Impact of international monetary policy in Uruguay: a FAVAR approach

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Resumen

Este estudio analiza la vulnerabilidad de la economía uruguaya a los shocks de política monetaria externos en los últimos veinte años. La forma habitual de analizar los efectos de la transmisión de los shocks de política monetaria – tales como análisis de datos de panel, análisis de correlación e incluso estudio de casos – no han ofrecido mucha evidencia estadísticamente significativa con respecto a los efectos sobre el crecimiento económico en Uruguay. Sin embargo, siendo una pequeña economía abierta dolarizada con un mercado de activos relativamente poco sofisticado, parece razonable que Uruguay sufra los choques de política monetaria internacional. Entonces, el desafío es revelar los canales a través de los cuales esos choques finalmente afectan las variables económicas uruguayas relevantes.

En este documento se utilizan modelos de factores aumentados autorregresivos (FAVAR) en dos etapas. Primero, se establece el impacto de la política monetaria externa sobre precios de commodites, producto externo y producto regional. En una segunda etapa, se analizan los efectos sobre el tipo de cambio real, activos domésticos (como el precio de la vivienda) y el producto doméstico.

JEL: E42, R31, E62
Palabras clave: reversión restricción cuantitativa en EEUU, economías emergentes, precios de vivienda, Uruguay

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Abstract

This study analyzes the Uruguayan economy's vulnerability to foreign monetary policy in the last twenty years. The usual way of assessing monetary policy transmission effects - such as panel data analysis, correlation analysis and even case studies - have not offered much statistically significant evidence for Uruguayan economic growth. However, being a small open dollarized economy with a relatively less sophisticated asset market, it seems plausible that Uruguay may suffer from international monetary policy shocks. The challenge, then, is to unveil the channels through which those monetary shocks finally affect relevant Uruguayan variables.

In this paper, factor augmented vector autoregressive (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.

JEL: E42, R31, E62
Keywords: tapering, emerging economies, housing prices, Uruguay.

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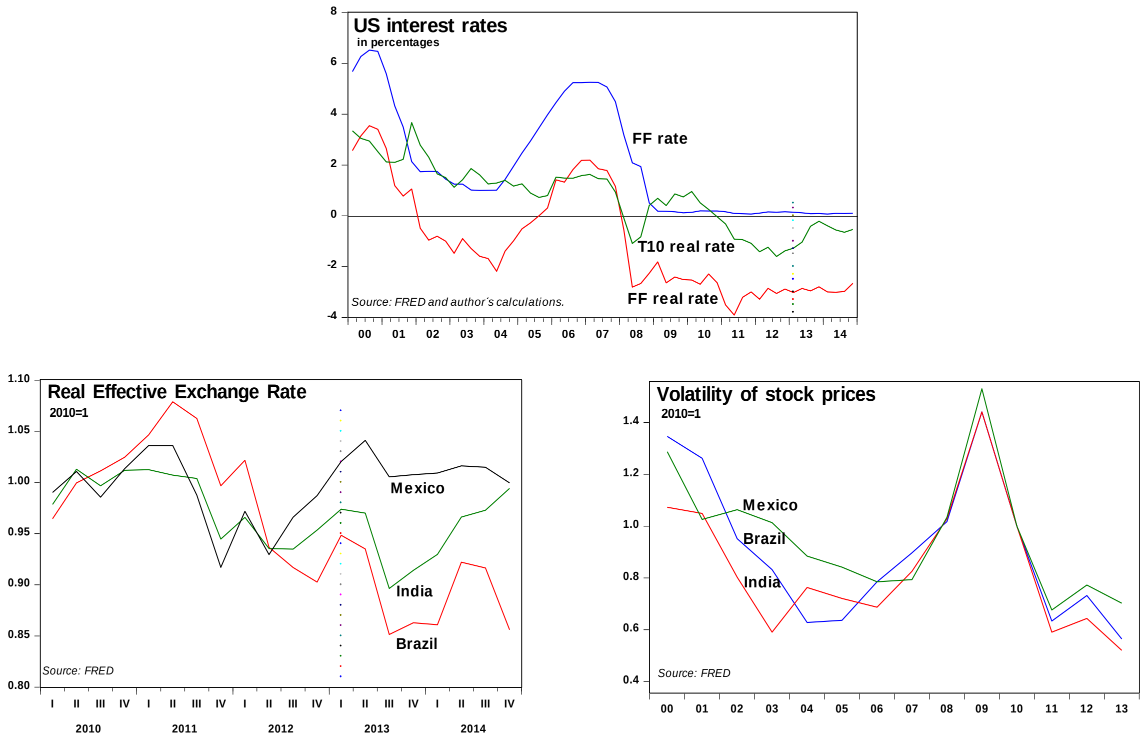
1. Introduction

On May 22th, 2013, in his testimony to Congress, the chairman of the Federal Reserve ("the Fed") announced the possibility of a decrease in security purchases from $85 billion a month to a lower amount. This "tapering talk" had significant consequences for economic and financial conditions in emerging markets (EM), reflected in the movements in EM exchange rates and stock prices following the announcements (Figure 1). As many commentators and analysts point out, not only was the impact sharp but it was surprisingly large (Eichengreen and Gupta, 2013).

Figure 1. US interest rates and exchange rates and stock prices for selected emerging markets.



The 2014 IMF Regional Economic Outlook (REO) reports:

"*Overall, the results presented so far suggest that a gradual and orderly normalization of U.S. monetary conditions should affect emerging market bond markets in a relatively moderate fashion. Local yields have historically tended to respond to U.S. monetary shocks, but less than one for one. Other news shocks, which include positive U.S. growth surprises, appear to have even more limited (and possibly benign) effects on emerging market bond yields."* It points out that there may be effects, though, in the flow of capital to EM.[3]

[3] According to the IMF´s reported simulations, gross inflows decline markedly, falling by almost 2 percent of GDP over six quarters in response to a 100-basis-point increase in the real Treasury rate. When controlling for

There are similarities and differences among EM. In particular, Uruguay is a small open economy still highly dollarized with a relatively poorly developed asset market. It is basically a commodity producer (mainly beef, wool, and most recently soybean),Brazil, Argentina, China, the US, and other EU developed countries being its main product destinations; on the other hand, Uruguay is a net oil importer.[4] Another important feature of Uruguayan economy is its service sector which provides 56% of total income both from foreign (especially regional tourism) and internal demand.

A stylized fact of Uruguay is dollarization. There have been important attempts to alleviate this problem, but Uruguayan economy still remains highly dollarized: almost 80% of total deposits and more than 50% of total credits in the banking system are foreign currency-denominated. The main problem, though, is currency mismatches. According to recent studies, 87% of Uruguayan firms report to have liabilities denominated in currencies (mainly US dollars) different from those of their incomes (mainly Uruguayan pesos).[5]

Figure 2 . URUGUAY: dollarization

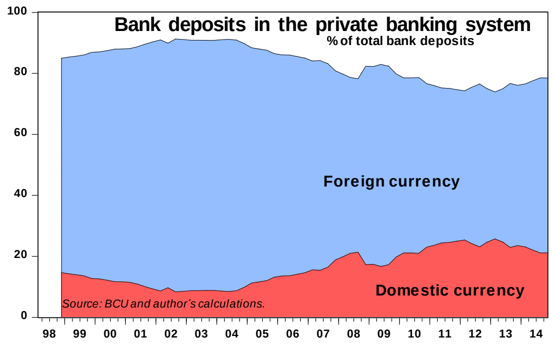


Figure 3. URUGUAY: dollarization

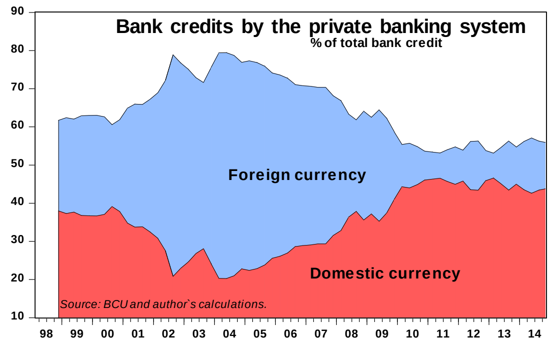
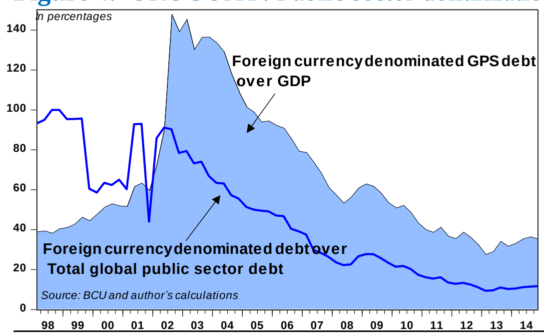


Figure 4. URUGUAY: Public sector dollarization



In addition, the public sector (33% of total GDP) is mainly endebted in foreign currency. An important change in the Uruguayan economy in the last decade is the decrease in the dollarization of the public debt[6] and

output growth in the US – the counter face of the normalization of US monetary policy -, they found that net capital flows to emerging markets respond positively to an increase in US GDP growth despite the associated rise in US interest rates.

