An indicator of monetary bias for emerging and dollarized economies: The case of Uruguay

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An indicator of monetary bias for emerging and dollarized economies
The case of Uruguay[☆]

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Resumen
La inestabilidad de las relaciones entre tasas de interés, cantidad de dinero y tipo de cambio, y los problemas de transmisión entre diferentes tasas de interés, dificultan la medición de la política monetaria a través de una única variable. Esta dificultad es particularmente relevante en economías emergentes y dolarizadas. Este artículo propone un indicador multivariado de sesgo monetario para estas economías, en el que las variables monetarias y financieras se ponderan según el impacto que tengan en la inflación de cada período. Analizamos el caso de Uruguay, y utilizamos un modelo de vectores autorregresivos, medias móviles y variable exógenas, aumentado con factores (FAVARMAX, por su sigla en inglés) para estimar estos efectos. La evolución del indicador propuesto, denominado Índice de Condiciones Monetarias (ICM), nos permite caracterizar a la política adoptada por el Banco Central de Uruguay entre 2010-2019, período en que se adoptó un régimen de metas de inflación.

JEL: E58, E52, E31, C32
Palabras clave: sesgo de la política monetaria; indicador multivariado; inflación; FAVARMAX.

Abstract
The instability of the relationships between interest rates, amount of money, and exchange rate, and the transmission problems between different interest rates hinder the measurement of monetary policy through a single variable. This difficulty is particularly relevant in emerging and dollarized economies. This paper proposes a multivariate indicator of monetary bias for these economies in which the monetary and financial variables are considered according to the impact they have on inflation in each period. We analyze the case of Uruguay and use a Factor Augmented Vector Autoregressive Moving Average model with exogenous variables (FAVARMAX) to estimate these effects. Using the evolution of the indicator proposed, called the Monetary Conditions Index (MCI), we characterize the policy adopted by the Central Bank of Uruguay between 2010-2019, a period of inflation targeting.

Keywords: monetary policy bias; multivariate Indicator; Inflation; FAVARMAX

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1 Introduction

Measurements of bias and stance in monetary policy are of particular interest to central banks, which manage their monetary and exchange instruments to achieve their inflation targets and economic activity level. In the literature, the first approaches to these topics focused on the evolution of the money supply. However, money demand instability, originating for both portfolio and transactional reasons not linked to the activity level, blurred the relationship between the nominal amount of money and the nominal GDP growth rates.

In response to this problem, recent approaches have focused on the monetary policy adopting a more contractive bias when the central bank increases the reference interest rate -usually the overnight interbank rate- while when the rate drops the bias is expansive. In this context, monetary policy adopts a contractive (expansive) approach when the interest rate gap is positive (negative), *i.e.*, when the overnight interbank rate, measured in real terms, exceeds (is less than) the natural or neutral rate. We consider that the real neutral rate is that in which, under conditions of full employment, the savings and investment of an economy are balanced. In this situation there are no inflation pressures and the unemployment rate is at its natural level.

However, the instability of the relationship between the interest rate and the nominal exchange rate, and the importance of the latter in the transmission of monetary policy, led some economists to discard the interest rate evolution as unique element to determine the policy bias or evaluate the policy stance. For this reason, the idea of monitoring a Monetary Conditions Index (MCI) emerged at the end of the 1990s. In its original version, the MCI was computed as the weighted average of the variations in the real short-term interest rate and Real Exchange Rate (RER), both calculated with respect to a base period. The weights are obtained from the estimation of the aggregate demand equation.

The use of this indicator has been very diverse. Some central banks used it as operational objectives that guided their monetary policy, but the problems this indicator had in both, the choice of the weightings and its application as a policy instrument, led to a gradual decline of its use in this latter aim.

In addition to the instability of the relationships of the policy interest rate (the overnight interbank rate) with the amount of money, and with the nominal exchange rate, there were also problems in the transmission of interest rates at different terms, and between the different market rates. Since the international financial crisis of 2008, obstacles to the transmission of monetary policy began to particularly affect advanced economies, when they began to implement unconventional monetary policies, consisting of programs for the purchase of public and private assets by central banks (Quantitative Easing), and the management of the yield curve through these transactions, at a time when overnight interbank rates were close to the Zero-Lower Bound (ZLB), and some official rates were situated en negative values. These difficulties for the transmission of monetary policy were very significant for emerging economies, as the simultaneous use of multiple monetary and exchange instruments by many central banks had to be added to financial markets imperfections and a strong exposure to external shocks. In this global framework, a need has arisen for multivariate indicators that reflect the bias and stance of monetary policy.

The main purpose of this paper is to build a multivariate indicator of monetary bias, which reflects the global direction adopted by monetary and exchange policy. This is not a monetary stance indicator, since a neutral level does not mean that the inflation and GDP gaps are closed (with respect to the inflation target and potential output, respectively), but it rather implies that there are no changes in the direction of the policy with respect to the previous period. We estimate this indicador for a small, open and partially dollarized economy, Uruguay, and asses the impact of monetary and exchange rate policy on inflation in the last decade.

To this end, the variables used are grouped into Strict Monetary variables (SM), those over which central banks have greater control, Financial Monetary variables (FM), those whose evolution is determined not only by central banks, but also by commercial banks, and Nominal Exchange Rate (NER), a variable that, while influenced by the actions of the Central Bank and commercial banks, is very much affected by the international financial context (international rates, risk aversion, etc). This is a key variable in small, open and dollarized economies.[1] To summarize the information contained in the SM and FM groups, a principal component analysis is applied. This way, the joint evolution of the variables of each group can be adequately represented through the first principal component, called the Strict Monetary Factor (SMF) and Financial Monetary Factor (FMF), respectively. With these factors, the exchange rate, and the international prices as an exogenous variable, we estimate a Factor Augmented Vector AutoRegressive Mov-

[1]When we refer to commercial banks' decisions, acting as secondary money creators, we include public's decisions, acting as depositors or borrowers.

ing Average model with eXogenous variables (FAVARMAX) for the Uruguayan monthly inflation rate, during the period February 2006-September 2019. From this model, a Monetary Conditions Indicator (MCI) was built, where shocks on the SMF, FMF and NER are weighted according to the impact they have on the inflation rate at each period.

The paper is divided into six sections. Section 2 reviews the literature on the measurement of monetary policy. In Section 3 the methodology to obtain the multivariate indicator of monetary bias is exposed. Section 4 presents the data, the variables of the model and the principal components analysis. Specification and estimation of the FAVARMAX model, impulse response functions, and historical decomposition of the monthly inflation rate are shown in Section 5. Finally, Section 6 concludes.

2 Background

This section reviews the main suggestions of the literature to estimate the bias and stance of monetary policy, and measure its impact on inflation and economic activity level.

2.1 Money supply growth-based approaches

The first approaches to this issue focused on the evolution of money supply. Friedman and Schwartz (1963) used the observed variations in the amount of money -Monetary Base and other broader aggregates- to evaluate monetary policy in the United States during the period 1867-1960.

However, the relationship that these authors found between the money supply and the nominal GDP growth rates, which includes the economic activity and prices, has blurred in recent years, as a result of the variations that money demand has experienced both for portfolio reasons, and transactional reasons not linked to the activity level. The latter are associated with strong financial and technological innovations, and regulatory changes that modified the agents payment habits. This money demand instability is one of the reasons that have caused some central banks to abandon the use of monetary aggregates as a policy instrument.[2] Thus, it is not possible to directly associate an increase in money supply with an expansive monetary policy, nor a fall in it with a contractive one.

[2]The control of monetary aggregates was gradually abandoned in the 1980s and 1990s, first by the US, the United Kingdom and Canada, and then by Switzerland and Germany, the two most successful cases in this regime. In South America, *e.g.*, during some periods of the last two decades, the Central Bank of the Argentine Republic and the BCU have used monetary aggregates as a monetary policy instrument. In these periods, they have had difficulties in communicating the policy stance, and relating it to the behavior of the objective variables.

