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International Spillovers of Monetary Policy

Editors:
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Alberto Ortiz Bolaños

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PREFACE

Since 2005 CEMLA's Central Banks have conducted joint research activities to bolster economic research on topics of mutual interest. Annual or multiannual joint research activities have been developed in the following topics: *i)* Estimation and use of nonobservable variables in the region; *ii)* The development of dynamic stochastic general equilibrium models; *iii)* The transmission mechanism of monetary policy; *iv)* Economic policy responses to the financial crisis; *v)* Inflationary dynamics, persistence and price and wage formation; *vi)* Capital flows and its macroeconomic impact; *vii)* Asset pricing, global economic conditions and financial stability; *viii)* Monetary policy and financial stability in small open economies; *ix)* Monetary policy and financial stability; *x)* Monetary policy and financial conditions; and *xi)* Households' financial decisions.

These topics cover most of central banks' main tasks and the developments and changes introduced since 2005. In this respect, the response of central banks in advanced economies to the global financial crisis, basically low interest rates and unconventional policies, marked a radical change in the traditional approach to monetary policy. Among other things, concerning for example objectives and instruments, the idea that a central bank can abstract from the consequences that its decisions could have on other economies was clearly called into question. Along these lines, the crisis gave also rise to a growing interest to understand the international spillovers of monetary policy.

In this context, in the 2014 Meeting of CEMLA's Research Network, CEMLA's Central Banks decided that starting in 2015 they would conduct joint research on international spillovers of monetary policy. The Associate Directorate General International Affairs of Banco de España, with technical assistance from CEMLA, coordinated this joint research. Researchers from the Central Banks of Brazil, Chile, Colombia, Costa Rica, Dominican Republic, England, Europe (European Central Bank), Guatemala, Jamaica, Mexico, Peru, Spain and Uruguay participated in the activities of this joint research. Research work was supported by webinars of academic specialists, virtual meetings where research progress was presented, a workshop at CEMLA, presentations and discussions at the 2015 CEMLA Research Network Meeting hosted by the Banco Central de República Dominicana and an internal blind review process. The documents that integrate this book represent a memoir of the work done by this group of researchers and it gives a comprehensive analysis of the spillover effects of US monetary policy in Latin America and the Caribbean. This book, in line with CEMLA's objectives, promotes a better understanding of monetary and banking matters in Latin America and the Caribbean.

Fernando Tenjo Galarza
General Director
CEMLA

EDITORS

Ángel Estrada García

He currently works as Executive Coordinator of International Affairs at the Banco de España. Among others, he is responsible for defining and supervising the department's research agenda.

Ángel Estrada has a long research experience, having published articles in specialized journals such as IMF Economic Review, Journal of Financial Stability or Series. At present, its areas of research are global imbalances and different aspects of macroprudential policies.

Most of his professional career has developed in different departments of the Banco de España. Initially he was responsible for the short/medium-term developments of the Spanish economy, including forecasts. At that time, he developed various models of forecasting and simulation of the Spanish economy to different horizons. Afterwards, he specialized in the long-term challenges of the Spanish economy, building tools to assess the impact of different structural reforms.

In the following years, he left the Banco de España to be advisor to the President of the Government of Spain. There, he was responsible for the coordination of policies aimed at enhancing the productivity of the Spanish economy. Subsequently, he was appointed Director General of Macroeconomics and International Economics at the Ministry of Economy and Finance. In that position he had to draw up yearly the Stability Program for the Spanish economy, evaluate the National Reform Program and represent Spain in various international economic forums such as the European Union, the OECD and the G20. Upon his return to the Banco de España he worked on the implementation of operational aspects related to macroprudential policies, before joining the Associate Directorate General of International Affairs.

Ángel Estrada holds a Master degree in Monetary and Financial Economics from the Center for Monetary and Financial Studies (CEMFI) and a degree in Economics and Business from the Universidad Complutense de Madrid.

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His main research areas are *1)* the study of macrofinancial linkages; *2)* the measurement of the sources of economic fluctuations in emerging markets; and *3)* the analysis of macroeconomic and financial regulation policies.

Among others phenomena, he has analyzed the economic consequences of credit market imperfections and the role of monetary policy and credit contract indexation in economic stabilization; has compared the relative importance of domestic and foreign factors in emerging market economic fluctuations and the role and interaction of monetary and fiscal policies for economic outcomes; and has also studied the determinants of capital buffers in a panel of more than 7,000 banks across 143 countries and he has analyzed the role of banks' net stable funding ratio in explaining future financial instability.

At CEMLA, Dr. Ortiz conducts research in the above mentioned areas, coordinates conferences, seminars, courses and research related activities. A big part of his efforts are aimed at supporting the coordination of research activities among central bank researchers from CEMLA's membership, including: the Joint Research program, the internship program and the on-line research seminars.

Regarding his academic activies, Dr. Ortiz has taught courses on Microeconomics of Banking, Market Failure in Financial Markets, Macroeconomic Theory, Money and Banking, Open Macroeconomics, Economic Development, Mathematical Methods for Economists, Economic Environment of the Organization, Fundamentals of Global Business, Fundamentals of Economics and International Financial Policy at Boston University, Oberlin College and Harvard University.

He earned his Ph.D. in Economics from Boston University in 2009, having previously acquired a Master Degree in Political Economy at the same institution and a Bachelor Degree in Economics from the Centro de Investigación y Docencia Económicas (CIDE) in 2002.

Introduction

Ángel Estrada García
Alberto Ortiz Bolaños

The current tasks of central banks officials have become much more complex than they used to be before the Great Recession. Not only new possibilities have been added to the toolkit of the policymaker (quantitative easing, forward guidance, among others), but also the international dimension seems to be more relevant now. On the one hand, before the Great Recession, monetary policy was implemented exclusively through changes in official interest rates in order to meet some established domestic objectives in the long run: price stability and, for some central banks, maximum employment. Interest rates affect business and household decisions through changes in liquidity and the assets portfolio; thus, the challenge for the monetary authorities was to determine the magnitude of the tightening or relaxation of monetary conditions, minimizing the uncertainty for other domestic agents on the path that these financial conditions will follow.

On the other hand, in normal times, central banks in each country make their monetary policy decisions solely in response to their domestic conditions and, according to some scholars, this was the best way to stabilize global demand. Traditionally, it was considered that trade was the main transmission channel of a central bank's decisions to the rest of the world.

Thus, as a monetary tightening (relaxation) in a particular country reduces (increases) its GDP, it also diminishes (increases) the external demand from the rest of the world. Obviously, the other countries would be more or less affected depending on the intensity of their trade linkages.

However, it is possible that the growing globalization of financial markets has increase the relevance of the financial channel. This process of financial globalization has very well-known gains, among them a more efficient allocation of financial resources around the world and an improved risk-sharing. Nevertheless, it has also generated closer and faster interlinkages among economies. This probably implies that the effects of policy actions in one country to the rest of the world are stronger today than they used to be. In fact, after the Great Recession some central banks have expressed concerns about their ability to influence domestic interest rates as a result of the so-called global financial cycle even in the presence of flexible exchange rate regimes.