[4] ANCAP (Administración Nacional de Cemento, Alcohol y Portland) is the public enterprise that monopolistically imports and refines oil.

[5] See Licandro et al (2014).

[6] During the 2002 crises, more than 80% of total public debt was denominated in foreign currency; in 2002Q2-Q3, the nominal exchange rate jumped 16% and public debt denominated in foreign currency over GDP rose from 70% to more than 150%, but dropped to around 30% ten years later. It was 37% in 2014Q4.

the increase in the average time for maturity. We expect that these changes reduce the Uruguayan economy's vulnerability to global shocks.

Under those circumstances, a tighter monetary policy decided by the Fed sounds like bad news for a dollar-indebted country that does not print dollars. First, a rise in the federal funds rate leads to a rise in market rates through arbitrage, increasing Uruguay's debt burden and worsening its external debt conditions.[7] Twelve-year sustained economic growth that began in 2003 may be put to a hold. Second, a rise in the federal funds rate appreciates the dollar against other currencies, in particular the Uruguayan peso. This local currency depreciation may fuel domestic inflation, which is already out of the target zone, because many prices of the consumption basket are updated according to the depreciation rate.[8] Third, higher inflation may reduce investment projects, which are needed for growth.

The concern that rising US interest rates could slow or reverse the flow of capital to emerging markets is somehow mitigated for the case of Uruguay by the shallowness of its financial market. For instance, real assets are the biggest part of a household´s net wealth, and not only are they intensive in using cash (70%) but also there is a low and stable use of credit (22%) and debit cards (8%).[9] As a result, an observer might wonder the true dimension of the effects of a new foreign monetary scenario. The challenge, then, is to unveil the channels through which those foreign (US) monetary shocks might finally affect Uruguayan relevant variables. The strategy rests on using information on past performances to try to figure out the most probable path.

There has been a lot of research on the effects of regional factors on Uruguayan performance.[10] Favaro and Sapelli (1986) use VAR models to quantify the regional linkages of the Uruguayan economy for the period 1943-1984 and they find a large impact of regional variables especially bilateral real exchange rates. Talvi (1994) calibrates the importance of Argentina during two exchange-rate-based stabilization programs attempted in Uruguay (October 1978 and December 1990, respectively) through an intertemporal optimization model with both tradable and regional goods.

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[7] Although fixed-rate foreign public debt accounts for almost 90% of total foreign public debt, it is denominated in US dollars and, in that way, varies according to the exchange rate evolution.

[8] A one-time adjustment in relative prices does not necessary lead to inflation, but it may put inflationary pressures into action because other relevant economic variables are CPI-indexed.

[9] See Lluberas and Odriozola (2014) and Lluberas and Saldain (2015).

[10] Sosa (2010) presents a detailed review of the related literature.

Bergara et al. (1994) develop a model stemming from the ones with Dutch disease and a booming sector and incorporate a regional tradable sector in order to analize the effects of a regional demand shock and a shock to external capital inflows on Uruguayan performance. Masoller (1998) uses a near-VAR model to study the mechanisms of transmissions of regional shocks in Uruguay. Bevilaqua, Catena and Talvi (1998) concentrate on trade linkages, formalize the concept of regional goods and analyze the vulnerability of Argentina, Paraguay and Uruguay to real devaluations in Brazil. Kamil and Lorenzo (1998) study the correlation between the Uruguayan business cycle and the cyclical component of some key regional macroeconomic variables, finding that the Uruguayan business cycle is strongly influenced by regional factors. Voekler (2004) studies how regional shocks affect sectoral Uruguayan output, finding that the most important causes of fluctuations at the sectoral level are shocks to output and relative prices in the region – with shocks from Argentina having the largest impact. In the same line, Eble (2006) finds that Uruguay's exposure to regional shocks has adversely affected growth in recent decades. Sosa (2010) examines the role played by regional factors in Uruguay, identifies the sources and transmission mechanisms of shocks stemming from the region and assesses how vulnerable Uruguay is to a potential crisis in the region. He uses a VAR model with block exogeneity restrictions and finds that shocks from Argentina – which account for about 20 percent of Uruguayan output fluctuations – have large and rapid effects. Sosa points out that this is mainly due to the existence of idiosyncratic real and financial linkages between Uruguay and Argentina, which also explain the very high correlation between their business cycles. More recently, the IMF (2014) report on Uruguay establishes:

> *"The response of Uruguay's local currency bond yields to the change in U.S. yields was 1.7, in line with the LA5 average but lower than the betas of Colombian, Brazilian, and Peruvian local currency bonds (which were closer to 2.5). Similarly, the beta of Uruguay's long-term foreign currency bond yields to U.S. yields was 1.4, in line with Colombia and Mexico, but lower than the betas of Brazil, Chile and Peru. Thus, as in other EMs, Uruguayan yields moved more than one-for-one with U.S. bond yields in the aftermath of the tapering announcement, although the increase in Uruguayan yields was at the moderate end of LA6 reactions."*

Nevertheless, the impact on real activity of a stronger US recovery accompanied by an increase in EM risk premiums would moderately dampen growth in Uruguay through financial channels, according to the IMF.

In this paper, Factor-Augmented Vector Autoregressive (FAVAR) models are used for the first time with Uruguayan data 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, the effects on real exchange rate, domestic assets (as housing prices) and domestic output are analyzed.

An interesting alternative to the FAVAR approach is the global VAR (GVAR) model introduced by Dees et al. (2007) and recently applied to Uruguayan data by Zunino et al. (2015). The GVAR incorporates an explicit model for each country which are linked by a set of observed and unobserved international factors. In this way, the GVAR is particularly convenient when shocks come from very specific foreign countries instead of "the rest of the world". As argued by Mumtaz and Surico (2008), the FAVAR approach is particularly convenient when one of the main goals is to analyze the response of a large number of home variables.

The rest of the paper is organized as follows. Section 2 develops the prior research. Section 3 describes the data set and explains the way it is used. Section 4 presents the results. Section 5 performs some robustness tests and, finally, section 6 concludes.

2. Prior research

There is a vast empirical literature on the international transmission of monetary and nonmonetary shocks using small-scale structural VARs. The main purpose of structural VAR (SVAR) estimation is to obtain non-recursive orthogonalization of the error terms for impulse-response analysis. This alternative to the recursive Choleski orthogonalization requires the user to impose enough restrictions to identify the orthogonal (structural) components of the error terms.

Several researchers have proposed alternative identification structures including, among others, the recursive schemes in Grilli and Roubini (1995), Eichenbaum and Evans (1995), and Faust and Rogers (2003); the nonrecursive schemes in Cushman and Zha (1997), Kim and Roubini (2000), and Kim (2001); and the sign restrictions in Canova (2005) and Scholl and Uhlig (2005). All of them employ a relatively small number of variables (a VAR with 14 variables) and have difficult to solve long-lasting puzzles in international macroeconomics,[11] simultaneously. Mumtaz and Surico (2009) use a wider information set in order to achieve a better understanding of international transmission of shocks and to get new evidence to solve those long-lasting puzzles.

This section proposes a Factor-Augmented Vector Autoregresssive (FAVAR) model to assess the impact of a foreign monetary shock on relevant Uruguayan economic variables. The model resembles Bernanke, Boivin and Eliasz (2005), Mumtaz and Surico (2009) and Fukawa (2012).

2.1 The FAVAR model

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.

Consider *n* observed stationary variables. Let us assume that each stationary variable of our macroeconomic data set x_{it} is composed of two mutually orthogonal unobservable components, the common component χ_{it} and the idiosyncratic component ξ_{it} :

$$(1)\ x_{it} = \chi_{it} + \xi_{it}$$

The idiosyncratic components 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. These components can be weakly correlated across variables but common and idiosyncratic components are orthogonal for each variable.

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):

$$(2)\quad \chi_{it} = a_{1i}f_{1t} + a_{2i}f_{2t} + \cdots + a_{ri}f_{rt} = \boldsymbol{Af_t}$$

The optimal number of factors can be determined by several statistical tests, such as Bai and Ng (2002) and Onatski (2010) or Velicer`s (1976)[12]. Although factors do not need to have an economic meaning and their main purpose is to summarize the information content of the observed variables,

[11] Delayed exchange-rate overshooting and forward discount puzzles.