In addition, as Lenz (2001) points out, it becomes difficult to determine whether changes in the amount of money react to a discretionary decision of central banks or are the result of changes in demand, obviously validated by supply.

2.2 Overnight interest rate evolution-based approaches

More recent aproaches on the measurement of monetary policy (bias and stance), are based on the evolution of the overnight interest rate (Woodford, 2003; Fuentes, 2008).

It should be clarified that measures of monetary bias, such as the one proposed in this paper, are not absolute measures as those of monetary stance. They do not indicate how far the monetary variables are from the levels that ensure a long-term macroeconomic equilibrium, which supposes that GDP is at its potential level, inflation at the Central Bank's target, and the RER at the fundamental level. The indicators of monetary bias only inform whether the monetary policy is more expansive or contractive than the previous period, *i.e.*, they aim to measure the direction of the policy.

The use of a single reference interest rate to determine both the stance and the bias of the monetary policy has several problems. The first question that arises is: what rate is considered to assess the monetary stance or monetary bias? Usually the overnight rate of the interbank market is used, but this choice assumes there is a good transmission between the different interest rates. Unfortunately, this is not always the case. For example, after the international financial crisis in 2008, the overnight interbank rates departed from the official rates (operational objectives) established by the central banks. This occurred especially in the months that followed the outbreak of the crisis, due to a greater perception of risk. In turn, long interest rates did not react to short rate movements, at a time when overnight interbank rates -objective and effective- had reached the ZLB. In this framework, several central banks adopted unconventional monetary policies. Some of them, in advanced economies, such as the Fed, the ECB, the Bank of England, and the Bank of Japan, sold short-term securities and bought long-term securities with the goal of reducing the longer term rates (known as *twist* operations), which are the ones that affect aggregate demand the most. Others, such as the Central Bank of the Republic of Turkey, adopted a multiple policy rates monetary framework. In some South American countries, such as Peru, Chile, Uruguay, and Brazil, measures such as reserve requirements and new temporary taxes on local currency bonds were imposed as a mean to discourage capital inflows, and avoid local currency appreciation. In this global financial environment, where central banks focus not only on prices but also on financial stability, it is no longer possible to assess bias and monetary stance through the evolution of a single monetary policy rate (see, *e.g.*, Binici et al., 2016, 2018; Babecká-Kucharcuková et al., 2016; Varlik and Berument, 2017).

A second question raised by the interest rate gap as an stance measure is that, when assessed in real terms, it is not clear what expected inflation rate is considered to deflate the nominal rate that has been chosen. Expectations of inflation are also an unobservable variable, so it is necessary to decide whether to use the expectations arising from a survey or those arising from the financial market data. For different reasons, both types of measures have their own problems, and the choice of one or the other likely lead to different conclusions.

Moreover, the interest rate gap does not: (a) consider issues of financial market structure, segmentation, failures, etc.; (b) consider the timing of the policy, *i.e.*, it does not take into account the lags with which the movements of the policy rate affect inflation and GDP; and, (c) take into account either that the relationships the policy interest rate keeps with the amount of money, and with the NER, are far from being stable and predictable (so, just considering it is not enough to reflect either the stance or the bias of monetary policy).

Based on the above weaknesses, the overnight interbank rate is not sufficiently representative of the functioning of the transmission mechanisms of monetary policy.

2.3 Multivariate approaches

The problems associated with measuring the bias and monetary stance through a single variable led to the first multivariate analysis carried out at the end of the 1990s, through the so-called Monetary Conditions Indexes (MCI). Its way of weighting the variables according to the impact they have on the evolution of aggregate demand, presents the problem that monetary and exchange policy not only affect inflation through aggregate demand. There are, at least, two additional channels that should by considered: (i) the expectations, which reflects the equilibrium conditions of the money market (see Gerlach, 2004; Gerlach-Kristen, 2007; Greiber and Neumann, 2004; Brum et al., 2013); and, (ii) the direct pass-through of the nominal exchange rate to domestic tradable prices, which is particularly relevant in small, open, and partially dollarized economies (see Salter, 1959; Swan, 1960; Bergara et al., 1995; Guenaga, 2017).

The use of this indicator has been very diverse. While some central banks, such as those in Canada and New Zealand, came to use it as operational objectives that guided the conduct of their monetary policy, others, such as Sweden and Norway, have only used it as useful indicators for analysis and policy formulation. For this last aim, the MCI was also calculated by the IMF, the ECB, the OECD, and various private financial institutions (see Ericsson et al., 1998, for more details).

Differently, Lenz (2001) and Winkelried (2004) present a state space model that treats the monetary position as a latent (unobservable) variable, estimated from a set of indicators (observable variables) linked to the monetary stance. This is based on the idea that macroeconomic variables influenced by money have a common co-movement source. This common source is the latent variable of the model while the observable variables are the monetary variables.[3] The methodology applied in these two studies has the following advantages: (1) it does not require information on the way the policy is implemented (and so it is robust to the use of different instruments); (2) it does not focus on the impact of a single variable, since it considers several transmission mechanisms operating simultaneously; (3) it comprises nominal and non-real variables, so it avoids having to estimate inflation expectations, an unobservable variable. In addition, if the aim is to measure the impact of the MCI on inflation, it is not convenient due to an endogeneity problem, that the inflation rate appears as a variable of the system to be explained, and, in turn, as a deflator of the nominal monetary variables as occurs when working with real variables (monetary aggregates, interest rate, exchange rate); (4) when considering the nominal exchange rate and not the real one, it makes it possible to better capture exchange rate pass-through to domestic prices, a very important phenomenon for small and open economies.[4]

The unconventional monetary policies adopted by several central banks in the world after the international financial crisis of 2008-2009, characterized by the simultaneous use of several instruments, led to the emergence of numerous studies based on multivariate approaches to measure bias and monetary stance.

Particularly, Lombardi and Zhu (2018) specify a dynamic factor model to represent the policy followed by the Fed after the crisis. They estimate a Shadow Policy Rate for the period in which the policy rate (Fed Funds Rate) was zero. This indicator is located close to the Fed Funds Rate until the beginning of the crisis. At the end of 2008, they separate from each other until the beginning of 2016, when they move back together again. The study shows that the Shadow Policy Rate is particularly useful for

[3] Lenz (2001) and Winkelried (2004) work with data from Switzerland and Guatemala, respectively.

[4] As already noted, this effect, which is even more significant in dollarized economies, is mainly verified through the price increase of consumer and intermediate goods imports.

characterizing the periods in which the Fed adopts unconventional monetary policies, as it is located much closer than the Fed Funds Rate of the rates prescribed by Taylor's rule for those periods.

2.4 FAVAR models to measure the impact of monetary policy

Within the multivariate approaches, Vector Autoregressive models (VAR), with their different variants, have been the common statistical tool used to measure the effects of monetary policy on economic activity level and inflation.

Regarding these models, Christiano et al. (1999) raise the problems of some papers that use them to identify the impact of monetary policy on the main macroeconomic variables. For example, in some cases they identify a positive impact on prices of a contractive monetary policy shock, which makes a complete lack of sense economically (Prize Puzzle). In the US, on several occasions in the post-war period, increases in inflation were preceded by increases in the Fed Fund Rate (policy interest rate) and in the commodity prices, which could lead to the conclusion that it was the contractive monetary policy which led to the rise in inflation. However, Christiano et al. (1999) explain that when the Fed took its decisions at times such as those described previously, a policy rule was followed that supposed an endogenous response to the behavior of GDP and inflation in the previous period (Fedback Rule), and also had different signs on the existence of inflationary pressures, contained in the inflation index itself or in other activity or price indicators. In their opinion, these elements should be incorporated into the model in some way, in order to avoid reaching erroneous conclusions about the effect of monetary policy shocks. On some occasions, it is possible that the Fed was detecting inflationary pressures on the side of commodity prices (due to the rise in the price of oil), and that is why it decides to apply a contractive monetary policy with the intention of mitigating the impact of these pressures, although without fully compensating for them. In a situation like this, if the model does not incorporate the set of relevant information available to the Fed when making its decisions in some way, it could come to identify a positive impact of the monetary shock on prices, when in fact prices are growing for a different reason.