The financial channel operates mainly through changes in capital flows and the prices of the different financial assets, transmitting the liquidity conditions globally. Gross cross-border capital flows surged by a multiple of four in the two decades up to the global financial crisis in 2008. In fact, by that time capital flows to advanced economies reached a value equivalent to 25% of their aggregate GDP and those to emerging economies over 10% of their aggregate GDP (7% for Latin America). Capital flows showed significant shifts in composition over time, gaining relevance those among banks, in line with the growing importance of global banks. A tightening (relaxation) of the monetary policy in a given country will induce a capital outflow (inflow) in the rest of the world, which will have an impact in the price of the external financial assets.

Besides, the exchange rate also reacts when the stance of monetary policy changes in a context of free capital movements. In particular, it is expected that a tightened (relaxed) of monetary policy appreciates (depreciates) the currency of that country as a result of the increase in the yields of the assets denominated in that currency. This would mean gains in the rest of the world competitiveness, counteracting to some extent the impact of the trade channel. Besides, long-term interest rates in other countries can also be affected by changes in those of the country that is taking monetary policy decisions.

However, there is great uncertainty about the magnitude of these impacts and their dynamics. Specifically, interest rates of the public debt often show a high correlation between countries, but in addition to moving in response to monetary policy actions and/or expectations in other countries, they also do so in response to changes in other macro variables such as the expected behavior of growth or inflation at the global level. In the same way, and given the degree of financial integration between countries, long-term interest rates in other economies will react to an increase in rates in another country depending on investors' perception of risk. It is therefore crucial to determine whether the transmission between countries of monetary policy shocks is different depending on the situation in those countries.

United States is the world's largest economy by the size of its GDP; moreover, it is the centerpiece of the international financial system and the dollar is the main global reserve currency. Therefore, it is not surprising that most of the empirical analysis on the effects of the international transmission of monetary policy has focused on the decisions of the Federal Reserve (Fed). Notice that these factors are even more relevant for Latin America, as the US is its main trading partner and foreign investor. Now that the Federal Reserve has initiated the process of monetary policy normalization, it is of paramount importance to determine how this is going to affect the different economies.

The empirical evidence before the Great Recession, when the main monetary instrument was the official interest rate, indicates that US monetary disturbances have a significant effect in the rest of the world but with differences in the spillovers among countries, being higher in Latin America or Asia than in Europe. These results suggest that the exchange rate channel is more important than the commercial one, and that the structure of financial markets in each country determines the magnitude and dynamics effects of the shock.

However, these are average results. Focusing on past episodes of monetary tightening by the Federal Reserve, singularities can be seen in the spillovers to the rest of the world, suggesting the need to control for the circumstances in which they occur. In particular, the 1994-1996 episode produced the biggest contagion. The impact on financial markets was unexpected and of great magnitude, with an increase in bond yields in most advanced economies. Emerging markets saw a sharp increase in risk perception, a depreciation of their currencies and falling prices of other assets. By contrast, during the 2004-2006 period of monetary tightening, uncertainty was reduced, long-term interest rates diminished and even the dollar depreciated.

Since late 2008, the central banks of the major advanced economies have embarked on the implementation of unconventional monetary policy measures once the official interest rates reached the limit of 0%. These measures can be classified into two groups. First, financial assets purchase programs, which intend to reduce the yields of public or private instruments in the medium and long term. The key transmission channel in this case is the recomposition of portfolios of investors, which replace instruments of different degree of liquidity, risk and term. Obviously, this channel also acts globally, especially in the case of the US, as their Treasury bonds play a pivotal role in the international financial markets and dollar-denominated assets are part of the portfolio of most investors. Another identified channel, the confidence, could also operate internationally.

The second category of unconventional monetary policy measures is the forward guidance, which aims to signal the tone of monetary policy in the future. The goal is to reduce uncertainty about the path of official interest rates in the future and, thus, reduce the term premium. As US plays a central role in the international financial system, this could also reduce the term-spread around the world.

Obviously, the empirical evidence is scarcer in this case, as the experience is still reduced. However, it tends to show that the actions adopted by the Federal Reserve reduced long-term rates of emerging and developed economies, increasing demand for assets with higher returns. Also, a positive effect is observed in the flows of capital to these economies, jointly with currency appreciations. Obviously, this has also made to resurge the interest in the tools to manage capital flows. The empirical analysis put much emphasis on the need to differentiate the effects of the various programs of unconventional monetary expansion in the US (and the announcement of the end of the purchases in 2013), to identify the channels through which these policies act and to determine the characteristics of the countries that make spillovers more or less intense.

The process of normalization of monetary policy in the US started some years ago, in 2013, when Fed's officials begin talking about the possibility of tapering the securities the central bank was buying in the financial markets. This only possibility generated important turbulences in the capital flows, with a clear reduction in those directed to emerging economies but differentiating depending on domestic conditions, and important increases in long run interest rates. After numerous clarifying interventions by the Fed, turbulences receded and, finally, by the end of 2014 the third financial assets purchase program was closed. It was necessary to wait for more than one year, until December 2015, to see the first increase in official interest rates in the US. The second increase took place one year later, in December 2016. The unusual slowness in the current process of monetary policy tightening relates to various factors. For example, inflation was below the target and, in fact, inflation expectations seem anchored according to surveys, but not so, by that time, according to financial markets. Besides, there were some doubts on the current stance of the labor market, even taking into account the reduced unemployment rate. Not less, there was some evidence on the reduction of the equilibrium real interest rate.

The situation changed very quickly when the presidential candidate Donald Trump won the elections by November 2016. Financial markets, probably incorporating in their prospects the expansionary fiscal program presented by this candidate during the campaign, reflected an increase in long run interest rates, which transmitted worldwide. In the case of emerging economies, not only interest rates increased, but also spreads, have been showing a contraction in capital flows similar to those observed during the tapering talk period. Although in the last few months, the situation has calm down substantially, with flows coming back and spreads diminishing, the analysis seems to have greater importance now. The Fed announced they will continue with the process of normalization of monetary policy at a faster path than before and, for the first time after the Great Recession, this view is also shared by the financial markets. However, provided the uncertainty that still surrounds the fiscal plans of the new US administration, the risks are on the side of higher monetary policy tightness.

This book tries to add evidence on the international transmission mechanism of monetary policy, focusing on emerging countries and, particularly, in Latin America. The book is eclectic in the sense that it uses various methodologies, analyzes the effects on different variables (real, financial, prices) and for a number of countries. But it has the same common thread, the effects in the rest of the world of the various nonconventional monetary programs implemented by the Federal Reserve of the United States.

The book group the nine papers finally published here in three sections. The first one tries to disentangle the main theoretical channels of the international spillovers of monetary policy. It includes three papers that make use of advanced dynamic stochastic general equilibrium models (DSGE) to analyze these channels in three economies, Mexico, Chile and Costa Rica, whose main difference is the degree of integration, in financial and also trade terms, with the US economy.