[12] The first two tests are used when principal components analysis (PCA) are applied to estimate the factors while the latter is used when factors analysis (FA) is applied. In PCA, it is assumed that all variability in an item should be used in the analysis while in FA only the variability that the item has in common with the other items is used. PCA is preferred as a method for data reduction while FA is often preferred when the goal is to detect structure. See Discussion section.

sometimes it is possible to find an economic interpretation for the first few factors. When allowing a VAR model for vector $\boldsymbol{f_t}$ components, dynamic relations among macroeconomic variables arise:

$$(3)\quad f_t = D_1 f_{t-1} + D_2 f_{t-2} + \cdots + D_p f_{t-p} + \varepsilon_t$$

$$(4)\quad \varepsilon_t = R u_t$$

where R is an r×q matrix and $u_t = (u_{1t} u_{2t} \ldots u_{qt})$ is a q-dimensional vector of orthonormal white noises, with $q \leq r$. Such white noises are the “common” or “primitive” shocks or “dynamic factors” (whereas the entries of f_t are the “static factors”). Observe that, if q < r, the residuals of the above VAR relation have a singular variance covariance matrix. From equations (2.1) to (2.3) it is seen that the variables themselves can be written in the dynamic form $x_{it} = b_i(L)u_t + \xi_{it}$, where $b_i(L) = a_i(I - D_1 L \quad - \cdots - D_p L^p)^{-1} R$.

The dynamic factors u_t and $b_i(L)$ are assumed to be structural macroeconomic shocks and impulse response functions, respectively.[13]

Vector autoregressive (VAR) models are very useful in handling multiequation time-series models because the econometrician does not always know 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.

$$(5)\qquad O_t = \sum_{i=1}^{p} A_i O_{t-i} + u_t^O$$

Nevertheless, there are some tools – such as Granger causality, impulse response analysis and variance decomposition – that can shed some light on the understanding of their relationship and guidance into the formulation of more structured models.

Factor-augmented VAR (FAVAR) models combine factor models and VAR models at the same time: (6)

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

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. Unobserved factors are extracted from the informational time series included in the data set. The number of the

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[13] They are called Dynamic Factor models.

informational time series is large and must be greater than the number of factors (r) and observed variables in the FAVAR system.

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

$$(7) \qquad X_t = \Lambda^f F_t + \Lambda^O O_t + e_t$$

where F_t is a (k x 1) vector of common factors,[14] 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 assumes a small cross-correlation, which vanishes as N goes to infinity.

2.2 The empirical model

The FAVAR approach developed by Bernanke et al. (2005) was extended to the open economy by Mumtaz and Surico (2009) in order to model the interaction between the UK economy and the rest of the world, which they call the "foreign" block. They occupy a large panel of data covering 17 industrialized countries and around 600 price, activity, and money indicators. They have only one observable variable, though, the UK short-term interest rate. In our model, however, there are six domestic observable variables because our main goal is to investigate domestic transmission channels of a foreign shock, in particular, US monetary shock.

The model presented here consists of three blocks: the foreign observable variables, O^*_t; the information about the industrialized world, the relevant Region and the Uruguayan economy, which is summarized in *k* "unobserved" factors, F_t; and the domestic observable variables, O_t. As a result, the dynamic system moves according to the following transition equation:

$$(8) \qquad \begin{bmatrix} O_t^* \\ F_t \\ O_t \end{bmatrix} = B(L) \begin{bmatrix} O_{t-1}^* \\ F_{t-1} \\ O_{t-1} \end{bmatrix} + u_t$$

where B(L) is a comformable lag polynomial of finite order *p*, and $u_t = \Omega^{1/2} e_t$ with the structural disturbances $e_t \sim N(0,1)$ and $\Omega = A_0(A_0)'$.

The unobserved factors are estimated by maximum likelihood and the optimum number of factors is determined using Velicer´s minimum average parcial (MAP) method, and starting values for the

[14] Unobservable factors in FAVAR do not have exact meanings. The Forni and Gambetti (2010) model is different from FAVAR in that they tried to give the factors themselves a structural interpretation.

communualities[15] are taken from the squared multiple correlations (SMCs). Other authors consistently estimate the unobserved factors by the first *r* principal components of X (Stock and Watson, (2002)). For this result to hold, it is important that the estimated number of factors, *k*, is larger than or equal to the true number, *r*. Because N is sufficiently large, the factors are estimated precisely enough to be treated as data in subsequent regressions.[16]

The estimated loadings and factors are not unique; that is to say, there may be others that identically fit the observed covariance structure. This observation lies behind the notion of factor rotation, in which transformation matrices are applied to the original factors and loadings in the hope of obtaining a simpler and easier-to-interpret factor structure. I apply an orthogonal rotation implying that the rotated factors are orthogonal.

In the second step, I estimate the FAVAR equation, replacing F_t with $\widehat{F_t}$. As a result, the response of any observable variable to a shock in the transition equation (8) can be traced out applying the factor loadings and equation (7).

2.3 Discussion

Several criticisms of the VAR approach to policy shock identification focus on the small amount of information used by low-dimensional VARs. To conserve degrees of freedom, standard VARs rarely employ more than 10 variables, even though this small number of variables is unlikely to span the information sets actually used by the policymaker. Using low-dimensional VARs means that the measurement of policy innovation is likely to be contaminated.

Factor-augmented VAR (FAVAR) models initiated by Bernanke et al. (2005) are a mixture of a factor model and a VAR model. The factors can provide an exhaustive summary of the information in large datasets, and in this sense they are precious to alleviate omitted variable problems in empirical analysis using traditional small-scale models (see Bernanke and Boivin (2003)). In fact, Bernanke and Boivin (2003) and Bernanke et al. (2005) proposed exploiting factors in the estimation of VAR to generate a more general specification. Chudik and Pesaran ((2007), (2011)) illustrate how a VAR augmented by factor could help in keeping the number of parameters to be estimated under control without loosing relevant information.

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[15] *Communualities* are the common portion of the variance of the variable. See EViews 9 Reference Manual.
[16] See Fukawa (2010).

Factor models impose a considerable amount of structure on the data, implying restricted VAR relations among variables (see Stock and Watson (2005) for a comprehensive analysis). In this sense, factor models are less general than VAR models. On the other hand, factor models, being more parsimonious, can model a larger amount of information. The ability to model a large number of variables without requiring a huge number of theory-based identifying restrictions is a remarkable feature of structural factor models. If economic agents base their decisions on all of the available macroeconomic information, structural shocks should be innovations with respect to a large information set, which can hardly be included in a VAR model.

The estimation of FAVAR models is usually done following a two-step procedure in which the factors are found first and then the co-movements among the observed variables and the factors are analyzed. Some authors suggest extracting factors by the first of principal components of the series involved, such as Bernanke et al. (2005) and Boivin et al. (2009), among others. There are other researchers that prefer to apply a maximum-likelihood method in the first step. Results given by principal components analysis (PCA) and factor analysis (FA) are very similar in most situations, but this is not always the case, and there are some problems where the results are significantly different.

Both PCA and FA create variables that are linear combinations of the original variables. But different from PCA, FA is a correlation-focused approach seeking to reproduce the inter-correlations among variables, in which the factors "represent the common variance of variables, excluding unique variance.” In terms of the correlation matrix, this corresponds with focusing on explaining the off-diagonal terms (i.e. shared co-variance), while PCA focuses on explaining the terms that are on the diagonal. However, as a side result, when trying to reproduce the on-diagonal terms, PCA also tends to fit relatively well the off-diagonal correlations. PCA results in principal components that account for a maximal amount of variance for observed variables; FA accounts for common variance in the data. That is one of the reasons why FA is generally used when the research purpose is to detect data structure (i.e., latent constructs or factors) or causal modeling while 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 the latent factors.

An important drawback of FA, however, refers to its “heuristic” analysis of factors, because more than one interpretation can be made from examining the same data factored in the same way.

3. Data

3.1 Policy rate

The effective federal funds rate 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. But since the end of 2008, the effective federal funds rate 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. To provide a further boost to the economy, the Federal Open Market Committee (FOMC) has embarked on unconventional forms of monetary policy (a mix of forward guidance and large-scale asset purchases) since then.[17] Attempts to summarize current policy have led some researchers to create a "virtual" federal funds rate. Specifically, 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. This combination makes the best use of both series" (p. 11). On the other hand, Bauer and Rudebusch (2015) write:

> "*The sensitivity of estimated shadow short rates raises a warning flag about their use as a measure of monetary policy, as in Ichiue and Ueno (2013) and Wu and Xia (2014). 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. More promising approaches have recently been suggested by Lombardi and Zhu (2014), who infer a shadow short rate that is consistent with other observed indicators of monetary policy and financial conditions and Krippner (2015), who considers the area between shadow rates and their long-term level*."

Although there is still no consensus regarding which variable to use for monetary policy analysis, it is clear that the effective federal funds rate does not seem very appealing for it was not an accurate reflection of the monetary policy decisions taken by the Fed during the ZLB period when the effective federal funds rate did not move. But as shadow interest rates are unobserved, there is no absolute certainty about their estimated values and they differ greatly among different researchers. As

[17] For a detailed list see Engen et al. (2015).

a result, in this study I perfom a sensitivity analysis and I alternatively use the effective federal funds rate (FFR) and the Wu-Xia virtual funds rate (FFR_im), both in real terms.