Along the same lines, Bernanke et al. (2005) and Blaes (2009) develop Factor Augmented Vector Autoregressive models (FAVAR) to adequately identify the transmission mechanisms of the monetary policies of the US and the Euro Zone, respectively. These models incorporate factors, obtained with Principal Components Analysis (PCA), with the aim of summarizing a wide set of variables that influence the decisions of the Fed and other economic agents, and therefore have an impact on transmission mechanisms. In the set of variables considered, they do not discriminate between monetary or financial variables and the rest. They measure the impact of a movement on the policy rate (called observable factor) in the most relevant variables.

Since the financial crisis of 2008, a series of VAR models have been developed with the aim of measuring the macroeconomic impact of unconventional monetary policies implemented by central banks of advanced economies (Quantitative Easing), after their monetary policy rates reached the ZLB.[5]

Meinusch and Tillmann (2016) specify a Qual VAR, which incorporates information about announcements of long-term securities purchase programs by the Fed into the traditional VAR used to measure the effects of monetary policy. As the Fed's announcements are a binary variable, the model incorporates this information through a latent, and therefore unobservable, variable that represents the propensity of the monetary authority to implement a Quantitative Easing program. This propensity depends endogenously on the economic cycle.

Halberstadt and Krippner (2016) estimate a VAR model for the Euro Zone that incorporates an Effective Monetary Stimulus variable, which allows us to measure the impact of monetary policy on conventional and unconventional monetary policy environments. This indicator is obtained from the yield curve, and is calculated from the distance that the rates have at different terms with the long-term neutral nominal rate. Its evolution allows us to measure the bias of the monetary policy at all times, and its incorporation into a VAR model allows us to estimate its effect on GDP growth and inflation.

As mentioned, Lombardi and Zhu (2018) estimate a Shadow Policy Rate for the United States to measure the bias of the monetary policy applied by the Fed in the ZLB period. In order to validate their estimate, the authors compare the Shadow Policy Rate with the benchmarks prescribed by the Taylor Rule, and examine, in the framework of canonical VAR models, whether it provides a good description of the monetary policy structural shocks of the ZLB period. In all these exercises, the Shadow Policy Rate performs well.

Regarding the emerging economies, since the 2008 crisis, several authors have analyzed the use of unconventional monetary policies by central banks.

[5]In advanced economies, unconventional monetary policies have basically consisted of buying long-term securities with the aim of increasing their price, reducing their interest rates, and stimulating aggregate demand. The US, the Euro Zone, the United Kingdom, Japan, and Australia, among others, adopted these policies.

Varlik and Berument (2017) develop a FAVAR model to assess the impact of each of the multiple instruments used by the Central Bank of the Republic of Turkey during the last decade. They classify the set of variables into economic and monetary, calculating a vector of unobservable common factors for each group. Then, they measure the impact of each instrument separately (considering four different interest rates) on the different economic variables, considering the other three instruments within the vector of monetary variables used to obtain the unobservable factors representative of the group. In short, the paper applies the same methodology as Bernanke et al. (2005) and Blaes (2009) to study the effect of monetary policy on different economic variables, but admits the use of several instruments simultaneously (and not only the overnight interest rate).[6]

Fernald et al. (2014) apply the FAVAR approach to analyze the impact of monetary policy in China, a country where, for various reasons, inflation and GDP are imperfectly observed. With this aim, they use multiple monetary instruments and estimate several FAVAR models with different specifications. All of them include a factor that summarizes economic activity and another one that summarizes inflation. Then they add one or more monetary instruments, one at a time, or all together, and the impact of the instruments used on the factors of economic activity and inflation is estimated. In order to estimate the impact of monetary policy more accurately, control variables related to fiscal policy are also included.

A different line followed by the literature on VAR or similar models applied to monetary policy focused on the impact of unconventional monetary policies in the US and the Euro Zone on other economies, particularly on emerging economies. Some papers analyze the impact of the aforementioned policies on activity and consumer prices (see Hajek and Horvath, 2018), others estimate their effect on production, short-term interest rates, and financial uncertainty (see Potjagailo, 2017), while many focus on the impact on financial variables, such as capital flows, share prices, interest rates, sovereign risk premiums, and exchange rates (see Bowman et al., 2015; Tillmann, 2016; Anaya et al., 2017).

Interestingly, Babecká-Kucharcuková et al. (2016) measured the impact of conventional and unconventional monetary measures on the Euro Zone, and also on some

[6] In the Cholesky ordering established in this work, the policy instruments (the individual ones, and those that are grouped in the factor of the monetary variables) are allowed to simultaneously affect the factor of economic variables, although the reverse is not true. This approach is supported by the fact that monetary variables move faster than economic variables. Binici et al. (2016, 2018) also analyzed the impact of unconventional monetary policies in Turkey, although they did not use VAR or similar models. Both papers focus on the impact of these policies on bank, asset and liability rates.

economies in Eastern Europe. They built an MCI based on a set of monetary variables that are grouped into five blocks: (i) interest rates at different terms; (ii) different monetary aggregates; (iii) some assets that make up the balance sheet of the central bank; (iv) some obligations of the central bank (including Monetary Base), and (v) NER dollar/euro. This information is summarized in three factors. Factor 1 is primarily associated with the conventional monetary policy.[7] Factor 2 mainly represents blocks (iii) and (iv), although it is also related to (v), it is related to unconventional monetary measures. Factor 3 represents block (ii) and cannot be directly associated to conventional or unconventional monetary measures. Finally, they calculate an MCI with these factors, and estimate its impact on inflation and an activity index. Impulse response functions were calculated for the Euro Zone and some non EU member European economies.

3 Methodology

As in most of the previous papers cited, here we build a multivariate indicator of monetary bias, where the variables are weighted according to the impact they have had on the inflation rate. However, contrary to most of the literature, to measure this impact here we specified a FAVARMAX model estimated through a maximum likelihood procedure. The general formulation of this model (notice that we allow multiplicative seasonal components) is:

$$\mathbf{\Phi}_P(B)\boldsymbol{\phi}_p(B)\boldsymbol{Z_t} = \alpha_r(B)\boldsymbol{G_t} + \mathbf{\Theta}_Q(B)\boldsymbol{\theta}_q(B)\mathbf{A}_t \tag{1}$$

where B is the lag operator, such that $B^k X_t = X_{t-k}$; $\boldsymbol{Z_t}$, $\boldsymbol{G_t}$ and $\mathbf{A}_t$ are, respectively, the vector of endogenous variables, of exogenous variables and the vector of unexpected shocks to the endogenous variables; $\boldsymbol{\phi}_p(B) = [I - \phi_1 B - \phi_2 B^2 - ... - \phi_p B^p]$ are the matrices of parameters of the regular autoregressive polynomials; $\mathbf{\Phi}_P(B) = \left[I - \Phi_s B^s - \Phi_{2s} B^{2s} - .... - \Phi_{Ps} B^{Ps}\right]$ are the matrices of parameters of the seasonal autoregressive polynomials; $\boldsymbol{\theta}_q(B) = [I - \theta_1 B - \theta_2 B^2 - .... - \theta_2 B^q]$ are the matrices of parameters of the regular moving average polynomials; the matrices of parameters of the seasonal moving average polynomials are defined as $\mathbf{\Theta}_Q(B) = \left[I - \Theta_s B^s - \Theta_{2s} B^{2s} - .... - \Theta_{Qs} B^{Qs}\right]$, and $\boldsymbol{\alpha}_r(B) = [I + \alpha_1 B + \alpha_2 B^2 + ... + \alpha_r B^r]$ are the matrices of parameters associated to the exogenous variables. We assume that AR and MA polynomials hold: (1) the usual conditions for stationarity and invertibility, and (2) left coprimeness to assure identifiability.[8]

[7] According to the loading factors of each variable reported in the study.