The first one, *The Transmission of US Monetary Policy Normalization to Emerging Markets*, was written by Kólver Hernández while he was working for CEMLA. This paper uses a two-country DSGE monetary model, with several real and financial channels needed to capture the international transmission of shocks, to analyze the potential macroeconomic effects for the Mexican economy in response to an increase in the US monetary policy rate. Based on the real model of Hernández and Leblebicioğlu (2016),[1] extended with monetary factors and estimated with quarterly data for Mexico and the US from 2001Q1 to 2015Q2, Hernández describes the transmission mechanisms and performs an out-of-sample forecast for scenarios where the US interest rates rises. Hernández's model describes that an expansionary US preference shock, which through demand increases US GDP, puts pressure on US inflation and leads the Federal Reserve to increase interest rates. This demand-side preference shock would, through the higher US demand for Mexican goods and the peso depreciation, increase Mexican GDP, inflation, and lead to an increase in the Mexican interest rates. Meanwhile, a positive US technology shock increases US GDP and lowers US inflation and US real interest rates, which by lowering Mexican financial costs, increases Mexico's GDP, reduces Mexico's inflation and appreciates the peso. Furthermore, a pure contractionary US monetary policy shock lowers US inflation, causes peso depreciation and generates inflationary pressures in Mexico leading to a contractionary increase in Mexican interest rates. The forecasting exercise predicts that an increase in US interest rates is likely to take place under a recovery of US economic growth, which will imply a positive externality through US demand for Mexican goods, but that would require an aggressive response of

1 Hernández, K., and A. Leblebicioğlu (2016), *The Transmission of US Shocks to Emerging Markets*, mimeo., CEMLA.

Mexico's policy interest rate to contain the depreciation of the real exchange rate and stabilize inflation.

The second paper goes further as it tries to analyze empirically the relevance of the spillovers. In particular, in *Reassessing the Effects of Foreign Monetary Policy on Output: New Evidence from Structural and Agnostic Identification Procedures*, Jorge Fornero, Roque Montero and Andrés Yany, from the Banco Central de Chile, compare the impulse response functions of a recursive VAR model, an agnostic VAR model and a DSGE model to analyze the propagation of a foreign monetary policy shock over the Chilean economy. Based on the Banco Central de Chile core DSGE model, this chapter shows that a tightening of foreign monetary conditions causes capital outflows from the domestic economy, an increase in its country risk premium and nominal and real exchange rate depreciations. Within the DSGE model, the presence of inflationary pressures associated to the exchange rate movements prompts the domestic central bank to raise interest rates, which contracts investment and consumption. They find that the recursive VAR model does not properly identify the shock and that it gives counterfactual responses of inflation and investment. Meanwhile, the agnostic VAR model does identify the shock and have impulse response functions in line with macroeconomic theory. A point to note is that despite a sharp depreciation of the domestic currency, the agnostic VAR model shows no impact over domestic prices due to the strong drop in economic activity, while the estimated DSGE model has an increase in prices as the depreciation prompts an expansion of output. Therefore, monetary policy prescriptions based on the agnostic VAR would call for leaving the interest rate unchanged, while the inflationary pressures captured in the DSGE model requires the central bank to raise interest rates.

In *The Effect of International Monetary Policy Expansions on Costa Rica,* José Pablo Barquero, from Banco Central de Costa Rica, and Pedro Isaac Chávez López, at the time working for CEMLA, study if the international monetary policy has a major effect on the Costa Rican economy. The analysis is performed estimating a structural Bayesian Vector autoregression (SBVAR) and a dynamic stochastic general equilibrium (DSGE) small open economy model with Bayesian Maximum Likelihood methods using data from 2000 to 2014. The SBVAR estimation provides evidence that shocks to US interest rates, US inflation and US output in conjunction accounts for the following share of fluctuations: 43.2%, of nominal exchange rates, 52.2% of

Costa Rican interest rates, 35.1% of Costa Rican inflation and 51.4% of Costa Rican output. The DSGE model describes the mechanisms through which the local and foreign disturbances affect Costa Rica.

The common element of the second section of the book is that the spillovers of US monetary policy to various countries are studied and compared, analyzing if there are country specific characteristics which explain the differences observed. Each of the three papers focus in different aspects of the economy: financial market variables, capital flows and macroeconomic aggregates.

Thus, Fructuoso Borrallo, Ignacio Hernando and Javier Vallés, from the Banco de España, perform an event analysis study in *The Effects of US Unconventional Monetary Policies in Latin America* with financial market variables. Using daily data from October 1, 2008 to April 24, 2015, this chapter documents that quantitative easing (QE) announcements in 2008/2009 and the *tapering talk* in 2013 affected sovereign yields, the exchange rate and the stock market prices in a set of emerging market countries. The event study analysis is complemented with a monthly panel data setup to study the effect of country-specific fundamentals on the transmission channel of US financial disturbances. Inflation, CDS spread, official reserves ratio and market capitalization are determinants of emerging market economies' vulnerabilities to US monetary policy announcements.

A different focus (capital flows) and methodology (panel data) is considered in the second paper of this section. In *Have QE Programs Affected Capital Flows to Emerging Markets?: A Regional Analysis*, Claudia Ramírez and Miriam González, from Banco de México, use a panel of 15 emerging market economies to analyze the determinants of gross capital flows in the 2005Q1-2015Q1 period. Their analysis incorporates real monetary policy rate and economic growth differentials of each of the 15 emerging market economies relative to the US levels as pull factors attracting capital inflows. In addition, to measure the impact of US QE programs on capital flows, the authors use treasuries purchases and 10-year interest rates, which together with the VIX index, introduced as a proxy for global risk aversion, are the push factors expelling capital out from advanced economies. A dummy variable identifying the period of QE stimulus from 2008Q4 to 2015Q1 is introduced alone and interacted with the 10-year interest rate. Overall, the results show that external factors are an important driver of total and portfolio capital flows, but the results are not significant for foreign direct investment. Based on their analysis, since the first QE program was implemented, capital flows as a percentage of GDP have increased 19.5% and portfolio investment 11.8%. A 1% increase in the treasuries purchases increase capital flows by 8.8% and portfolio investment by 2.7%. A 1% decrease in the US 10-year interest rate leads, on average, to a 2.2% increase in gross capital flows and 0.7% increase in portfolio flows. An increase in risk aversion is associated with capital outflows from emerging market economies. Of the pull factors, per 1% GDP growth that the emerging market economy exceeds US growth rate, capital flows as a percentage of GDP increase on average 0.7%, while the real monetary policy rate even though positive, it is not significant.

The third paper in this section compares the response of macroeconomic variables in the countries of Central America using country specific VAR models. In particular, in *The Effects of US Monetary Policy on Central America and the Dominican Republic*, Ariadne M. Checo, Salomé Pradel and Francisco A. Ramírez, from the Banco Central de la República Dominicana, use a factor augmented vector autoregressive (FAVAR) model with sign restrictions to estimate the impact of US monetary policy shocks on the eponymous economies. The results provide evidence that an unexpected increase in the US shadow federal funds rate causes contractions in output, exports and imports for each of the analyzed economies, while interest rates and the risk premium increase, with limited effects on inflation. For these economies, nominal and real exchange rate adjustments are not significantly different from zero, reflecting what the authors interpret to be a limited role of the exchange rate as a shock absorber. Finally, this increase in monetary policy shocks leads to a contraction in US industrial production which produces a negative outflow of remittances to Central America and the Dominican Republic.

Finally, the third section is reserved for individual country's analysis of Brazil, Jamaica and Uruguay. Again, the three papers considered here are relatively heterogeneous in terms of the variables analyzed and the methodology used.

