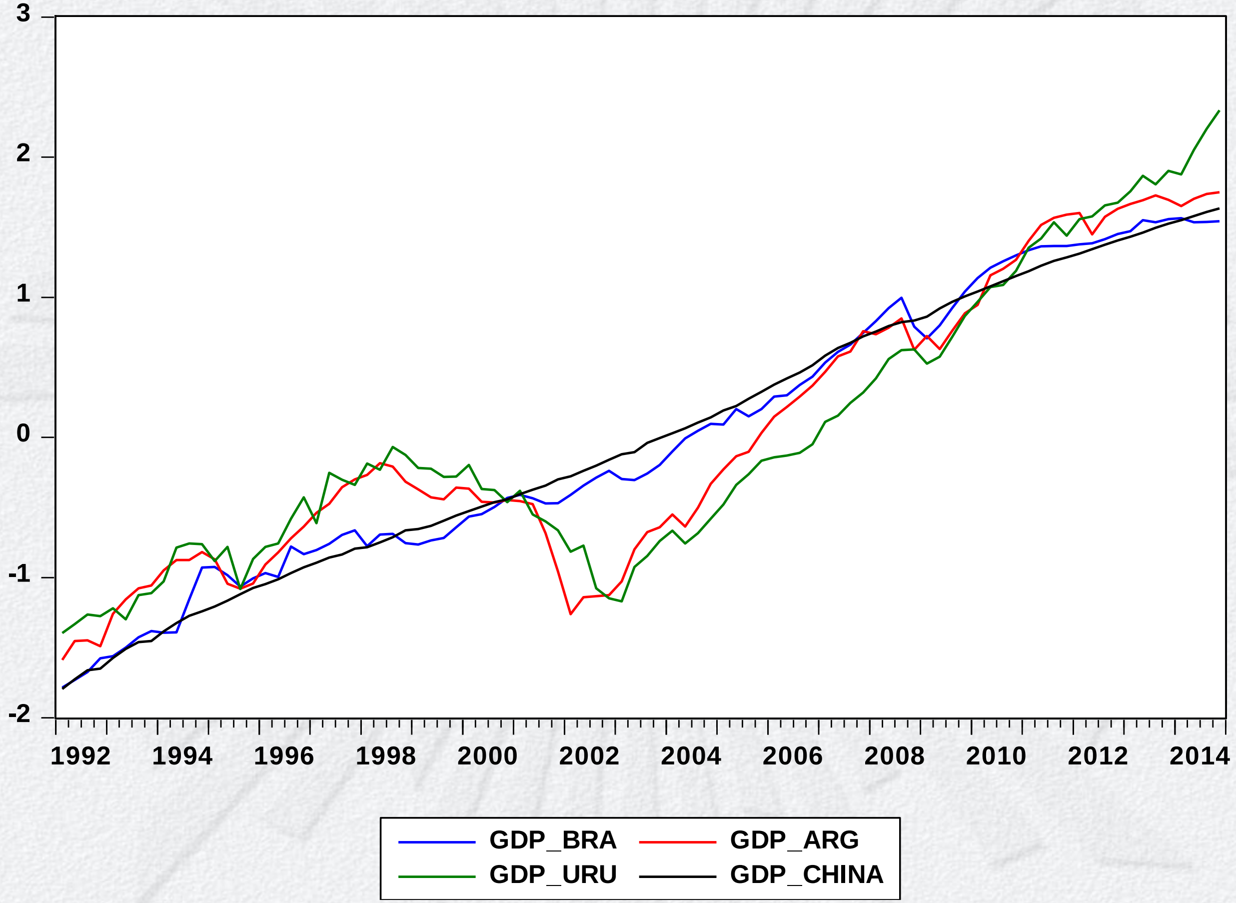
DATA

- "Developed" world



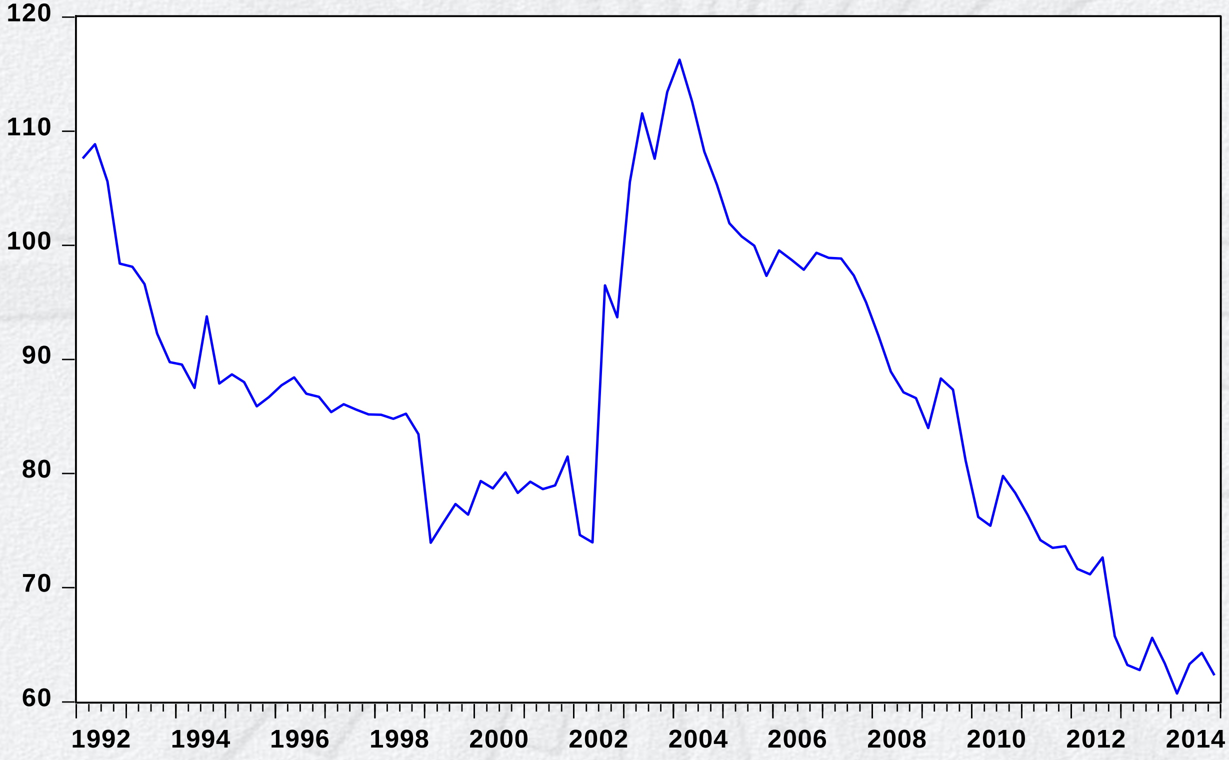
DATA

- Relevant region



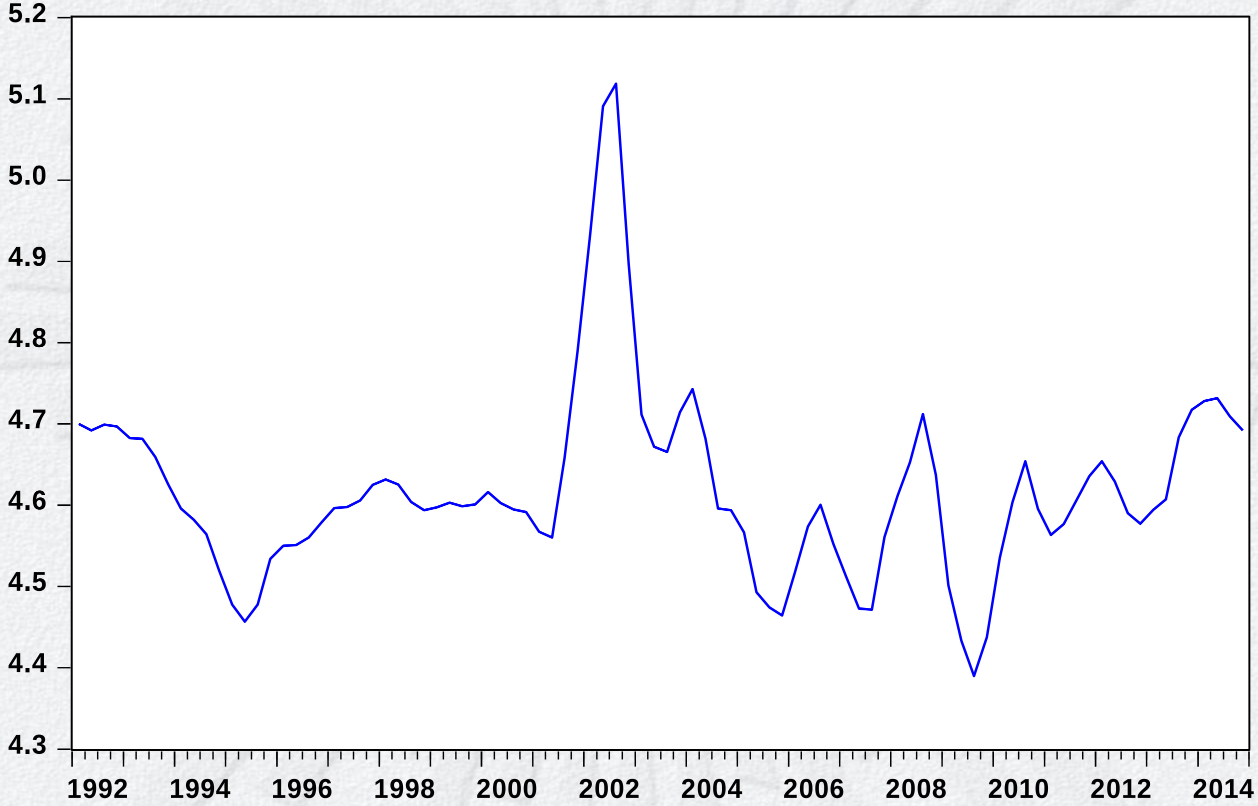
DATA

- URUGUAY: real exchange rate



DATA

- URUGUAY: housing prices



RESULTS – FAVAR

- In the *recursive scheme (Choleski)*, the restrictions are:

- $$\begin{pmatrix} u_{R_t^*} \\ u_{T10_t} \\ F_{1_t} \\ F_{2_t} \\ F_{3_t} \\ u_{rer_t} \\ u_{UBI_t} \\ u_{ip_t} \\ u_{ph_t} \\ u_{y_t} \\ u_{pb_t} \end{pmatrix} = \begin{pmatrix} \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & \times & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & \times & \times & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & \times & \times & \times \end{pmatrix} \begin{pmatrix} e_{R_t^*} \\ e_{T10_t} \\ F_{1_t} \\ F_{2_t} \\ F_{3_t} \\ e_{rer_t} \\ e_{UBI_t} \\ e_{ip_t} \\ e_{ph_t} \\ e_{y_t} \\ e_{pb_t} \end{pmatrix}$$

RESULTS – FAVAR

- In the *non-recursive scheme*, the restrictions are:

$$\begin{pmatrix} u_{R_t^*} \\ u_{T10_t} \\ u_{F1_t} \\ u_{F2_t} \\ u_{F3_t} \\ u_{rer_t} \\ u_{UBI_t} \\ u_{i_{p_t}} \\ u_{p_{h_t}} \\ u_{y_t} \\ u_{pb_t} \end{pmatrix} = \begin{pmatrix} \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & 0 & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & 0 & \times & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & 0 & \times & 0 & 0 & \times & \times & 0 & 0 & 0 & 0 \\ 0 & \times & 0 & 0 & \times & 0 & \times & 0 & 0 & 0 & 0 \\ 0 & \times & \times & \times & 0 & \times & \times & \times & 0 & 0 & 0 \\ \times & \times & \times & \times & 0 & \times & \times & \times & \times & 0 & 0 \\ 0 & \times & \times & 0 & 0 & 0 & 0 & \times & 0 & \times & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \times \end{pmatrix} \begin{pmatrix} e_{R_t^*} \\ e_{T10_t} \\ e_{F1_t} \\ e_{F2_t} \\ e_{F3_t} \\ e_{rer_t} \\ e_{UBI_t} \\ e_{i_{p_t}} \\ e_{p_{h_t}} \\ e_{y_t} \\ e_{pb_t} \end{pmatrix}$$