[8] The left coprimeness property assures that there are no common factors in the AR and MA parts, except for unimodular operators.

The use of this formulation, which is a secondary contribution of our paper, against the most common VAR (or alternative) models deserves some comments. In this case, Model (1) presents the following advantages: (i) by including factors, as FAVARs do, it is possible to summarize the information contained in several variables, which, by their very nature, have a common co-movement source; (ii) the VARMAX representation requires us to estimate fewer parameters than VAR, and so, the model is more parsimonious. Typically, models that do not include moving average parameters require the inclusion of a large number of lags in order to capture the entire dynamic structure; (iii) it also allows one to work with multiplicative seasonality (without an excessive number of parameters to be estimated), capturing effects that are repeated every 12 periods, in our monthly data; (iv) it includes exogenous variables, as VARXs, which is specially relevant for small and open economies; and, finally, (v) it allows one to focus on statistically significant relationships and incorporate restrictions (*e.g.*, exclusion) in the estimation of the model. The latter, as a consequence of estimating Model (1) by maximum likelihood is, in our viewpoint, the main advantage of the suggested approach and allows us to keep us closer to the data and the classical statistical inference. In fact, our maximum likelihood procedure directly estimates the Cholesky factor (by iterating over it, instead of the covariance matrix) and so individual statistical tests can be applied also on the elements of that matrix. We will come back to this feature in Section 5.

After the estimation, the FAVARMAX model is expressed as a pure VMA representation, and the errors orthogonalized through the Cholesky decomposition. Then, the impact of each shock on the dynamics of each of the endogenous variables (Impulse Response Functions, IRF) is calculated. With the structural innovations orthogonalized and the estimated IRF, we will obtain the historical decomposition of each of the endogenous variables. Within this, the historical decomposition of the monthly inflation rate is of particular interest, as it will be used to build our MCI.

4 Data and factors estimation

Since 2005 Uruguay has adopted an inflation target system, with the feature of alternating the instruments used. From June 2005 to September 2007, a monetary aggregate management regime was adopted, establishing an indicative target for the growth of monetary aggregate M1. From September 2007 to June 2013, a Monetary Policy Rate was set, with the objective that the overnight interbank rate would be around this level. Since then, the BCU (Central Bank of Uruguay) has set indicative targets on the variation of

Table 1: Data description.

Variable description	Acronym	Transformation	Loading Factors	Factor name	Variable type
Monetary Base	MB	$\Delta\Delta_{12} ln(MB)$	0.94	Strict Monetary Factor (SMF)	Endogenous
Overnight interbank call rate	i_{call}	Δi_{call}	-0.35		
Monetary regulation notes rates 30 days	i_{30}	$\Delta ln(1+i_{30})$	-0.02		
Monetary regulation notes rates 90 days	i_{90}	$\Delta ln(1+i_{90})$	-0.02		
Monetary regulation notes rates 180 days	i_{180}	$\Delta ln(1+i_{180})$	-0.01		
Monetary aggregate M1	M1	$\Delta\Delta_{12} \ln(M1)$	0.64	Financial Monetary Factor (FMF)	Endogenous
Monetary aggregate M1′	M1′	$\Delta\Delta_{12} \ln(M1')$	0.57		
Monetary aggregate M2	M2	$\Delta\Delta_{12} \ln(M2)$	0.48		
Lending rate banks firms	i_{lrfi}	$\Delta \ln(1+i_{lrfi})$	-0.05		
Lending rate banks families	i_{lrfa}	$\Delta\Delta_{12} \ln(1+i_{lrfa})$	-0.06		
Lending rate banks credit cards	i_{lrcc}	$\Delta \ln(1+i_{lrcc})$	-0.03		
Deposit bank rates less 30 days	i_{dr30}	$\Delta \ln(1+i_{dr30})$	-0.11		
Deposit bank rates 30-60 days	i_{dr60}	$\Delta \ln(1+i_{dr60})$	-0.04		
Deposit bank rates 61-90 days	i_{dr90}	$\Delta \ln(1+i_{dr90})$	-0.08		
Deposit bank rates 91-180 days	i_{dr180}	$\Delta \ln(1+i_{dr180})$	-0.01		
Bilateral nominal exchange rate	NER	$\Delta \ln(NER)$	-	-	Endogenous
Consumer prices exclusion index	CPIX	$\Delta \ln(CPIX) - \mu$	-	-	Endogenous
External prices relevant to Uruguay	P^*	$\Delta \ln(P^*)$	-	-	Exogenous

Notes: The data source is the BCU database.

monetary aggregate M1′.[9] At all stages, it never stopped monitoring the evolution of all the monetary and financial variables, nor frequently intervening in the exchange market, in order to avoid excessive misalignment of the RER with respect to its fundamentals-based equilibrium level.[10]

To carry out our empirical analysis, we use data from the period 02/2006-09/2019. All the series, their descriptions and mathematical transformations are presented in Table 1. The data comes from the BCU database. The variables included in the model fulfill two main requirements.[11] First, they contain useful information on the evolution of inflation. Second, they fulfill a clear role in the transmission mechanisms of monetary policy. The monetary and financial variables are classified according to the influence the Central Bank has on its evolution. The following are included within the SM group, see Table 1: (1) Monetary Base; (2) Overnight interbank Call rate; and, (3) Monetary Regulation Notes rates issued at 30,90, and 180 days.[12] These variables are highly correlated to each other, so it makes sense to perform a PCA to reduce the dimensionality of the system to be estimated.[13] Their joint evolution can be adequately represented through the first main component, since it explains a significant percentage of the total variability of the series (63%). This factor is a linear combination of the five variables, in which the monetary base has a positive weight (associated load factor), and short-term interest rates present negative ones. Therefore, a positive value of this factor, named the Strict Monetary Factor (SMF) is expected to yield an expansive bias to monetary policy, while a negative value implies a contracting bias.

Similarly, the following variables are included into the FM group: (1) Monetary Aggregate M1 (includes currency held by the public, current accounts); (2) Monetary Aggregate M1′ (includes currency held by the public, current accounts, other demand deposits); (3) Monetary Aggregate M2 (includes currency held by the public, demand deposits, time deposits); (4) Lending Bank Rates (three different by type of debtor and term); and, (5) Deposit Bank Rates (four different by terms). Table 1 offers more details. Again, the joint evolution of the variables above can be adequately represented through the first principal

[9]An instrument of monetary policy similar to the one set from 2007 to 2013 will be resumed from the end of 2020.

[10]Licandro and Mello (2012b) describe the management of monetary policy in Uruguay since the adoption of a floating exchange rate regime in 2002 and Licandro and Mello (2012a) analyze the existence and functioning of the balance sheet channel of monetary policy in a dollarized economy such as Uruguay, during the interest rate management period.

[11]The variables presented in this section are already transformed to induce stationarity.

[12]These are short-term Central Bank papers.

[13]To test that the correlations are statistically different from zero, we apply the Barlett sphericity test.

component, since it explains 57% of the total variability of the series.[14] We name this factor the Financial Monetary Factor (FMF). The different monetary aggregates have associated positive load factors, while for bank interest rates -active and passive- the weights are negative. Therefore, the interpretation is analogous to the SMF.

Finally, the third group is made up of only the bilateral NER (amount of Uruguayan pesos per US dollar), which is designated as an observable factor, as it was done with the monetary policy rate in Bernanke et al. (2005) and Blaes (2009).