In the first place, João Barata R.B. Barroso from the Banco Central do Brasil, author of *Quantitative Easing and Portfolio Rebalancing Towards Foreign Assets*, provides evidence that QE programs caused US investors' portfolio rebalancing towards foreign assets in emerging market economies. Taking advantage of a comprehensive dataset of monthly Brazilian capital flows from January 2003 to March 2014, this chapter disentangles the QE programs effects by comparing the differentiated portfolio's compositions of US investors, more affected by the QE programs, relative to that of investors from the rest of the world. Estimates show that additional flows due to QE programs range from 54 billion USD to 58 billion USD, which represent 54% of US flows and 10% of total flows to Brazil accumulated over the period. The effect on portfolio flow ranges from 41 billion USD to 48 billion USD and on portfolio debt flow ranges from 28 billion USD to 31 billion USD. The data also allows the author to directly measure the impact on the banking sector where the effect on portfolio flow ranges from 10 billion USD to 12 billion USD and on portfolio debt flow ranges from 6 billion USD to 7 billion USD.

Turning again to the effects of US monetary policy spillovers on macroeconomic variables using VAR methodologies, André Murray, from the Bank of Jamaica, has contributed to the joint research with the paper *Investigating Monetary Policy Spillovers from the United States of America to Jamaica*. He uses a structural vector autoregressive (SVAR) model to quantify the responses of Jamaican interest rates, inflation, GDP and the bilateral exchange rate versus US in response to US monetary policy shocks and Jamaican monetary policy shocks, domestic inflation shocks and exchange rate depreciation shocks. This chapter uses the method developed by Lombardi and Zhu (2014)[2] to derive a shadow policy interest rate for Jamaica and contrasts the dynamics of the SVAR when using actual and shadow interest rates reaching the conclusion that the use of the shadow interest rates generates impulse response functions that are more consistent with intuition. The results show that an unexpected increase in US shadow federal funds rate causes an initial increase in the Jamaican interest rates and a Jamaican dollar weakening, while GDP and inflation exhibit moderate contractionary responses. In response to an unexpected increase in Jamaican shadow interest rate, inflation decreases, there is a moderate expansion and a Jamaican dollar depreciation. In response to a Jamaican inflationary shock, the shadow interest rate increases, the Jamaican dollar depreciates and GDP contracts. Finally, in response to a currency depreciation shock, the interest rate increases, inflation surges and GDP expands.

In *Impact of International Monetary Policy in Uruguay: A FAVAR Approach*, Elizabeth Bucacos, from Banco Central del Uruguay, uses

[2] Lombardi, Marco, and Feng Zhu (2014), *A Shadow Policy Rate to Calibrate US Monetary Policy at the Zero Lower Bound*, BIS Working Papers, No 452.

Factor Augmented Vector Autoregressive (FAVAR) models and data from 1996Q2 to 2014Q4 to analyze the effects of changes in US monetary policy on the Uruguayan economy. The study carries out a two-stage analysis: in the first stage the impact of US monetary policy on commodity prices, US output and regional output is measured; in the second stage the effects on real exchange rate, Uruguayan assets and Uruguayan output are analyzed. An unexpected increase in US monetary policy rates increases Uruguayan interest rates and country-risk premium, while it reduces external demand, commodity prices and Uruguayan asset prices and output. Historical shock decomposition of the Uruguayan output growth shocks show that US monetary policy shocks have had a fairly large importance on Uruguayan expansions and recessions.

The Transmission Mechanism of International Spillovers of Monetary Policy

The Transmission of US Monetary Policy Normalization to Emerging Markets

Kólver Hernández

Abstract

In this chapter, I analyze the potential macroeconomic effects of the normalization of US monetary policy for emerging market economies (EMEs), in particular for Mexico. I build on the work of Hernandez and Leblebicioğlu (2016) by adding monetary elements to their two-country DSGE model that endogenizes multiple transmission channels for the transmission of international shocks. Among those channels are the exchange rate, international bank lending, international trade and monetary policy rates. Based on a Bayesian estimation of the deep parameters of the model, I simulate scenarios that yield an equilibrium in which US monetary policy rate would increase in the last two quarters of 2015. The underlying conditions that promote the normalization of monetary policy in USA imply favorable growth of around 2.4% in GDP and an average increase of 25 basis points in US policy rate. For Mexico, those conditions carry positive international spillovers that result in an average GDP growth of 2.8%. The increase in US rate calls for a response in Mexico's policy rate in more than one to one, i.e., it calls for an aggressive response. Mexico's policy rate hike contains the depreciation of the exchange rate and stabilizes inflation.

Keywords: emerging market business cycles; transmission of foreign shocks; estimated two-country model; international transmission of monetary policy.

JEL classification: E32, F41.

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1. INTRODUCTION

Through the lenses of a two-country dynamic stochastic general equilibrium (DSGE) model, this chapter analyzes multiple underlying conditions that yield an equilibrium in which USA normalizes its monetary policy by increasing the Federal Reserve funds rate. The question that I address is: What those conditions imply for emerging markets and in particular for Mexico? I build on the real business cycle model developed by Hernandez and Leblebicioğlu (2016) to add monetary features. The model features several channels for the international transmission of shocks, among them: the exchange rate channel, international bank lending, capital flows, USA and EME policy rates, and international trade. As shown first in Hernandez and Leblebicioğlu (2016), those channels are crucial to capturing the international transmission of shocks. In sharp contrast, Justiniano and Preston (2010) show that an estimated *standard* small open economy model fails to capture the international transmission of shocks from USA to a small open economy –Canada in that case.

In order to discipline the multiple channels modeled I use 20 time series from 2001Q1 to 2015Q2 for USA and Mexico to estimate the model. The model in-sample predictions are in line with the data. In particular, the model addresses very successfully the Justiniano and Preston (2010) criticism of estimated DSGE models in that this model predicts cross-country correlations consistent with the data.

With the purpose of produce *policy normalization* scenarios, I use the estimated model to simulate millions of paths for the full economy for the last two quarters of 2015 –which are out of sample. Then from the simulated paths I only consider those in which USA interest rate increases in one or both quarters. In the average policy normalization scenario, the model predicts conditions in USA that lead to a policy rate increase of 25 basis points jointly with an average growth of 2.4% in 2015. For Mexico those conditions imply a growth of 2.8%. The increase in US rate calls for an increase in Mexico's policy rate. Mexico's policy rate hike contains the ongoing depreciation of the real exchange rate and stabilizes inflation.

The rest of the chapter is organized as follows: Section 2 presents the two-country monetary DSGE model, Section 3 shows the scenario analysis and Section 4 concludes.

2. THE MODEL

In this section, I show the main ingredients of the two-country DSGE monetary model. The economy features domestic (EME) and foreign (US) households, two sectors of final goods producers (tradable and nontradable) in each economy. Following Christiano et al. (2014) it also features a capital owner, entrepreneurs and a financial intermediary, additionally it has a fiscal and a monetary authorities.