3.2 Description of the data

X_t consists of 36 quarterly macroeconomic time series.[18] All of them are 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.[19] The data span the period from 1995Q2 to 2014Q4[20]. Federal funds rate (FFR), 10-year bond rate (T10), real exchange rate (rer), domestic passive interest rate (i_p), Uruguayan country-risk (UBI), domestic output (y), and housing prices (p_h) are the observable variables O_t. The informational variables also include several commodity prices (wheat, soybean, food, oil), foreign output (from Argentina, Brazil, USA, China, UK, Italy, Spain, Germany, Mexico), US debt-to-GDP ratio, 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, total public sector income, and total public sector expenditures including interests.

3.3 Model specification

I first estimate a baseline VAR model on eight variables of interest: federal funds rate in real terms (FFR_t), 10-year bond rate in real terms (*T10*), real exchange rate (*rer*), domestic passive interest rate (*i_p*) in real terms, Uruguayan country-risk ratio (UBI), real domestic output (*y*), housing prices (*p_h*)[21] in real terms, and the public sector balance (*pb*) in real terms. In order to assess the impact of foreign monetary policy changes, I propose the following transmission mechanism. If we suppose that the Fed decides to change its rate (FFR), it will affect other market rates both foreign and domestically through arbitrage (*T10* and *i_p*) and will determine changes in domestic real exchange rate (*rer*), affecting domestic real output (*y*), domestic asset prices (*p_h*) and public sector balance (*pb*):

$$(5) \qquad O_t = \sum_{i=1}^{p} A_i O_{t-i} + u_t^O$$

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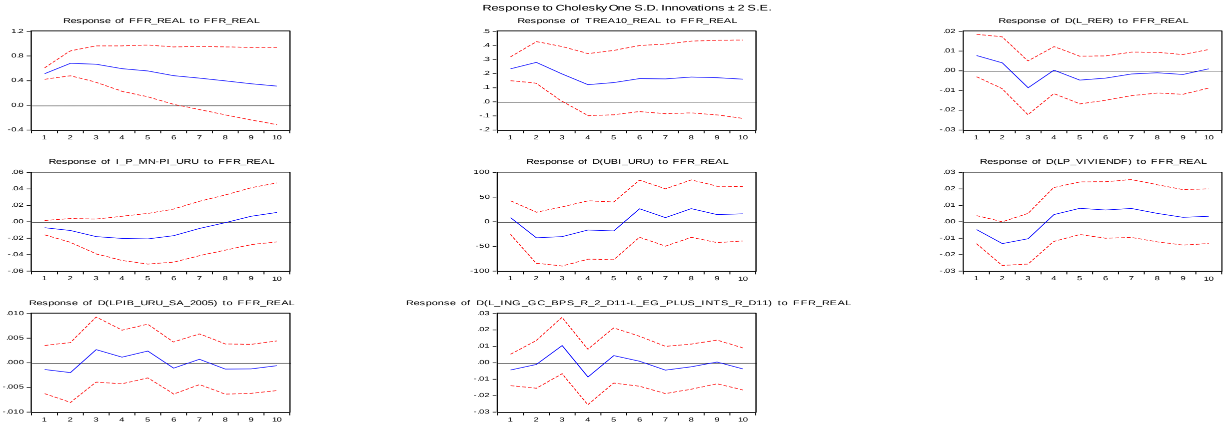
[18]Although the literature advises handling a larger number of time series, data availability was binding in this study.
[19] Standard unit root tests (augmented Dickey-Fuller and KPSS) show that all variables are stationary in first differences, except for the interest rates; deseasonalization techniques were applied when necessary.
[20] China GDP is available only since 1995Q2.
[21] This will be the ordering that will be used afterwards when performing impulse-response analysis.

where $O_t = \left(FFR_t,, T10_t, rer_t, UBI_t,\ i_{p_t}, p_{h_t}, y_t,\ pb_t\right)$. The information criteria select three lags for the VAR model, which satisfies the stability condition. The results show that a contractionary foreign monetary policy (a one-time rise of FFR) has no clear effects on Uruguayan real output, nor housing prices or fiscal accounts (see Figure 5, graphs 7, 6 and 8, respectively).

Figure 5 . Graphs 1 to 8. Impulse-response functions, baseline VAR (5.000 Monte Carlo replications)



Then, I explore the possibility of the existence of other unobserved variables that may influence the behavior of the observable ones. These variables may resume valuable information and be part of a more global transmission mechanism that is not very easy to describe at first sight. It seems plausible to try to find a few factors that could act as vehicles once the foreign monetary shock takes place. Next, I consider the extension of the baseline VAR model:

$$(8) \qquad \begin{pmatrix} O_t^* \\ F_t \\ \mathrm{O}_t \end{pmatrix} = \begin{bmatrix} \Phi_{11}(\mathrm{L}) & \Phi_{12}(\mathrm{L}) & \Phi_{13}(\mathrm{L}) \\ \Phi_{21}(\mathrm{L}) & \Phi_{22}(\mathrm{L}) & \Phi_{23}(\mathrm{L}) \\ \Phi_{31}(\mathrm{L}) & \Phi_{32}(\mathrm{L}) & \Phi_{33}(\mathrm{L}) \end{bmatrix} \begin{pmatrix} O_{t-1}^* \\ F_{t-1} \\ \mathrm{O}_{t-1} \end{pmatrix} + \begin{pmatrix} \mathrm{u}_t^{O^*} \\ u_t^F \\ \mathrm{u}_t^{\mathrm{O}} \end{pmatrix}$$

where $O_t^* = (FFR_t, T10_t)$, $O_t = \left(rer_t, UBI_t,\ i_{p_t}, p_{h_t}, y_t,\ pb_t\right)$ and $\mathrm{F}_t = (\mathrm{F}_{1t}, \mathrm{F}_{2t}, \mathrm{F}_{3t})$ are the factors estimated in the first part by Maximum Likelihood. Four lags are used, based on information criteria (SIC) and stability considerations.

4. Results

4.1 Estimation

I estimate the model applying a two-step procedure. In the first step, the unobserved factors and their corresponding loadings are estimated by maximum likelihood. In the second step, I substitute the estimated factors into a VAR specification and estimate the FAVAR model by OLS.

The whole available data set is used in order to estimate the factors. Nevertheless, following measures of sampling adequacy (MSA) and goodness-of-fit criteria, several time series are dropped out of the data set. In effect, only time series whose MSA values are greater or very close to Kaiser`s MSA[22] remain. The final data set has a Kaiser´s MSA value of 0.79 which can be labled between "middling" and "meritorious" for common factor analysis. I take the decision to keep Argentine and Brazilian real output and wheat price, even though they have indicators a bit lower than 0.79 because there is a trade-off between a labeling of almost "middling" and the actual importance of those variables in domestic dynamics. It must be taken into account that the final data set had to be shortened a great deal[23] in order to have a balanced panel of time series.

Velicer's MAP[24] method has retained three factors, labeled "F_1", "F_2" and "F_3". A brief examination of the rotated loadings indicates that commodity prices (food, wheat and soybean) and real wages load on the first factor, while foreign real output (from the US, Germany, Spain, the United Kingdom, Italy, and probably Mexico) and American debt load on the second factor and oil price and a relevant regional foreign real output (Argentina, Brazil and China) load on the third factor. Therefore it is reasonable to label the first factor as a measure of commodity prices, the second factor as an indicator of foreign demand from developed countries and the third factor as an aggregate variable for the regional demand.[25]

4.2 Identification of structural shocks

The dynamics of the variables in the system depend on the structure imposed on the factor loadings. As such, I propose different identification schemes in order to ponder the sensitivity of the

[22] MSA is an "index of factorial simplicity" that lies between 0 and 1 and indicates the degree to which the data are suitable for common factor analysis. Values for the MSA above 0.90 are deemed "marvelous"; values in the 0.80s are "meritorious"; values in the 0.70s are "middling"; values the 60s are "mediocre", values in the 0.50s are "miserable", and all others are "unacceptable" (Kaiser and Rice, 1974).
[23] It spans from 1980Q1 to 2014Q4, originally.
[24] 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=0, …, p-1). The number of factor 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. Zwick and Velicer (1986) provide evidence that the MAP method outperforms a number of other methods under a variety of conditions. (EViews 9 Help Topics).
[25] Recall, again, that some authors do not give factors an economic interpretation, rather a statistical one.

responses when a specific unanticipated[26] rise in the foreign interest rate occurs: a recursive identification scheme (Choleski) and a non-recursive one.

In the *recursive scheme*, the impact matrix A_0 is lower triangular, implying that both US monetary policy and foreign variables do not respond to Uruguayan performance measured by real output, for instance) contemporaneously. On the other hand, the 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:

$$\begin{pmatrix} u_{R_t} \\ u_{T10_t} \\ u_{F_{1t}} \\ u_{F_{2t}} \\ u_{F_{3t}} \\ u_{rer_t} \\ u_{UBI_t} \\ u_{i_{p_t}} \\ u_{p_{h_t}} \\ u_{y_t} \\ u_{pb_t} \end{pmatrix} = \begin{pmatrix} \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & 0 & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & 0 & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & 0 & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & 0 & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & \times & 0 & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & \times & \times & 0 \\ \times & \times & \times & \times & \times & \times & \times & \times & \times & \times & \times \end{pmatrix} \begin{pmatrix} e_{R_t} \\ e_{T10_t} \\ e_{F_{1t}} \\ e_{F_{2t}} \\ e_{F_{3t}} \\ e_{rer_t} \\ e_{UBI_t} \\ e_{i_{p_t}} \\ e_{p_{h_t}} \\ e_{y_t} \\ e_{pb_t} \end{pmatrix}$$

where "×" stands for freely estimated parameters.