The variables chosen to integrate the SM and FM groups have a clear role in two transmission mechanisms of monetary policy. These variables affect both, the channels that operate through the expectations and those linked to aggregate demand. Thus, the inclusion of different monetary aggregates and nominal interest rates, both in SMF and FMF, makes it possible to reflect the equilibrium conditions of the money market, which affect the effective inflation through the inflation expectations. In turn, by adding the bank interest rates in the FM set, we capture the impact of monetary policy on aggregate demand, which ends up having an impact on inflation as well. Finally, the NER is intended to represent the direct pass-through of the exchange rate to domestic tradable prices.

To measure domestic inflation, we use the Consumer Prices Exclusion Index (CPI eXcluding volatile and administered prices), an indicator of core inflation, which does not consider very volatile (fruits and vegetables) and administered prices. We also include the international inflation relevant to Uruguay, P^*, measured through the variation in prices in dollars of Uruguay's business partners.[15]

Thus, the FAVARMAX model's vector of endogenous variables is:

$$\boldsymbol{Z}_t = \begin{bmatrix} SMF_t & FMF_t & \Delta \ln(NER_t) & \Delta \ln(CPIX_t) - \mu \end{bmatrix}^\top ,$$

where μ will capture the monthly average inflation. The vector of shocks affecting these variables is denoted by:

$$\boldsymbol{A}_t = \begin{bmatrix} a_{1t} & a_{2t} & a_{3t} & a_{4t} \end{bmatrix}^\top ,$$

[14] To test that the correlations are statistically different from zero, we apply the Barlett sphericity test.

[15] To compute P^* we consider retail price indexes of Uruguay's main business partners (in dollars), weighted by its share in total exports and imports of goods and services. The countries included, which represent around 2/3 of total foreign trade, are Argentina, Brazil, USA, China, Mexico, Germany, Spain, UK and Italy.

where a_{1t}, a_{2t}, a_{3t} and a_{4t} represent the exogenous shocks to $SMF_t, FMF_t, \Delta\ln(NER_t)$ and $\Delta\ln(CPIX_t)$, respectively, in period t. Particularly, a_{4t} represents the short-term inflationary pressures, originated in non-monetary or exchange rate factors, which may be originated either in supply shocks (wage costs among others) or in demand shocks not linked to financing costs, both of them affected by inflation expectations. Finally, the vector of exogenous variables is $\boldsymbol{G_t} = \Delta\ln(P_t^*)$.

The recursive scheme for the Cholesky decomposition of the covariance matrix of $\boldsymbol{A}_t$ is as follows. Contemporaneously, the variables over which the Central Bank has greater control, summarized in the SMF, are only affected by their own shocks, with no impact from the rest of the variables. In turn, those variables whose evolution is determined not only by the BCU, but also by commercial banks, which can be summarized in the FMF, are affected by both, the SMF shocks and their own's, with no contemporaneous impact from the rest of the variables. The choice of this ordering of the variables is based on the fact that when the central bank manages the liquidity of the interbank market, and set its operational objectives on the variables on which it has the greatest impact, it forecasts commercial banks behaviors. The NER is located in the third place in this recursive scheme, as it is influenced by the behavior of the Central Bank and commercial banks, but also greatly affected by the international financial context (international rates, risk aversion, etc.). Thus, we expect it to be affected contemporaneously by shocks in the SMF, the FMF, and -obviously- its own shocks. The last ones represent central bank interventions in the interbank exchange market and the international financial context. NER has no contemporaneous impact from the inflation rate. When the central bank and commercial banks make decisions that impact on the trajectory of the variables of the SM and FM groups, they take into account their expectations about NER, which are largely determined by international financial conditions. Finally, the inflation rate is contemporaneously affected by SMF, FMF, and NER shocks, and by its own innovations. This approach is consistent with the idea that when the central bank moves its monetary and exchange rate instruments, it does so paying more attention to future expected inflation than to current values.

5 Empirical evidence

In this section we specify and estimate the FAVARMAX model from the data presented in Table 1. Subsection 5.1 shows and discusses the main results of the estimation and the corresponding IRF. Subsection 5.2 uses these results to build and characterize a historical decomposition of the Uruguayan inflation.

5.1 Model estimation

We specify Model (1) using the correlograms and cross-correlograms of the series, jointly with t-student tests. The model was estimated by exact maximum likelihood through its state space equivalent form. The initial values are obtained from a subspace methods estimation. For details on pre-estimation, estimation, and computational issues the reader may consult Casals et al. (2016). The autoregressive, moving average and input-related estimated polinomial matrices are the following (where standard deviations are in parenthesis):

$$\hat{\mathbf{\Phi}}_P(B)\hat{\boldsymbol{\phi}}_p(B) = \begin{bmatrix} 1+\underset{(.067)}{.12}B+\underset{(.065)}{.19}B^2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1-\underset{(.052)}{.42}B & \underset{(.042)}{.64}B \\ 0 & 0 & 0 & 1-\underset{(.076)}{.32}B+\underset{(.067)}{.16}B^2-\underset{(.066)}{.16}B^5-\underset{(.068)}{.14}B^6 \end{bmatrix};$$

$$\hat{\mathbf{\Theta}}_Q(B)\hat{\boldsymbol{\theta}}_q(B) = \begin{bmatrix} 1-\underset{(.062)}{.64}B^{12} & 0 & 0 & 0 \\ 0 & (1+\underset{(.067)}{.14}B)(1-\underset{(.065)}{.82}B^{12}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & \underset{(.005)}{.014}B^3 & \underset{(.013)}{.03}B & 1 \end{bmatrix};$$

$$\hat{\boldsymbol{\alpha}}_r(B) = \begin{bmatrix} 0 & 0 & -\underset{(.055)}{0.59} & 0 \end{bmatrix}^\top; \quad \hat{\mu}(\%) = \underset{(.038)}{0.68},$$

where some non-statistically significant parameters have already been removed. The estimates adopt the expected sign in all cases, the diagnosis of the residuals (correlogram, cross-correlogram and Ljung-Box Q-statistics) shows no sign of misspecification and does not reject the normal distribution hypothesis.[16]

The estimates reveal a seasonal behavior only perceptible in the strict and financial monetary factors (SMF and FMF). This is not surprising as some of the variables included in these factors required a seasonal difference to be stationary (see Table 1). In turn, the autoregressive structure of SMF and $\Delta \ln(CPIX)$ presents imaginary roots that correspond to damped oscillations or a quasi-cyclical behavior in the series. The detection of significant parameters in lags 5-6 of the autoregressive structure of the inflation, reflects the semiannual periodicity of salary adjustments, which has a remarkable influence on non-tradable goods prices. Additionally, the estimated mean of the inflation ($\hat{\mu}$) was positive and highly significant resulting in a 0.68% monthly inflation for

[16]We run different estimations by including additional parameters (overfitting) outside the main diagonal of the AR and MA matrices of the model, but none of them was statistically significant at a 10% level and all worsen AIC and BIC information criteria.

the sample period. The (few) statistically significant estimates outside the main diagonal of the AR and MA matrix show lagged relationships among the endogenous variables.

When looking at $\Delta \ln(NER)$, a parameter associated with the inflation of the previous month results positive and statistically different from zero, meaning that the higher the inflation for the previous month, the lower the depreciation rate for the current month. The parameter captures the reaction of the exchange rate policy to inflation.

In turn, the parameter that links the depreciation rate, $\Delta \ln(NER)$, with the relevant international inflation for Uruguay, $\Delta \ln(P^*)$, reflects the impact of the monetary and exchange rate policy of the trading partners of Uruguay on the domestic exchange market. In this sample, these two variables have a contrasted evolution -usual behavior in floating exchange rate systems- which is reflected in a negative sign in the parameter that links both variables. The inclusion of $\Delta \ln(P^*)$, an exogenous variable into the model, allows us to isolate the shocks in $\Delta \ln(NER)$ from movements that are the counterpart of international inflation.