2.1 Households

Both the domestic and foreign households supply labor to the tradable and non-tradable sectors and trade bonds with the rest of the world. The preferences are of the GHH—Greenwood et al. (1988) type:

1
$$U=\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\frac{\xi_{C,t}\left[C_t-\varphi C_{t-1}-\frac{\vartheta}{1+\eta}L_t^{1+\eta}\right]^{1-\varsigma}-1}{1-\varsigma},$$

where C_t is consumption, L_t is labor, $\xi_{C,t}$ is a preference shock, $\varphi\in(0,1)$ is a habit parameter, η determines the Frisch elasticity, and ϑ is a preference parameter. The composite labor L_t is a CES basket with labor in the tradable sector $L_{T,t}$ and labor in the nontradable sector $L_{NT,t}$ with the elasticity of substitution χ. The consumption basket, C_t, is defined by a CES aggregator for the tradable consumption basket $C_{T,t}$ and the nontradable consumption basket $C_{NT,t}$ with the elasticity of substitution θ. In turn, the CES tradable consumption basket is formed by consumption of the foreign good $C_{F,t}$, the domestic good $C_{H,t}$ and a consumption good that comes from the rest of the world $C_{O,t}$. The elasticity of substitution across tradable goods is v.

Households trade risk-free bonds with the rest of the world B_t^o. The budget constraint is

2
$$C_t+B_t^o+\frac{\varpi}{2}\left(B_t^o-\bar{B}^o\right)^2=w_{T,t}^*L_{T,t}+w_{NT,t}^*L_{NT,t}+\frac{R_{t-1}^oB_{t-1}^o}{\pi_t}+\Omega_t-T_t,$$

where $w_{T,t}^*$ and $w_{NT,t}^*$ are the wage rates, T_t denotes lump-sum taxes, Ω_t is lump-sum payments to the households. Bond holdings are subject to quadratic costs of adjustment $\frac{\varpi}{2}\left(B_t^o-\bar{B}^o\right)^2$. The household chooses

$\left\{C_t, L_t, L_{T,t}, L_{NT,t}, B_t^o\right\}_{t=0}^{\infty}$ to maximize Equation 1 subject to the budget constraint, Equation 2, the labor and consumption composites, and a no-Ponzi-game condition.

2.2 Firms

There is a continuum of firms with mass one in each sector. They can be indexed by $z \in [0, 1]$. Firms are monopolistic competitive and set prices subject to a Calvo pricing scheme, i.e., firms can change prices only when they receive a random signal that arrives with probability (1−C) in every period. In the periods when the producer does not receive the random signal, it adjusts the nominal price according to the indexation rule:

3
$$P_{j,t}(z) = \left(\pi_{t-1}\right)^{\iota} P_{j,t-1}(z), \quad j \in \{T, NT\}$$

where $P_{j,t}(z)$ is the nominal price of the variety z in sector j, π_t denotes aggregate inflation and $\iota \in [0, 1]$ is the indexation parameter. The firm z faces a demand of the form

4
$$Y_t^j(z) = \left(\frac{P_{j,t}(z)}{P_{j,t}}\right)^{-\lambda_t} Y_t^j$$

where λ_t follows an AR(1) process specified below, $P_{j,t}$ is the aggregate price index in sector j and Y_t^j denotes total demand.

2.2.1 Technology

Firms in the tradable sector have the technology

5
$$Y_{T,t} = \xi_{AT,t}\left(u_t K_{t-1}\right)^{\alpha} L_{H,t}^{1-\alpha},$$

where u_t is the capital utilization rate, $\alpha \in (0, 1)$, and $\xi_{AT,t}$ denotes the productivity shock. In the non-tradable sector firms face the technology

6
$$Y_{NT,t} = \xi_{AN,t} L_{NT,t},$$

where $\xi_{AN,t}$ denotes the productivity process. I allow for the sectoral technology shocks to be correlated

$$corr\left(\xi_{AN,t}, \xi_{AT,t}\right) > 0.$$

Note that the correlation is across sectors within each country but there are not cross-country correlations among shocks.

Firms face a working capital constraint as in Neumeyer and Perri (2005) and Uribe and Yue (2006). They need to borrow a fraction κ_j of the payroll costs with an intra-period loan.

2.2.2 Pricing

Given the technology with constant returns to scale, real profits (in terms of the aggregate consumption basket) are given by

$$\Pi_t^j(z) = p_{j,t}(z)Y_t^j(z) - mc_t Y_t^j(z) \quad j \in \{NT, T\}$$

where mc_t is the marginal cost and $p_{j,t}(z) = \dfrac{P_{j,t}(z)}{P_t}$, where P_t is the aggregate price index. Firms receiving the Calvo signal to optimally change prices choose $p_{j,t}(z)$ to maximize

$$\mathbb{E}_t \sum_{i=0}^{\infty} \beta^i \mathcal{C}^{\,i} \frac{\Lambda_{t+i}}{\Lambda_t} \Pi_{t+i}^j(z)$$

where $\dfrac{\beta^i \Lambda_{t+i}}{\Lambda_t}$ is the household's stochastic discount factor, subject to the demand, Equation 4, and the indexation rule, Equation 3.

The Appendix A shows that the pricing scheme yields the Phillips curves:

$$\pi_{j,t} = \beta \mathbb{E}_t \pi_{j,t+1} + \iota \pi_{t-1} - \mathcal{C}\beta\iota\pi_t + \frac{(1-\mathcal{C})(1-\mathcal{C}\beta)}{\mathcal{C}} \left\{ mc_{j,t} - \frac{1}{\lambda - 1}\lambda_t - \mathcal{C}\beta\sigma_{ind,t} \right\} \quad (7)$$

with $j \in \{NT, T\}$, where

$$\sigma_{ind,t} = \sigma_{ind,t-1} + \iota\pi_t$$

and

$$\pi_t = (1-a)\pi_{NT,t} + a\pi_{T,t}.$$

2.3 Capital Producer, Entrepreneurs, and the Financial Intermediary

Following Christiano et al. (2014), the capitalist builds new raw capital with the technology

8
$$K_t = (1-\delta)K_{t-1} + \xi_{I,t} I_t \left[1 - \frac{\phi I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right],$$

and sells it to the entrepreneurs, where I_t is investment, $\xi_{I,t}$ is an investment shock and ϕ_I determines the convex adjustment cost of investment. The new capital is sold to the entrepreneur at the price Q_t^k.

The entrepreneur receives a productivity shock ω, with $ln(\omega) \sim \mathcal{N}(1, \sigma_\omega)$, that transforms the raw capital in effective capital ωK. The effective capital is rented to the final good producer and after it is used in production is sold back to the capitalist. The return on capital is ωR_t^k, where $R_t^k = \frac{u_t r_t^k - a(u_t) + Q_t^k(1-\delta)}{Q_{t-1}^k}$, and $a(u) := r^k\left[exp(\sigma_a(u-1)) - 1\right]\frac{1}{\sigma_a}$ gives the utilization adjustment cost $(\sigma_a > 0)$, and δ is the depreciation rate.

The optimal contract maximizes the expected value of the entrepreneur subject to a zero profit condition for the intermediary. The optimality conditions imply:

9
$$\mathbb{E}_t \Gamma'_{t+1} = \mathbb{E}_t \frac{\{\Gamma'_{t+1} - \mu G'_{t+1}\}[1 - \Gamma_{t+1}]R_{t+1}^k}{R_t - \{\Gamma_{t+1} - \mu G_{t+1}\}R_{t+1}^k}$$

10
$$R_{t+1}\left(L_{t-1}^N - 1\right) = L_{t-1}^N\{\Gamma_t - \mu G_t\}R_t^k$$

where ω_t is a threshold in the productivity shock that separates those that can repay the loan and those that default, $F(\omega_t) \equiv \int_0^{\omega_t} dF(\omega)$ and $G(\omega_t) \equiv \int_0^{\omega_t} \omega dF(\omega)$, $\Gamma(\omega_t) = [1 - F(\omega_t)]\omega_t + G(\omega_t)$ and Γ' and G' are the corresponding derivatives with respect to ω.