In the *non-recursive scheme*, the restrictions imposed[27] are:

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

which imply different reactions of unobserved factors to foreign interest rates. Mumtaz and Surico (2009) identify the unobserved factors through the upper *N x 3* block of the matrix Λ^f, which is assumed to be block diagonal. Here, I impose zero restrictions on some of the factor loadings. In effect, commodity prices do not seem to react to contemporaneous movements of the federal funds rate but to changes in the ten-year bond rate within the period, while foreign demands both from the developed countries (F_2) and the relevant region (F_3) react to unanticipated changes in both foreign interest rates. There is no contemporaneous response of domestic output to a FFR_t change because

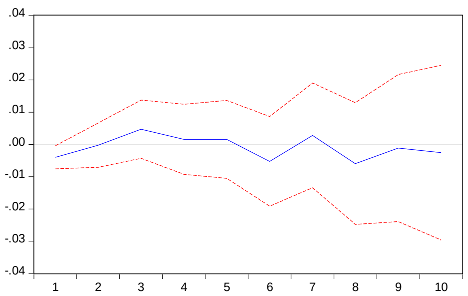
[26] US monetary policy normalization can be regarded as "unanticipated" because its precise timing of occurrence is unknown.
[27] In fact, they come after an optimization procedure applied on the data itself, that is, I tested for statistical significance of the contemporanoues effects from the Choleski factorization.

real activity seems to react through a specific pattern: those three unobserved factors canalize the initial change in US monetary policy instruments, affecting domestic interest rate directly and through real exchange rate and country-risk, and finally reaching domestic output. Only real exchange rate and country risk influence each other within the same period, besides US interest rate and commodity prices. Country risk varies contemporanously with 10-year bond interest rate and the relevant Region demand (F_3). Domestic interest rate does not respond to FFR contemporaneously but to other unanticipated innovations coming from the ten-year bond rate, commodity prices, developed countries' demand, real exchange rate and country-risk changes. The asset prices considered here (housing prices) are percieved as another type of financial investment, and thus they react contemporaneously to innovations stemming from foreign interest rates, commodity prices, developed-countries demand, real exchange rate, domestic interest rate and country risk. Finally, the domestic fiscal balance does not seem to react to changes in any of the variables considered that take place in the same period.

4.3 Impulse-response analysis

Once the baseline model is expanded into a FAVAR model, the dynamics seem more plausible because an unambiguous response of all the observed variables is reached, especially for domestic output. There is a clear and statistically significant impact effect but the following results are uncertain. (Figure 6).

Figure 6. FAVAR: Impulse-response function for D(y). (10.000 Monte Carlo replications)



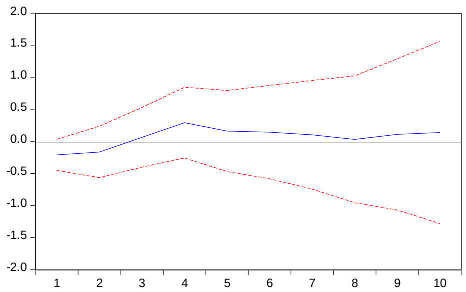
Under the recursive shock identification scheme, an increase of one standard deviation of FFR (2.3 or 230 basis points) reduces quarterly output growth by 0.40% on impact but as confidence intervals grow rather fast as time goes by, forecasts are not credible[28] (see Figures 6 to 12). Under the non-recursive shock identification scheme, an increase of one standard deviation of FFR (2.3 or 230 basis points) reduces quarterly output growth by 0.31% on impact but, again, as confidence intervals

[28] In impulse-response exercises, responses are determined from the estimated process parameters and are therefore also estimates. Generally, estimation uncertainty is visualized by plotting together confidence intervals with impulse response coefficients. See Luetkepohl (2011). If the confidence interval crosses the horizontal axis, however, the forcast can either be positive or negative with the same probability and therefore the estimate does not add any useful information. That is why I employ the expression "credible forecasts".

grow rather fast as time goes by, it is not possible to have credible forecasts. The responses of the variables when a non-recursive identification of structural shocks is applied are pretty similar to the ones described in Figures 6 to 12. The only difference is that they always have a smaller value. That is to say, their dynamic paths are the same but the actual responses are a bit lower[29].

There seems to be four channels through which a one-time rise in FFR affects real output in Uruguay. They are: the commodity price channel (Figure 7), the aggregate demand channel (OECD countries and relevant region, Figures 8 and 9) and the assets channel (exchange rate and housing prices, Figures 10 and 11). They can be outlined by analyzing the following IRFs.

Figure 7. FAVAR: Impulse-response function for F1 (10.000 Monte Carlo replications).



Once FFR rises, arbitrage makes market interest rates rise and some financial assets become interesting and commodities become less attractive as financial investments. Figure 7 plots the evolution of F1 factor (labeled "commodity prices" factor). Only a significant negative impact can be seen in response of a one-time rise in FFR in real terms. Afterwards, there is great uncertainty and nothing can be said.

Figure 8. FAVAR: Impulse-response function for F2 (10.000 Monte Carlo replications)

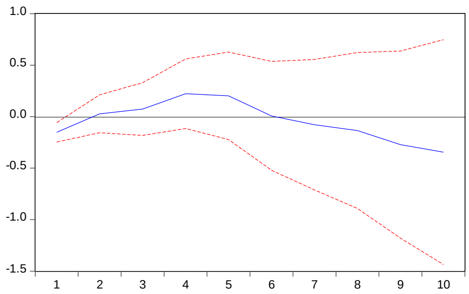
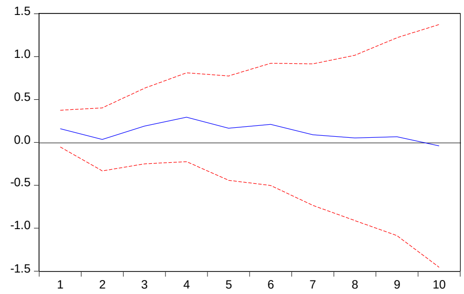


Figure 9. FAVAR:Impulse-response function for F3 (10.000 Monte Carlo replications)



Then, the demand channel appears. Developed countries'output declines, responding to the FFR rise and the decline in commodity prices. This can be seen in Figure 8, where factor F2 significantly drops on impact. The effect coming from the so-called region is not so clear. In essence, in Figure 9 no statistically significant response is reported. That may arise from the way the F3 factor is composed, that is, relevant regional output (Argentina, Brazil, and China which, except for China, have limited

[29] The results are available upon request.

linkages to the United[30]) and oil price. Foreign monetary policy transmission is usually done through changes in asset prices and capital flows. A tightening in foreign monetary policy usually leads to a depreciation of local currency as a consequence of the greater attractiveness of foreign currency-denominated assets and capital mobility (interest rate parity), which will lead to a local capital exit which in turn will affect financial asset prices (see Figures 10 and 11).

Figure 10. FAVAR:IRF for D(rer) (10.000 Monte Carlo replications)

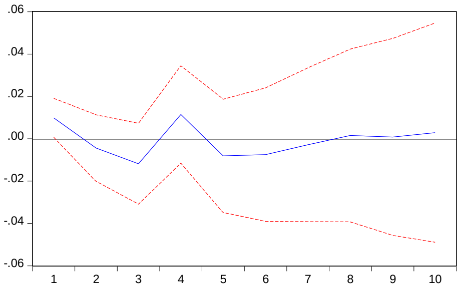
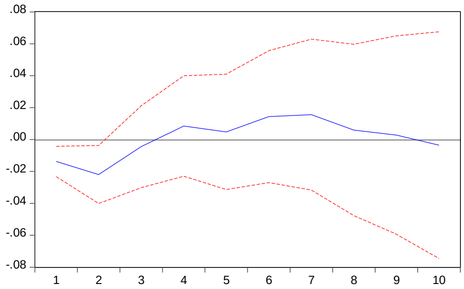


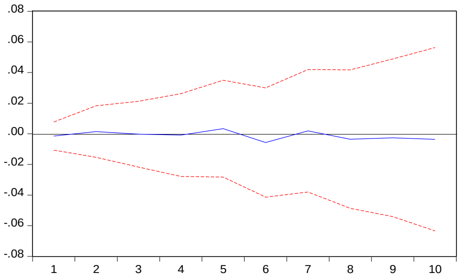
Figure 11. FAVAR:IRF for D(p_house) (10.000 Monte Carlo replications)



Finally, the assets channel points to a decrease in housing prices once FFR rises. As inflation had been present in the Uruguayan economy for a very long time,[31] economic agents in a shallow financial market sought hedge in other assets such as housing investment. It can be seen that an increase in FFR (in real terms) lowers housing prices (in real terms) because they lose relative value as an investment. Figure 11 shows a significant effect until the second period.