To obtain the IRF and the historical decomposition of the endogenous variables, we express the estimated FAVARMAX model as a VMA representation and orthogonalize the errors through the Cholesky decomposition (see Section 4 for the choice of the ordering of the variables).

We estimate the Cholesky matrix, $\boldsymbol{C}$, directly by iterating on its components in the maximum likelihood function instead of doing so with the covariance matrix. The result of this estimation is (again standard deviations are in parenthesis):

$$\boldsymbol{C} = \begin{bmatrix} \underset{(.20)}{3.608} & - & - & - \\ \underset{(.184)}{1.258} & \underset{(.127)}{2.203} & - & - \\ 0 & \underset{(.108)}{.338} & \underset{(.080)}{1.429} & - \\ \underset{(.018)}{0.045} & 0 & \underset{(.018)}{0.094} & \underset{(.012)}{0.217} \end{bmatrix}.$$

The two coefficients equal to zero were imposed after performing individual significance tests, and analyzing its economic implications.[17] The estimates were 0.068 and

[17] We use the well-known result that, under regularity conditions, being $\hat{\boldsymbol{\theta}}$ the maximum likelihood estimate of $\boldsymbol{\theta}$, $\hat{\boldsymbol{\theta}}$ asymptotically follows a Normal distribution with mean $\boldsymbol{\theta}$ and covariance matrix $[\boldsymbol{I}(\boldsymbol{\theta})]^{-1}$, which is the Fisher Information matrix (whose observed version is easily computed as the Hessian matrix of the log-likelihood with respect to the parameters).

-0.0208 (with standard deviations of 0.1154 and 0.0191, respectively) for the components {3,1} and {4,2} of $\boldsymbol{C}$. This means that there is no evidence in our sample of contemporaneous direct relationship between SMF and NER shocks, nor between FMF and inflation shocks.

With all these elements we compute the IRFs, which are depicted in Figure 1 for the inflation and Figure 2 for the nominal exchange rate, which are our varaibles of interest. All the IRFs and their corresponding bootstrapped confidence intervals at 95% are presented in the Appendix, Figure 5. Figure 1 shows positive and significant impacts of shocks to all the endogenous variables on $\Delta \ln(CPIX_t)$, not surprisingly implying that a more expansive monetary policy than expected, caused by positive shocks in the SMF, FMF or the depreciation rate, will generate significant inflationary pressures that will last up to a year (12 periods). Shocks to SMF and FMF have little -but significant- effect on short-term inflation (see Figure 1 and 5), so the aggregate demand channel of monetary policy transmission seems to have little power.[18] In the short term, monetary-exchange policy affects inflation mainly through the expectations channel (reflected in the shocks to SMF and FMF, but particularly in the idiosyncratic shocks to $\Delta \ln(CPIX_t)$), and through the exchange rate channel.[19]

In turn, Figure 2 shows that shocks to FMF, a_{2t}, have also positive and significant effects on $\Delta \ln(NER_t)$ implying that higher rates of increase in monetary aggregates or falls in bank rates, both further that it was expected, yield greater increases in the NER. The negative and significant effects of shocks to $\Delta \ln(CPIX_t)$, a_{4t}, on $\Delta \ln(NER_t)$ is related to the parameter estimated in the autoregressive matrix that links the inflation of the previous month with the current variation of NER. This parameter seems to capture the reaction of exchange rate policy to lagged inflation. Although the effects of the shocks in the endogenous variables, a_{jt} for $j = 1, ..., 4$, last longer on the inflation than on the nominal exchange rate (about a year for the inflation while half a year for the exchange rate), the long-term impact is usually stronger in the latter.

[18]Bank loans in nominal pesos (local currency) only finance firms' investment in working capital and families' current expenditure, but not residential investment. In addition to this, large companies often make very short-term deposits (less than 30 days), so the overnight interbank call rate movements, by affecting deposit rates in less than a month, can also slightly affect the aggregate demand through that channel.

[19]IRFs show the impact of monetary conditions on short-term inflation. The long-term component of inflation (represented by μ in our model), is determined by the core money growth, which is defined as the growth of long-lasting component of nominal money supply that exceeds the long-run increase of the real money demand (see Gerlach, 2004; Greiber and Neumann, 2004; Gerlach-Kristen, 2007; Brum et al., 2013).

Figure 1: CPIX impulse response functions.

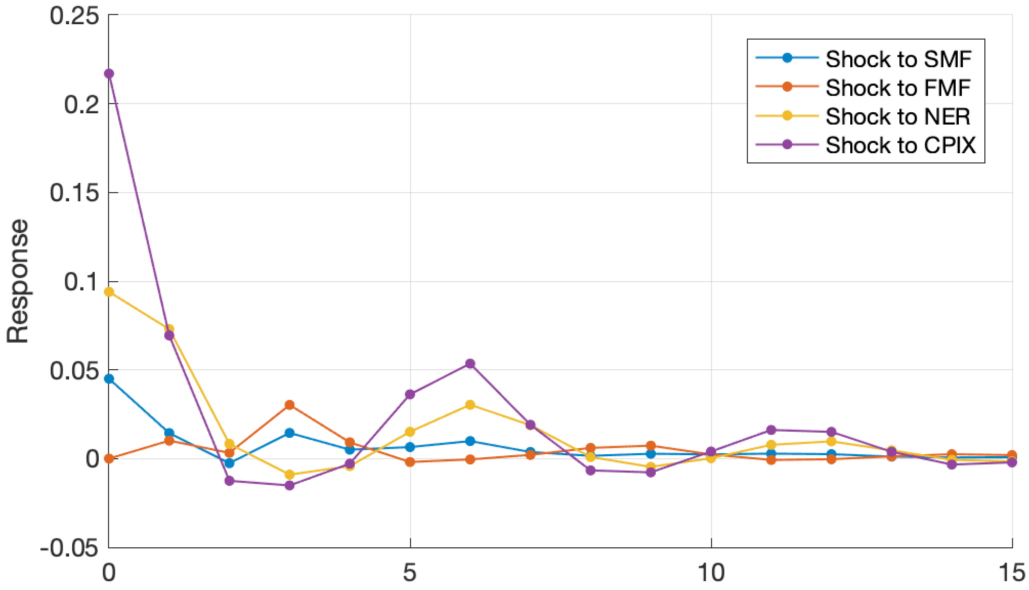
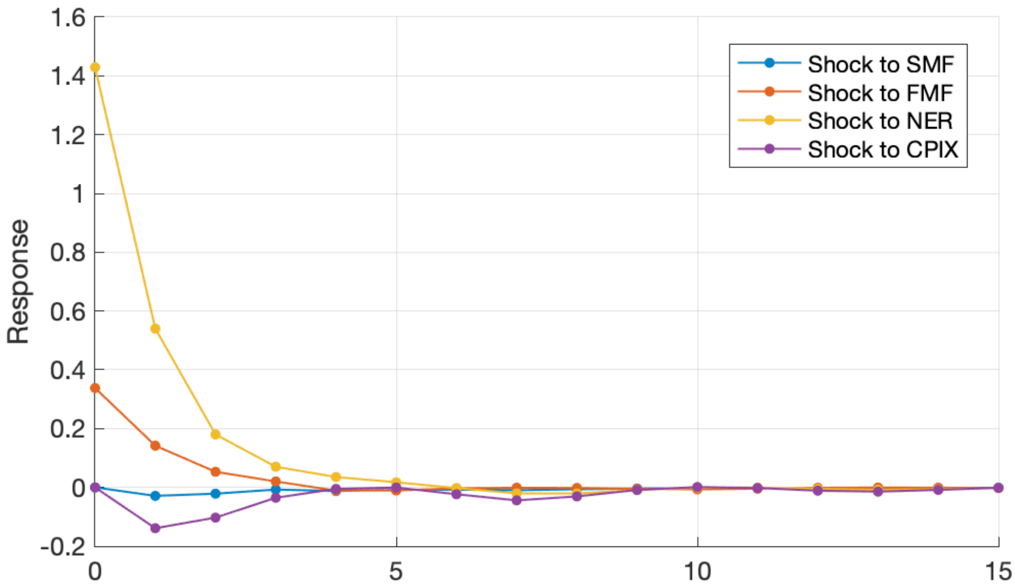


Figure 2: Nominal Exchange Rate (NER) impulse response functions.