2.4 Fiscal and Monetary Policies

The government purchases goods only from the domestic traded and nontraded sectors, which are combined in a composite good similar to the consumer's consumption basket. The government spending follows the rule

11 $$Gov_t = (Gov)\left(\frac{Y_t}{Y_{t-1}}\right)^{\psi_{G,Y}} \xi_{G,t},$$

where $\xi_{G,t}$ is an exogenous shock and $\psi_{G,Y}$ is a reaction coefficient.

The monetary authority follows the Taylor rule:

$$R_t^p = \rho_r R_{t-1}^p + \rho_\pi \pi_t + \rho_y Y_t + \epsilon_{mp,t}$$

where ρ_r is the smoothing coefficient and $\epsilon_{mp,t}$ is i. i. d. monetary-policy shock.

3. ESTIMATION AND MONETARY POLICY SCENARIO DESIGN

As a general rule, I estimate all the parameters that govern shocks and frictions in the model. I use the Random Walk Metropolis-Hasting (RWMH) algorithm, as described in An and Schorfheide (2007), in particular, to solve the model I use the algorithm discussed in Hernandez (2013) jointly with the solution method of Klein (2000). I use quarterly data for Mexico and USA from 2001Q1 to 2015Q2. The time series used are: JP Morgan EMBI+ Spread Mexico, spread between BAA and 10-year Treasury for USA, shadow federal funds rate for USA, the 90-day CETES rate for Mexico, GDP-deflator inflation for Mexico and the USA, GDP growth for Mexico and the USA, consumption growth for Mexico and USA, investment growth for Mexico and USA, bilateral imports growth for Mexico, bilateral exports growth for Mexico, GDP-deflator-based bilateral real exchange rate depreciation, government spending growth for Mexico and USA, non-bilateral trade over GDP for Mexico and USA, and growth in per capita work hours for USA.

3.1 The Transmission Mechanism of US Shocks

Figure 1 shows the impulse responses of key Mexico's variables to US shocks. That is, it shows the transmission mechanisms of USA shocks into the Mexican economy. First, an expansionary US preference shock increases Mexico's GDP, inflation, interest rates and depreciates the peso. The preference shock in USA acts as a USA demand shock that increases GDP in USA, generates inflation in USA and as a result the US monetary policy has to increase the policy rate. Given the US rate hike, the peso depreciates, which together with the larger US demand for Mexican goods stimulates net exports in Mexico and thus GDP in Mexico gets stimulated. That is, the trade channel is of key importance for the international transmission of these types of shocks. In turn, the depreciation pass-through to domestic prices and is inflationary for Mexico; with higher GDP, a more depreciated peso and higher inflation, the monetary policy response in Mexico is to increase policy rates to restore the long-term equilibrium.

Second, a US technology shock increases US GDP, lowers US inflation and drops the real US interest rate—as in any standard DSGE model. In turn, the financial channel in Mexico takes more relevance for the international transmission of these type of shocks, because lower international rates make the US technology shock to act as a Mexico technology shock. That is, it lowers the marginal cost of production in Mexico as production financing costs are lower. In turn, lower marginal costs in Mexico lower inflation and stimulate GDP with higher net exports and, as a result, the peso gets appreciated to help restore the long-term equilibrium.

Finally, a monetary policy shock in USA is contractionary for USA and lowers US inflation. An interest rate hike in USA depreciates the peso, which is passed-through to domestic prices in Mexico and inflation hikes; as a result, the monetary policy increases the policy rate. The lower US demand for Mexican goods—despite the depreciated peso—drops domestic GDP.

Of course, these impulse responses are ceteris paribus exercises aimed to understand the transmission mechanisms of the model. The actual conditions under which one should expect a hike of US interest rates must be the end result of realizations of various shocks that determine a state of the US economy that calls for a less accommodative monetary policy. The next subsection addresses that issue.

3.2 Scenario Analysis

The scenario analysis is conducted as follows. First consider the model's solution and the observables:

$S_t = TS_{t-1} + R_{\epsilon t}$ model's law of motion

$D_t = ZS_{t-1}$ observables

Figure 1

MEXICO: IMPULSE RESPONSES TO US SHOCKS IN THE ESTIMATED MODEL

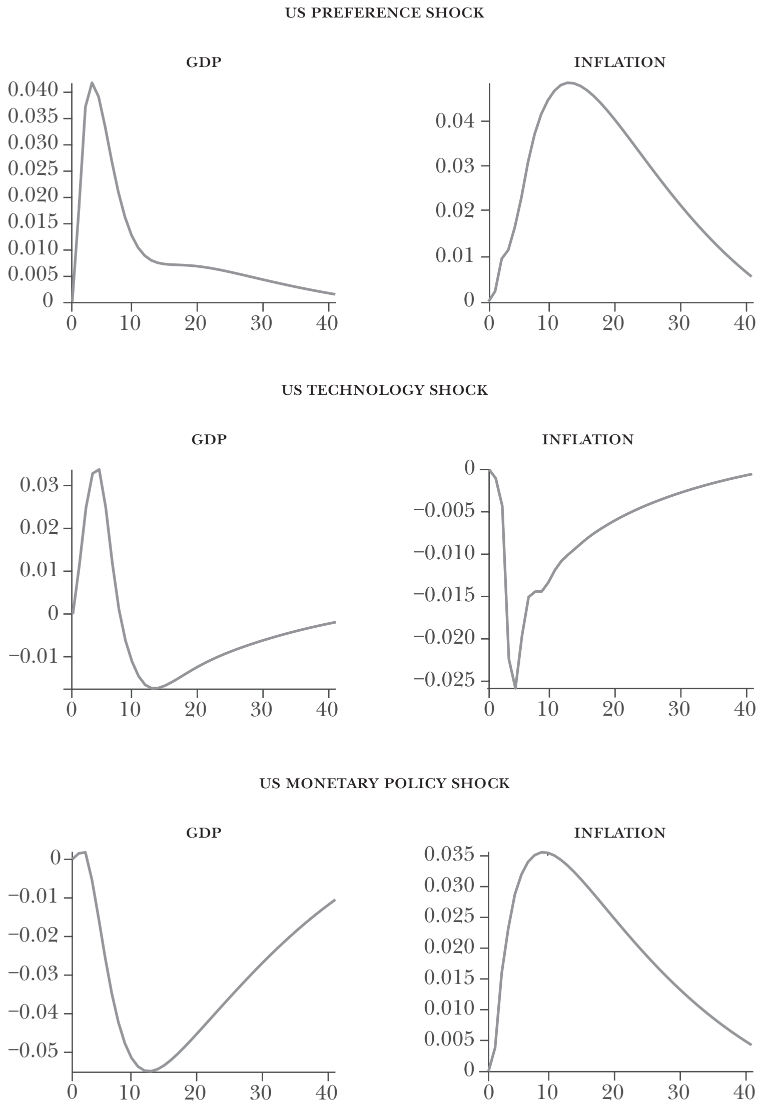
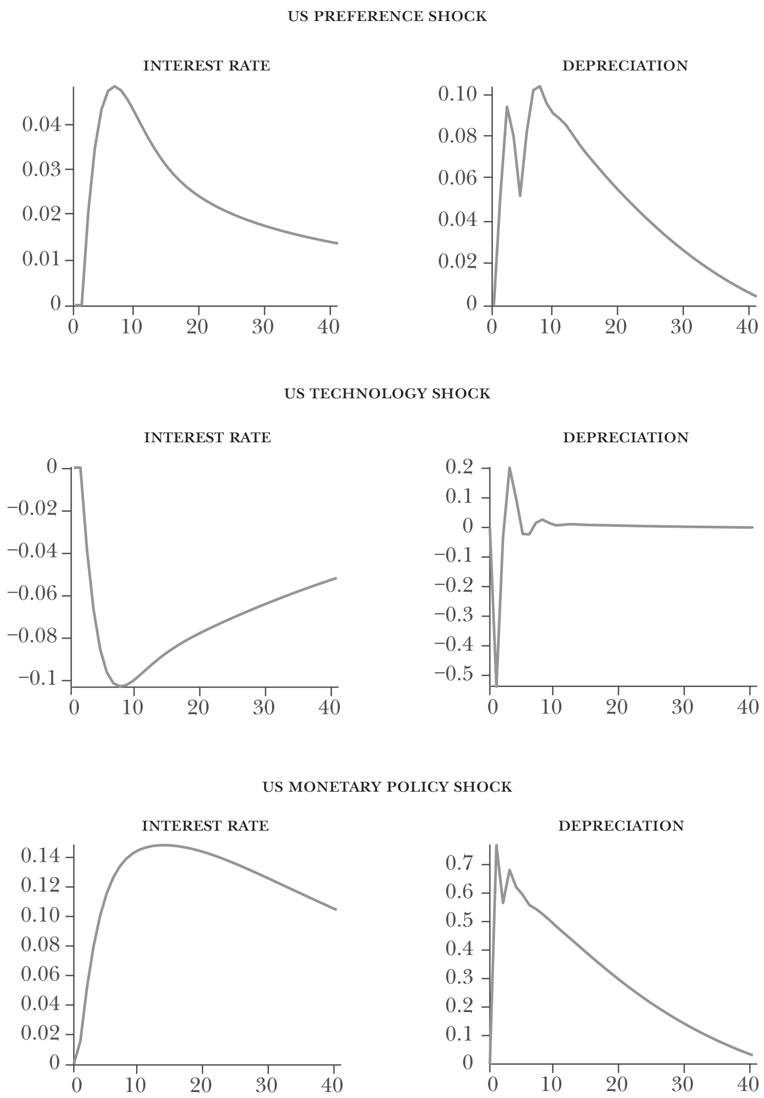


Figure 1 (cont.)

MEXICO: IMPULSE RESPONSES TO US SHOCKS IN THE ESTIMATED MODEL



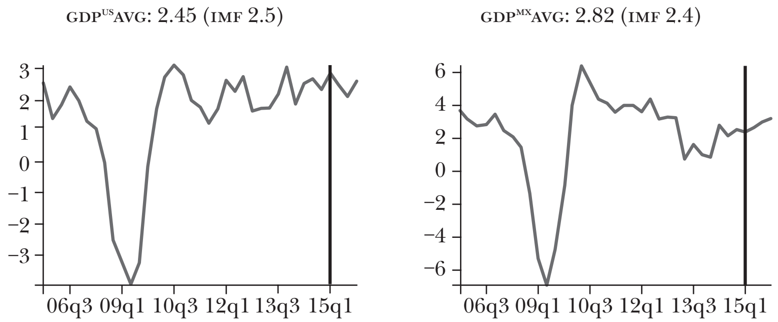
where T, R, and Z are matrices formed by functions of the deep parameters of the model.

- Use the Kalman filter to obtain an estimate of S_t and D_t for $t = 1 \ldots n$.
- Draw f draws of t and obtain S_{n+f} and D_{n+f}. Repeat many times to obtain many possible histories.
- Form a loss function to weight all draws of S_{n+f} and D_{n+f}. The weighted average is the forecast.
- The loss function can be very sophisticated for central banks.
- Here, I only impose more weight to those draws consistent with an increase of the US interest rate consistent with the FOMC announcement.

Figure 2 shows the model predictions for the effects of the normalization of US monetary policy. The model predicts conditions in USA that lead to a policy rate increase of 25 basis points and average growth of 2.5% in 2015. For Mexico those conditions imply a growth of 2.4%. The increase in US rates calls for an aggressive response of Mexico's policy rate. Mexico's policy rate hike will contain the ongoing depreciation of the real exchange rate and stabilize inflation.

Figure 2

FORECASTING WITH THE ESTIMATED MODEL



4. CONCLUSIONS

This chapter presents a DSGE model for the Mexican economy that contains important channels for the international transmission of US shocks to Mexico. Among the transmission channels are: the exchange rate channel, international bank lending, capital flows, monetary policy rates and international bilateral trade. Based on a Bayesian estimation of the deep parameters of the model, I simulate millions of scenarios under which the US monetary policy rate would increase in the last two (out of sample) quarters of 2015. Those scenarios are built by drawing stochastic macroeconomic shocks for the whole economy, that is, USA, Mexico and other international shocks are simultaneously considered. Out of those stochastic draws, I only consider those that yield an equilibrium in which the US monetary policy rate increases as a result. In average, those equilibria are characterized by favorable GDP growth in both countries, a modest increase in the Federal Reserve funds rate and a more than one-to-one response in Mexico's policy rate. The general conclusion is that those conditions that are needed for the normalization of US monetary policy are good conditions for both, USA and Mexico.

APPENDIX: PHILLIPS CURVE

In this Appendix I show the details to obtain the Phillips curve of the model. First I show how to write the optimal price chosen by a firm in a recursive fashion then I combine that optimal price with the aggregate price index to obtain the Phillips curve of the model.