The effect of a US monetary policy change on Uruguayan fiscal accounts is ambiguous, because its primary balance could either be 0.76% better or 1.05% worse on impact. This situation is never solved and the final outcome is inconclusive.

Figure 12. FAVAR: IRF for D(pb) (10.000 Monte Carlo replications).



On the one hand, a fall in domestic output will drag income taxes down, increasing the fiscal deficit; on the other hand, domestic currency depreciation may play a dual role. It will increase debt payments and imported goods purchases, which will increase the fiscal deficit and will also reduce domestic

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[30] There are modest trade linkages between Uruguay and the United States (only 4 percent of Uruguay's exports are destined for the United States). Indirect trade linkages are also limited: almost 30 percent of total Uruguayan exports go to Brazil and Argentina—which also have limited trade linkages with the United States.

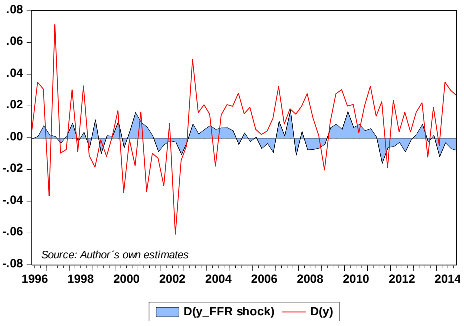
[31] Although several attempts to eliminate its negative effects had failed, until a successful stabilization plan was implemented in the 1990s.

expenses in real terms through higher inflation, which will reduce the fiscal deficit in real terms. Thus, the final result is ambiguous.

4.4 Variance decomposition analysis

While IRFs constitute a practical way to identify the dynamic responses of the Uruguayan economy to external monetary shocks, illustrating how growth in Uruguay has tended to react to different shocks, variance decomposition, in turn, provides a quantification of the relative importance of those variables as sources of shocks affecting output fluctuations in Uruguay. Thusly, around 9% of domestic output fluctuations in the first period can be explained by foreign interest rates[32] (both FFR and T10) and 6% by commodity prices (F_1). As time passes, the relative importance of foreign interest rates and regional demand are almost the same[33].

Figure 13. Historical decomposition.



The historical decomposition of Uruguayan output growth rate shows that US monetary policy shocks have had a relatively important impact on Uruguayan domestic output performance both during recession and during economic booms. The estimated time series D(y_FFR shock) plots what would have happened if only US monetary policy shocks had driven the data.

4.5 **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. I prefer to consider it endogenous because it can be argued that country risk may be influenced by real output performance which in turn is affected by foreign monetary policy.[34] When country-specific risk is treated as exogenous, an increase of one

[32] Recall that the impulse came from a rise in FFR.
[33] Recall that Choleski's ordering is: FFR, T10, F1, F2, F3, rer, UBI, i_p, , p_h, y, pb.. Results are available upon request.
[34] Changes in international real interest rates constitute an important factor driving portfolio capital inflows to Latin America, thus influencing business cycles across the region (Calvo, Leiderman, and Reinhart, 1993, and Calvo, Fernandez Arias, Reinhart, and Talvi, 2001). Low interest rates in mature markets may lead investors there to seek higher returns in other markets, increasing the demand for emerging market assets. Not only does external financing become more abundant for emerging markets, but also the cost of borrowing declines as a consequence of the lower interest rates in the U.S. In fact, Fernandez Arias (1996) shows that country-risk premia in emerging markets is indeed affected by international interest rates, amplifying the interest rate cycles in mature markets. (Sosa, 2012).

standard deviation of FFR (230 basis points) reduces quarterly output growth by 0.49% on impact but growing confidence intervals render future outcomes uncertain.

Impulse-response analysis is done on the FAVAR estimated equation using a simple recursive framework (Choleski decomposition) to identify structural shocks. Sensitivity analysis is performed by changing the ordering of the variables, and the main results remain unchanged.

Then, I proceed to substitute the effective federal funds rate (FFR) with the Wu-Xia virtual effective federal funds rate (FFR_im) in the FAVAR estimation. I perform impulse-response analysis and all the dynamics described before are found again. In the new scenario, however, there is more uncertainty. Specifically, an increase in one standard deviation of FFR_im (289 basis points) could make quarterly output growth either rise 0.34% or drop 0.60%, with a mean value of -0.14.

I also applied block restrictions on the FAVAR equation[35] in order to prevent feedbacks from the observed domestic variables to the foreign interest rate and the unobserved factors blocks:

$$(8`) \qquad \begin{pmatrix} O_t^* \\ F_t \\ \mathrm{O_t} \end{pmatrix} = \begin{bmatrix} \phi_{11}(\mathrm{L}) & 0 & 0 \\ \phi_{21}(\mathrm{L}) & \phi_{22}(\mathrm{L}) & 0 \\ \Phi_{31}(\mathrm{L}) & \Phi_{32}(\mathrm{L}) & \Phi_{33}(\mathrm{L}) \end{bmatrix} \begin{pmatrix} O_{t-1}^* \\ F_{t-1} \\ \mathrm{O_{t-1}} \end{pmatrix} + \begin{pmatrix} \mathrm{u}_\mathrm{t}^{O^*} \\ u_t^F \\ \mathrm{u_t^O} \end{pmatrix}$$

where $O_t = \left(rer_t, UBI_t,\ i_{p_t}, p_{h_t}, y_t,\ pb_t\right)$, $\mathrm{F_t} = (\mathrm{F_{1t}}, \mathrm{F_{2t}}, \mathrm{F_{3t}})$, are the factors estimated in the first part. Again, the unanticipated monetary policy shock affects the real economy by the same channels found in previous exercises in this study regardless of the foreign interest rate used (see Figure 1, panels a and b in annex.). When FFR_im is used as the Fed´s monetary policy stance, however, the effects on domestic variables are relatively sharper.

5 Conclusions

The aim of this study is to analyze the vulnerability of the Uruguayan economy to changes in US monetary policy by describing its linkages with other relevant variables in the last twenty years. The usual way of assessing monetary policy transmission effects - such as panel data analysis, correlation analysis and even case studies - have not offered much statistically significant evidence for Uruguay. However it seems plausible that Uruguay, as a small open dollarized economy with a relatively less

[35] A three-lag FAVAR with block restrictions was estimated as a seemingly unrelated regression (SUR).

sophisticated assets market, may suffer from international monetary policy shocks. The challenge, then, is to unveil the channels through which those shocks finally affect relevant Uruguayan variables.

A Factor-Augmented Vector Autoregressive (FAVAR) model is implemented for the first time on a quarterly balanced Uruguayan data set that span from 1996Q2 to 2014Q4[36]. This approach is preferred to a traditional VAR because FAVAR models, being a mixture of Factor models and VAR 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 stage, the effects on real exchange rate, domestic assets (as housing prices) and domestic output are analyzed.

While IRFs constitute a practical way to identify the dynamic responses of the Uruguayan economy to external monetary shocks, illustrating how growth in Uruguay has tended to react to different shocks, variance decomposition, in turn, provides a quantification of the relative importance of those variables as sources of shocks affecting output fluctuations in Uruguay. Historical decomposition helps to assess the relative importance of foreign monetary policy shocks in the Uruguayan economy.

According to the exercises conducted in this investigation, 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 delve deep into the transmission mechanism of a particular shock bearing in mind that VAR analysis should be complemented with other approaches.

No formal test for structural breaks were perfomed despite the presence of breaks in individual time series. Stationarity of the estimated FAVAR model, may suggest co-breaking, though. Finally, an important limitation of this study is the time span considered. Future research on this topic should include a broader data set to apply a dynamic factor model, analyze possible breaks and nonlinearities.

[36] Sample adjusted for lagged variables.