Interestingly enough, Figure 5 in the Appendix also reveals a positive response of a shock to SMF, a_{1t}, on the FMF, meaning that if the Central Bank expands the Monetary Base (a variable that makes up the SMF) at a faster rate than expected, it will be reflected in a greater growth of the Monetary Aggregates (which make up the FMF). Similarly, if the liquidity management by the Central Bank reduces Overnight interbank call rate, or Monetary regulation note short-term rates (variables that make up the SMF) further that it was expected, it will cause a drop in bank rates, lending and deposit, which make up the FMF.

5.2 Historical decomposition of inflation

In this section we obtain the historical decomposition of the endogenous variables from the orthogonalized residuals and the estimated IRFs. The decomposition of the monthly inflation rate is of particular interest, as it will be used to calculate the proposed MCI. We compute the MCI as the sum of the effects that shocks on SMF, FMF, and NER have on inflation. Non-monetary shocks with an inflationary effect, whether from supply or demand factors, are represented in the model by idiosyncratic inflation shocks (a_{4_t} orthogonalized).

To recover the inflation data for month t, we calculate the cumulative impact of each orthogonalized shock weighted by its corresponding estimated IRF. The latter shows that the impact is usually significantly greater the closer the shock occurred to moment t. Thus, we just consider the shocks that occurred in the last forty-eight months to carry out the historical decomposition of inflation.

For the period January 2010 to September 2019, this decomposition indicates that 29% of the total variance of monthly inflation is explained by our MCI, while the remaining 71% comes from either the non-monetary components of inflation (aggregate demand shocks, margins, salary costs, international inflation, etc.), or monetary components not captured by our model. Interestingly, when the results of the monthly frequency model are aggregated, the weight of the MCI in the explanation of the variance of the quarterly inflation grows to 37%, while it reaches 53% in the semi-annual inflation. This confirms that the importance of monetary and exchange elements increases when considering longer terms, which is consistent with the hypothesis that in longer terms inflation is dominated by the monetary conditions of the economy.

Next we will characterize several sub-periods in our sample based on the impact the different shocks had on the inflation. As the Uruguay is an open and small emerging economy, its evolution is greatly affected by the global context, in emerging markets in general, and in Argentina and Brazil particularly. Therefore, the different stages also accord with the relevant external framework in each period.

2010.Q3-2013.Q1. Very favorable international financial conditions for emerging economies

From the first years of the second decade of the 21st century, once emerging markets recovered from the 2008 global financial crisis, financial conditions were generally favorable for the Uruguayan economy. Beyond specific moments, such as the quarters following the second outbreak of the Greek crisis, this scenario remained until just before mid-2013, when the president of the Fed, Ben Bernanke, announced that the Fed would begin to withdraw monetary stimulus ("Bernanke Talking").[20]

This period was characterized by capital inflows to emerging countries, pressures towards the appreciation of their currencies, falls in risk premiums paid for their titles (measured with the Emerging Markets Bond Index, EMBI), and upward trends in most international commodity prices. In this context, the BCU bought a significant amount of foreign exchange in the market, to avoid further exchange misalignment.

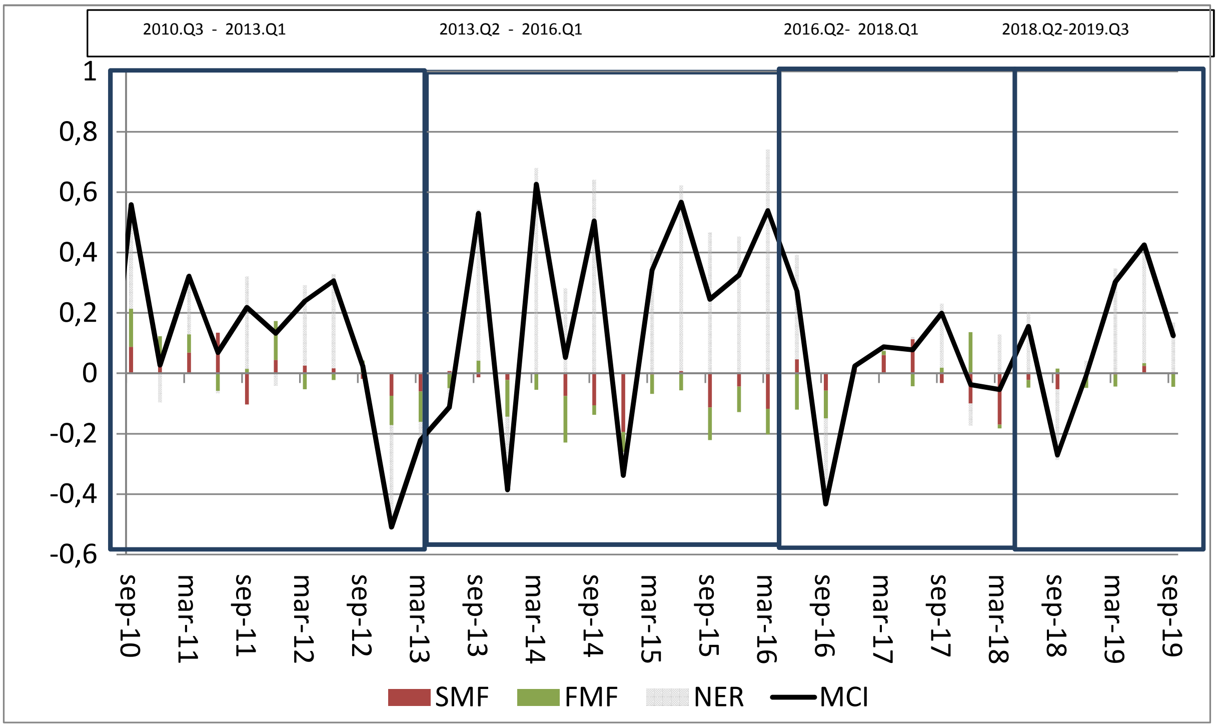
In our model, the international scenario of those years had a negative impact on NER shocks, while currency purchases had a positive impact. Thus, the NER shocks had an alternating sign. We distinguished two sub-periods. In the first one, which ended in mid-2012, the NER shocks adopted a positive net sign (see first two years in Figure 3). There were additional positive shocks on the SMF and FMF side, so the MCI showed an expansive bias during most of this sub-period. While this was partially offset by negative idiosyncratic inflation shocks (non-monetary factors), inflation in the period was above average (see Figure 4). In the second sub-period (2012.Q3- 2013.Q1), when idiosyncratic factors began to generate inflationary pressures, NER shocks began to have a negative net sign, and tightening biases were added from SMF and FMF shocks. Consequently, inflation began to subside and was similar to average levels.