6 ANNEX

6.1 Data

6.1.1- Data set list

Mnemonics	Description	Source	Transformation
FFR	Federal fund rate, deflated by US CPI inflation	Federal Reserve Board	FFR_REAL
T10	10-year bond rate, deflated by US CPI inflation	Federal Reserve Board	TREAL_10
Rer	Uruguayan Real effective Exchange rate, comprises Uruguay´s main trade partners measured in PPP US dollars.	Banco Central del Uruguay	D(L_RER)
i_p	Domestic passive interest rate, deflated by domestic inflation	Banco Central del Uruguay	i_p_mn
Y	Uruguayan GDP	Banco Central del Uruguay	D(LPIB_URU_SA_2005)
p_h	Housing price index in Uruguayan pesos	Instituto de Estadística (INE) and author´s own calculations to update it	D(LP_VIVIENDF)
PWheat	Commodity Price of wheat in US dollars; deflated by US CPI and deseasonalized	International Monetary Fund	D(L_Pwheat_IMF_SA_R)
PSoybean	Commodity Price of soybean in US dollars; deflated by US CPI and deseasonalized	International Monetary Fund	D(L_Psoybean_IMF_SA_R)
PFood	Commodity Price of food in US dollars; deflated by US CPI and deseasonalized	World Bank	D(L_Pfood_WB_SA_R)
POil	Commodity Price of oil in US dollars; deflated by US CPI and deseasonalized	International Monetary Fund	D(L_Poil_IMF_SA_R)
GDP_AR	Quarterly GDP of Argentina, deseasonalized	International Monetary Fund	D(L_GDP_AR_SA_2005)
GDP_BR	Quarterly GDP of Brazil, deseasonalized	International Monetary Fund	D(L_GDP_BR_SA_2005)
GDP_US	Quarterly GDP of USA	International Monetary Fund	D(L_GDP_US)
GDP_CHINA	Quarterly GDP of China	International Monetary Fund	D(L_GDP_CHINA)
GDP_UK	Quarterly GDP of UK	International Monetary Fund	D(L_GDP_UK)
GDP_IT	Quarterly GDP of Italy	International Monetary Fund	D(L_GDP_Italy)
GDP_SP	Quarterly GDP of Spain	International Monetary Fund	D(L_GDP_Spain)
GDP_GR	Quarterly GDP of Germany	International Monetary Fund	D(L_GDP_Germany)
GDP_MX	Quarterly GDP of Mexico	International Monetary Fund	D(L_GDP_Mexico)
D_GDP_US	US debt-to-GDP ratio	International Monetary Fund	D(D_GDP_US)
UBI_URU	Uruguayan country risk indicator	República AFAP	D(UBI_URU/100)
FBKF_TOTAL	Total domestic investment over GDP ratio	Author´s calculations on Banco Central del Uruguay data	L_FBKF_TOTAL
FBKF_PUB	Public domestic investment over GDP ratio	Author´s calculations on Banco	L_FBKF_PUB

		Central del Uruguay data	
FBKF_PR	Private domestic investment over GDP ratio	Author´s calculations on Banco Central del Uruguay data	L_FBKF_PR
EXP	Uruguayan total exports of goods and services, deseasonalized	Banco Central del Uruguay	D(L_EXP_D11)
IM	Uruguayan total imports of goods and services, deseasonalized	Banco Central del Uruguay	D(L_IMP_D11)
IMS	Real domestic wages. Average nominal wages deflated by consumer Price index, deseasonalized	Author´s calcluations on INE data	D(L_IMS_D11-L_IPC)
DES	Unemployment. Average quarterly unemployment rate for the whole country	Instituto Nacional de Estadística (INE)	DESEMPLEO_D11
PUBLIC_DEBT_TO_GDP	Total public debt-to-GDP ratio	Author´s own calculations on Banco Central del Uruguay data	PUBLIC_DEBT_TO_GDP_D11
PUB_EXT_DEBT_TO_GDP	Foreign public debt- to-GDP ratio	Author´s own calculations on Banco Central del Uruguay data	PUB_EXT_DEBT_TO_GDP
PUB_DOM_DEBT_TO_GDP	Domestic public debt-to-GDP ratio, deseasonalized	Author´s own calculations on Banco Central del Uruguay data	PUB_DOM_DEBT_TO_GDP_D11
PUB_FC_DEBT_TO_GDP	Foreign currency-denominated public debt-to-GDP ratio, deseasonalized	Author´s own calculations on Banco Central del Uruguay data	PUB_FC_DEBT_TO_GDP_D11
PUB_DC_DEBT_TO_GDP	Domestic currency-denominated public debt-to-GDP ratio, deseasonalized	Author´s own calculations on Banco Central del Uruguay data	PUB_DC_DEBT_TO_GDP_D11
PUB_ASS_TO_GDP	Public assets-to-GDP ratio, deseasonalized	Author´s own calculations on Banco Central del Uruguay data	PUB_ASS_TO_GDP_D11
ING_GC_BPS	Total public sector income. Includes total taxes from Central Government and from Banco de Previsión Social (BPS).	Banco Central del Uruguay	D(L_ING_GC_BPS_R_2_D11)
EG_GC_BPS	Total public sector expenditures excluding interests, deflated by Uruguayan CPI and deseadonalized	Banco Central del Uruguay	D(L_EG_GC_BPS_R_20_D11)

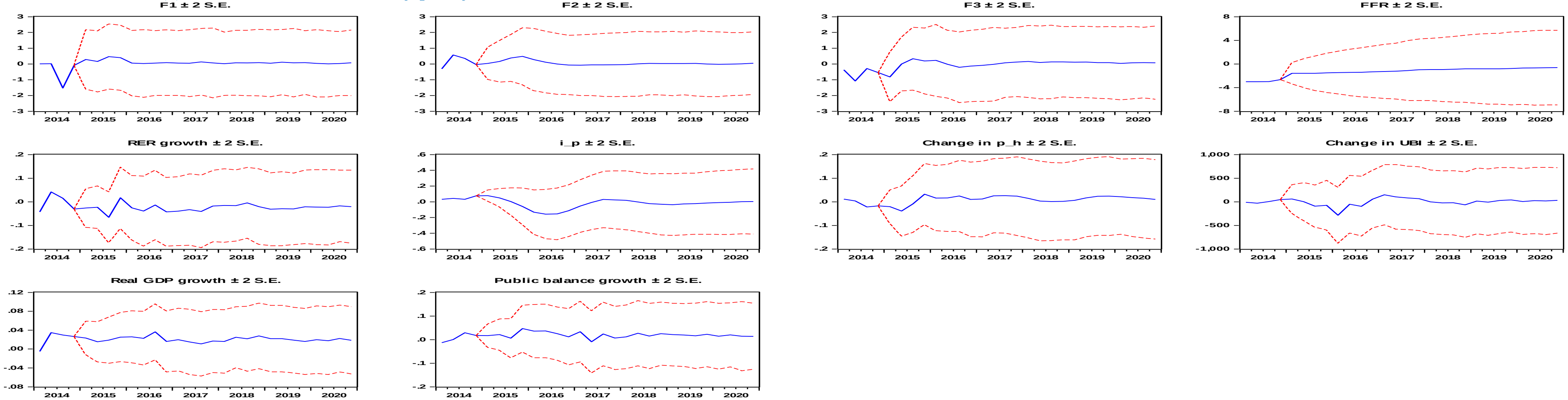
6.1.2 - Data set main characteristics

Sample 1994Q1- 2014Q4

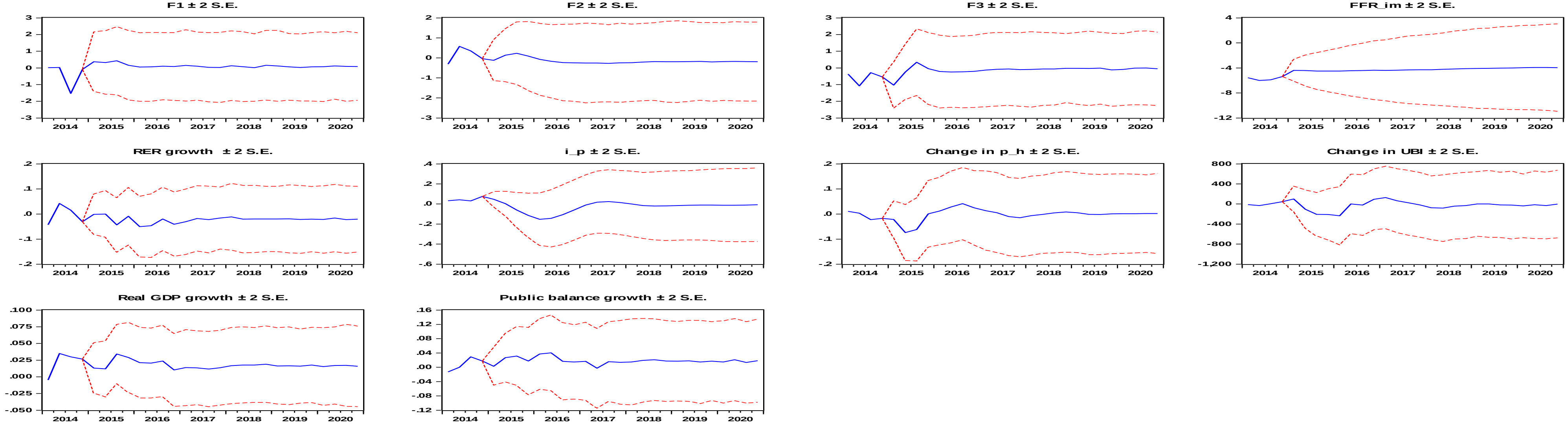
	FFR	FFR_im	TREA10	L_RER	I_P	UBI_URU	LP_PH	LPIB_URU	LPB
Mean	-0.059316	-0.449928	1.482898	4.435432	0.159987	3.183950	4.612495	4.690928	0.040967
Median	-0.142352	-0.142352	1.483108	4.448396	0.064279	2.013412	4.596872	4.623138	0.049052
Maximum	3.551656	3.551656	4.628083	4.755818	0.789422	21.53000	5.118561	5.132638	0.147044
Minimum	-3.909450	-6.002276	-1.603331	4.106394	0.014426	0.214014	4.389822	4.433622	-0.201149
Std. Dev.	2.333080	2.888234	1.635783	0.153982	0.166934	3.839881	0.119555	0.192288	0.057452
Skewness	-0.048280	-0.378219	-0.162183	-0.120841	1.621532	3.534520	1.862415	0.743983	-1.185490
Kurtosis	1.416123	1.751660	1.986006	2.567832	5.391289	16.00186	8.687507	2.289168	5.632344
Jarque-Bera	8.812968	7.456928	3.966887	0.858128	56.82507	766.5688	161.7773	9.517630	43.92772
Probability	0.012198	0.024030	0.137595	0.651118	0.000000	0.000000	0.000000	0.008576	0.000000
Sum	-4.982559	-37.79392	124.5634	372.5763	13.43894	267.4518	387.4496	394.0380	3.441190
Sum Sq. Dev.	451.7909	692.3773	222.0902	1.967975	2.312965	1223.809	1.186362	3.068884	0.273957
Observations	84	84	84	84	84	84	84	84	84

6.2 Figure 1. Impulse-response functions, FAVAR with block restrictions.

Panel (a) FFR as the Fed´s monetary policy stance.



Panel (b) FFR_im as the Fed`s monetary policy stance.



References

Bai, Jushan and Serena Ng (2002). “Determining the Number of Factors in Approximate Factor Models”, *Econometrica*, Vol. 70, pp. 191-221, January 2002.

Bauer, Michael D. and Glenn D. Rudebusch (2015). *Monetary Policy Expectations at the Zero Lower Bound*, Working Paper 2013-18, Working Paper Series, Federal Reserve Bank of San Francisco.

Bernanke, Ben, J. Boivin and P. Elizas (2005). “Measuring the Effects of Monetary Policy: Factor-Augmented Vector Autoregressive (FAVAR) Approach”, *The Quarterly Journal of Economics*, 120 (1), pp:387-422.

Bernanke, Ben and J. Boivin (2003). *Monetary Policy in a Data-Rich Environment, NBER* Working Paper No. 8379, Issued in July 2001.

Borraz, Fernando and Elizabeth Bucacos (2014). *Impact of the normalization of the FED policy in Uruguay*, Documento de Trabajo, Área de Investigaciones Económicas, Banco Central del Uruguay.

Calvo, Guillermo, Leonardo Leiderman, and Carmen Reinhart (1993). *Capital Inflows and the Real Exchange Rate in Latin America: the Role of External Factors*, Staff Papers, Vol. 40, pp. 108–50 (Washington: International Monetary Fund).

__________, Eduardo Fernandez Arias, and Ernesto Talvi, 2001, *The Growth-Interest-Rate Cycle in the United States and its Consequences for Emerging Markets*, Working Paper No. 458. IADB, Inter-American Development Bank.

Canova, Fabio (2005) “The Transmission of US Shocks to Latin America.” *Journal of Applied Econometrics*, 20, pp:229–51.

Chudik, Alexander and M. Hashem Pesaran (2007). *Infinite Dimensional VARs and Factor*, IEPR Working Paper No. 07.21, November 2007.

-- (2011). “Infinite Dimensional VARs and Factor Models", *Journal of Econometrics*, 163, 2011, pp:4-22.

Cushman, D. O., and T. Zha. (1997) “Identifying Monetary Policy in a Small Open Economy under Flexible Exchange Rate ”, *Journal of Monetary Economics*, 39, pp:433–48.

Dees, S., F. di Mauro, V. Smith, and H. Pesaran. (2007) "Exploring the International Linkagesof the Euro Area: A Global VAR Analysis." *Journal of Applied Econometrics,* 22, pp:1–38.

Eichenbaum, M., and C. L. Evans. (1995) "Some Empirical Evidence on the Effects of Monetary Policy Shocks on Exchange Rates", *Quarterly Journal of Economics,* 110, pp:975–1010.

Eichengreen, Barry and Poonam Gupta (2013). "Tapering talk: the impact of expectations of reduced Federal Reserve security purchases on emerging markets", available at CEPR´s Policy Portal: <http://www.voxeu.org/article/fed-tapering-and-emerging-markets>

Engen, Eric, Thomas Laubach, and Dave Reifschneider (2015). *The Macroeconomic Effects of the Federal Reserve's Unconventional Monetary Policies,* Finance and Economics Discussion Series Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C., Federal Reserve Board.

Faust, J., and J. H. Rogers. (2003) "Monetary Policy's Role in Exchange Rate Behavior." *Journal of Monetary Economics,* 50, pp:1403–23.

Favaro, Edgardo and Claudio Sapelli, 1989, "Shocks externos, grado de apertura y política doméstica," *Banco Central del Uruguay,* Montevideo, Uruguay.

Forni, Mario, L. Gambetti, (2010). *Fiscal Foresight and the Effects of Government Spending,* CEPR Discussion Papers No. 7840.

Fukawa, Kohei (2012). *Estimation of an Empirical FAVAR Model and DSGE Model for Evaluation of Government Expenditure Effects in Japan,* City University of New York, Graduate Center, February 19, 2012.

Grilli, V., and Nouriel Roubini (1995). *Liquidity and Exchange Rates: Puzzling Evidence from the G-7 Countries,* Working Paper, Yale University.

Ichiue, H. and Y. Ueno (2013). *Estimating term premia at the zero bound: An analysis of Japanese, US, and UK yields,* Bank of Japan Working Paper Series, No. 13-E-8.

Kaiser, H. F., and Rice, J. (1974). "Little Jiffy, Mark IV" in *Educational and Psychological Measurement,* 34, pp.111–117.

Kim, S. (2001) "International Transmission of U.S. Monetary Policy Shocks: Evidence from VAR's." *Journal of Monetary Economics,* 48, pp.339–72.

Kim, S., and N. Roubini. (2000) "Exchange Rate Anomalies in the Industrial Countries: A Solution with a Structural VAR Approach." *Journal of Monetary Economics*, 45, pp.561–86.

Licandro, Gerardo, Miguel Mello y Juan Odriozola (2014). *Uso de derivados en Uruguay*, Documento de Trabajo Nº 004-2014, Banco Central del Uruguay.

Lluberas, Rodrigo and Juan Odriozola (2014). *Inflation, wealth and households balance sheet in Uruguay*, mimeo, Banco Central del Uruguay.

Lluberas, Rodrigo and Joaquín Saldain (2015). "Paper or plastic? Payment instrument choice in Uruguay*"*, *Revista de Economía*, Mayo 2015, Segunda Época, Volumen 22, Nº1, pp: 35-64.

Luetkepohl, Helmut (2011). *Vector Autoregressive Models*, ECO 2011/30, Department of Economics, EUI Working Papers, European University Institute.

Masoller, Andrés (1998). "Shocks Regionales y el Comportamiento de la Economía Uruguaya entre 1974 y 1997," *Revista de Economía*, Banco Central del Uruguay, Vol. 5, Nº141-214 , pp. 141-214.

Mumtaz, Haroon and Paolo Surico (2008). "The transmission of international shocks: A factor-augmented VAR approach", *Journal of Money, Credit and Banking*, Supplement to Vol. 41, Nº 1, February 2009.

Onatski, A (2010). "Determining the Number of Factors from Empirical Distribution of Eigenvalues," *The Review of Economics and Statistics*, 92(4), pp.1004–1016.

Powel, J.H. (2013). "Advanced Economy Monetary Policy and Emerging Market Economies" Speech at the Federal Reserve Bank of San Francisco 2013 Asia Economic Policy Conference, San Francisco, CA, November 4.

Regional Economic Outlook 2014. Western Hemisphere, Rising challenges, IMF.

Scholl, A. and H. Uhlig. (2005). *New Evidence on the Puzzles—Results from Agnostic Identification on Monetary Policy and Exchange Rates.* SFB 649 Discussion Paper 2005– 037, Humboldt University.

Sosa, Sebastian (2010). *The Influence of "Big Brothers": How Important are Regional Factors for Uruguay?,* IMF Working Paper No. 10/60, International Monetary Fund.

Velicer, Wayne F. (1976). "Determining the number of components from the matrix of partial correlations", *Psychometrika*, September 1976, Volume 41, Issue 3, pp 321-327.

Wu, Jing Cynthia and Fan Dora Xia (2014). "Measuring the Macroeconomic Impact of Monetary

Policy at the Zero Lower Bound", available at Federal Reserve Bank of Atlanta web page: <https://www.frbatlanta.org/cqer/research/shadow_rate.aspx?panel=2>

Zwick, W. R. and Wayne F. Velicer (1986). "Comparison of five rules for determining the number of components to retain", *Psycologic Bulletin*, 99, pp. 432-442.