2013.Q2-2016.Q1. Less favorable international financial conditions for emerging economies

With the "Bernanke Talking" in May 2013, international financial conditions for emerging economies began to be less favorable. Net capital inflows were somewhat lower, while the EMBI showed a general upward trend and the dollar tended to strengthen against the currencies of emerging countries. On the other hand, international commodity prices showed a fall. With the pause of the first half of 2014, these trends generally remained

[20] "In the next few meetings, we could take a step down in our pace of purchase,...", Ben Bernanke, United States Congress Joint Economic Committee, May 22, 2013

Figure 3: Historical decomposition of Quarterly MCI



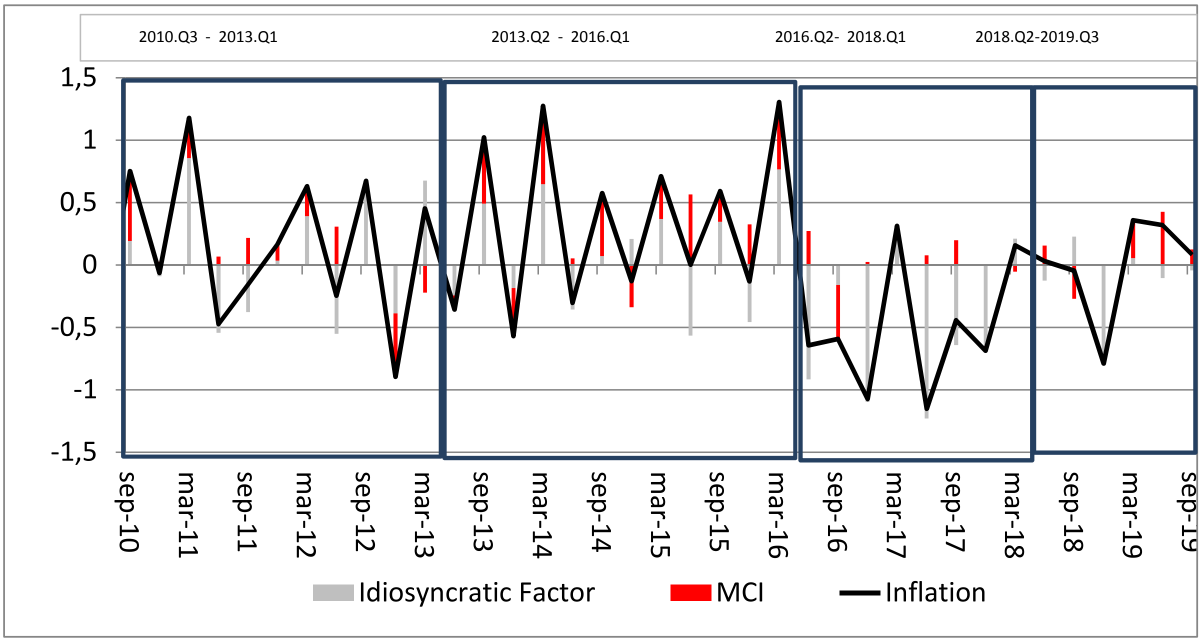
the same until the first months of 2016.

In this period there were events that generated greater risk aversion and deepened the trends of the emerging markets described above. In this regard, the devaluation of the Chinese currency (Yuan) in mid-2015, and the sharp decline in shares in that market are particularly noteworthy. In those months the situation in Brazil was also complicated, where the public debt of that country lost the investment grade, and the impeachment process of President Dilma Rouseff began, which culminated a year later. In the context of strong upward pressures from the NER from abroad, the BCU decreased dollar purchases at the beginning of this period, and since mid-2014 began to sell.[21] This was particularly important in the second half of 2015, when the problems in China and Brazil coincided.

These interventions in the foreign exchange managed to mitigate the rate of increase of the NER, although the shocks of this variable in the model were very positive anyway. Innovations in the SMF and the FMF had a contractive bias in most quarters, although the MCI had an expansive bias (see Figure 4). In addition to this, idiosyncratic shocks were slightly positive on average in this period, so inflation was above average.

[21] Always in net terms.

Figure 4: Historical Decomposition of Quarterly Inflation



2016.Q2-2018.Q1. Increased appetite for risk and return of capital to emerging economies

The announcements by the Federal Reserve of the United States that the normalization of monetary policy would be processed more gradually (Feb, 2016), and the continuity of monetary stimulus in the rest of the advanced economies, generated more favorable financial conditions for emerging economies: the EMBI began to fall steadily, while the currencies of these countries appreciated against the dollar, and the international prices of most commodities showed a growing trajectory. In this scenario, the BCU initially reduced foreign exchange sales, and since the end of 2016 has been making net purchases, which have been very significant since 2017.Q2.

As a result of the international context that generated pressures towards the exchange rate appreciation, and the interventions of the BCU operating in the opposite direction, the NER shocks were slightly positive in the period (on average). Shocks in the SMF and FMF had no significant impact, and in many quarters they had conflicting signs. While the MCI displayed a slightly positive bias, the idiosyncratic inflation factor operated in a markedly deflationary manner (greatly influenced by wage moderation), and so, as shown in Figure 4, the variation in the CPIX was well below the average.

2018.Q2-2019.Q3. New problems in emerging economies

During this period, the greater risk aversion at a global level, largely explained by the trade war between the United States and China, again worsened the financing conditions for emerging economies, with increases in the EMBI, depreciation of their currencies, and falls in commodity prices, particularly during 2018.

In addition to this global framework, there were specific problems in Argentina, one of the emerging economies with weaker foundations, and with a great weight in terms of expectations in Uruguay. In this period, there were three currency crises in that country, which generated strong upward pressures in the domestic NER. The BCU sold significant amounts of foreign currency, but the NER shocks were positive in almost all quarters. However, the handling of other policy instruments and the behavior of the banks led to innovations in the SMF and the FMF presenting a contractive bias.

As a result of these two opposite effects, our MCI had a slightly contractive bias in the last three quarters of 2018, and an expansive bias in the first three of 2019. On the other hand, idiosyncratic inflation shocks operated in a downward sense in most quarters of the entire period, surely as a result of wage moderation and the slowdown in domestic demand. Therefore, inflation was below the average between 2018.Q2 and 2018.Q4, and above it between 2019.Q1 and 2019.Q3.

6 Conclusions

The instability of the relations among the different interest rates, these with the monetary aggregates, and both groups with the nominal exchange rate, generates the need to build a multivariate indicator that reflects the global position of monetary policy. Since the 2008 international financial crisis, these difficulties have also reached the advanced economies, although they are particularly relevant in emerging, small and dollarized economies, where the simultaneous use of multiple monetary and exchange instruments adds to the imperfections of financial markets and strong exposure to external shocks.

The purpose of this paper is to build a multivariate indicator of monetary bias in which the monetary and financial variables are weighted according to the impact they had on inflation in each period, for emerging and dollarized economy: Uruguay. To this end, the variables are grouped into: (i) Strict Monetary (SM) variables, which are those over which central banks have greater control, (ii) Financial Monetary (FM) variables, which are those whose evolution is determined also by commercial banks acting as secondary creators of money, and (iii) Nominal Exchange Rate (NER), which is influenced by the Central Bank and commercial banks, but also very much affected by the international financial context (international rates, risk aversion, etc). With these groups of monthly variables and the international prices, as an exogenous one, we estimate a Factor Augmented AutoRegressive Moving Averages vector model with eXogenous variables (FAVARMAX) model for Uruguay during the period February 2006 to September 2019.

We use our model to propose a Monetary Conditions Indicator (MCI), where shocks on the SMF, FMF and NER are weighted according to the impact they have on inflation. The MCI is useful in two regards. First, we find that our MCI explains 29% of the total variance of monthly inflation for the period January 2010-September 2019. When the results are aggregated, it explains 36% of quarterly inflation, and 53% of semi-annual inflation. Second, the MCI allows us to characterize the inflation of Uruguay from a monetary and exchange policy viewpoint. This analysis shows that, within the MCI, shocks to the NER have had a greater preponderance during the present decade, and their trajectory has been greatly affected by external events, and by the interventions of the BCU in the exchange market. Since 2018, the Uruguayan economy has received strong positive shocks from the NER due to both, global events and regional factors. To mitigate the inflationary effect, the BCU sold significant amounts of foreign currency, to which a contractive bias was added from the rest of the monetary and financial variables (SMF and FMF). On the other hand, idiosyncratic inflation shocks showed a downward trajectory likely as a result of wage moderation and the slowdown in domestic demand.

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Figure 5: IRF of the endogenous variables. The shaded area represents the 95% bootstrapped confidence interval.