A.1 Optimal Price Recursion

Consider a firm that can re-optimize its price in period t, the firm chooses $P_{j,t}(z)$ to maximize—we only show the relevant part of profits, that is, the case when the firm has to keep the non-optimal price $P_{j,t+i}(z)\forall i=1,...,$ which happens with probability $\mathcal{C}$ in each future period:

$$\mathbb{E}_t\sum_{i=0}^{\infty}\mathcal{C}^i\beta^i\lambda_{t+i}\Pi_{t+1}^j=\mathbb{E}_t\sum_{i=0}^{\infty}\mathcal{C}^i\beta^i\lambda_{t+i}\left[P_{N,t+i}(z)Y_{t+i}^j(z)-MC_{t+i}Y_{t+i}^j(z)\right]$$

Using the indexation rule (3) profits can be written as

$$\mathbb{E}_t \sum_{i=0}^{\infty} \mathcal{C}^{\,i} \beta^i \lambda_{t+i} \left[ind_{t+i} P_{j,t}(z) \left(\frac{ind_{t+i} P_{j,t}(z)}{P_{j,t+i}} \right)^{-\lambda_{j,t+i}} \left(Y_{t+i}^j \right) \right.$$
$$\left. - MC_{t+i}^j \left(\frac{ind_{t+i} P_{j,t}(z)}{P_{j,t+i}} \right)^{-\lambda_{j,t+i}} \left(Y_{t+i}^j \right) \right].$$

The first order condition is

$$\mathbb{E}_t \sum_{i=0}^{\infty} \mathcal{C}^{\,i} \beta^i \lambda_{t+i} \left[\left(ind_{t+i} \right)^{-\lambda_{j,t+i}+1} \left(-\lambda_{j,t+i} + 1 \right) \left(P_{j,t}(z) \right)^{-\lambda_{j,t+i}} \left(\frac{1}{P_{j,t+i}} \right)^{-\lambda_{j,t+i}} \left(Y_{t+i}^j \right) \right.$$
$$\left. + MC_{j,t+i\lambda j,t+i} \left(P_{j,t}(z) \right)^{-\lambda_{j,t+i}-1} \left(\frac{ind_{t+i}}{P_{j,t+i}} \right)^{-\lambda_{j,t+i}} \left(Y_{t+i}^j \right) \right] = 0.$$

Note that

$$\frac{P_{j,t+i}}{P_t} = \frac{P_{j,t}}{P_t} \frac{P_{j,t+1}}{P_{j,t}} \frac{P_{j,t+2}}{P_{j,t+1}} \cdots \frac{P_{j,t+i}}{P_{j,t+i-1}} = p_{j,t} \Pi_{s=0^{\pi N,t+s}}^{i} := p_{j,t} ind_{\pi_j,t+i}$$

where I use $\Pi_{j=0}(\cdot) := 1$. Divide the expression above by P_t and rewrite it as a note that I multiply by −1 in the term $-1(\lambda N, t + i - 1) = (1 - \lambda N, t + i)$–:

$$\mathbb{E}_t \sum_{i=0}^{\infty} \mathcal{C}^{\,i} \beta^i \lambda_{t+i} \left[\left(ind_{t+i} \right)^{-\lambda_{j,t+i}+1} \left(\lambda_{j,t+i} - 1 \right) \left(P_{j,t}(z) \right)^{-\lambda_{j,t+i}} \left(\frac{1}{p_{j,t} ind_{\pi_j,t+i}} \right)^{-\lambda_{j,t+i}} \left(Y_{j,t+i} \right) \right]$$
$$= \mathbb{E}_t \sum_{i=0}^{\infty} \mathcal{C}^{\,i} \beta^i \lambda_{t+i} \left[MC_{j,t+i} \lambda_{j,t+i} \left(P_{j,t}(z) \right)^{-\lambda_{j,t+i}-1} \left(\frac{ind_{t+i}}{p_{j,t} ind_{\pi_j,t+i}} \right)^{-\lambda_{j,t+i}} \left(Y_{j,t+i} \right) \right].$$

Linearizing the expression above and using the steady-state relation $mc_j = \dfrac{\lambda_j - 1}{\lambda_j}$ we get

$$\mathbb{E}_t \Big\{ \lambda \left(\lambda_j - 1 \right) Y_j \left\{ P_{j,t}(z) - MC\, j,t \right\} + \lambda Y_j \lambda_{j,t}$$
$$+ \mathcal{C} \beta \lambda \left(\lambda_j - 1 \right) Y_j \left\{ + ind_{t+1} + P_{j,t}(z) - MC_{j,t+1} \right\} + \mathcal{C} \beta \lambda Y_j \left\{ \lambda_{j,t+1} \right\}$$
$$+ \mathcal{C}^{\,2} \beta^2 \lambda \left(\lambda_j - 1 \right) Y_j \left\{ + ind_{t+2} + P_{j,t}(z) - MC_{j,t+2} \right\} + \mathcal{C}^{\,2} \beta^2 \lambda Y_j \left\{ \lambda_{j,t+2} \right\}$$
$$+ \ldots \Big\} = 0.$$

simplifying and solving for $P_{N,t}(z)$

$$P_{j,t}(z)\sum_{i=0}^{\infty}\mathcal{C}^{\,i}\beta^{i}=\left\{MC_{j,t}-\frac{1}{\lambda_j-1}\lambda_{j,t}\right\}$$

$$+\mathcal{C}\,\beta\left\{-ind_{t+1}+MC_{j,t+1}-\frac{1}{\lambda_j-1}\lambda_{j,t+1}\right\}$$

$$+\mathcal{C}^{\,2}\beta^{2}\left\{-ind_{t+2}+MC_{j,t+2}-\frac{1}{\lambda_j-1}\lambda_{j,t+2}\right\}+$$

$$+\mathcal{C}^{\,3}\beta^{3}\left\{-ind_{t+3}+MC_{j,t+3}-\frac{1}{\lambda_j-1}\lambda_{j,t+3}\right\}+\ldots$$

note

$$ind_{t+1}=\tilde{\pi}_{t+1}$$

$$ind_{t+2}=\tilde{\pi}_{t+1}+\tilde{\pi}_{t+2}$$

$$ind_{t+3}=\tilde{\pi}_{t+1}+\tilde{\pi}_{t+2}+\tilde{\pi}_{t+3}$$

thus define

$$\sigma_{ind,t}=\sigma_{ind,t-1}+\tilde{\pi}_{t+1}$$

with $\sigma_{ind,0}=0$. Then rewrite the price as

$$P_{j,t}(z)\sum_{i=0}^{\infty}\mathcal{C}^{\,i}\beta^{i}=\left\{MC_{j,t}-\frac{1}{\lambda_j-1}\lambda_{j,t}\right\}$$

$$+\mathcal{C}\,\beta\mathbb{E}_t\left\{-\sigma_{ind,t}+MC_{j,t+1}-\frac{1}{\lambda_j-1}\lambda_{j,t+1}\right\}$$

$$+\mathcal{C}^{\,2}\beta^{2}\mathbb{E}_t\left\{-\sigma_{ind,t+1}+MC_{j,t+2}-\frac{1}{\lambda_j-1}\lambda_{j,t+2}\right\}+$$

$$+\mathcal{C}^{\,3}\beta^{3}\mathbb{E}_t\left\{-\sigma_{ind,t+2}+MC_{j,t+3}-\frac{1}{\lambda_j-1}\lambda_{j,t+3}\right\}+\ldots$$

or recursively:

$$P_{j,t}(z) = \left(1-\mathcal{C}\,\beta\right)\left\{MC\,j,t - \frac{1}{\lambda_j - 1}\lambda_{j,t} - \mathcal{C}\,\beta\sigma_{ind_t}\right\} + \mathcal{C}\,\beta\mathbb{E}_t P_{j,t+1}(z)\,.$$

A.2 Phillips Curve

Dropping the index z because all firms choose the same price, from the price index:

$$\left(P_{j,t}\right)^{1-\lambda_{j,t}} = \mathcal{C}\left(\tilde{\pi}_t P_{j,t-1}\right)^{1-\lambda_{j,t}} + \left(1-\mathcal{C}\right)\left(P^*_{j,t}\right)^{1-\lambda_{j,t}}\,.$$

In log-linear and solving for $P^*_{j,t+1}$ from the price index

$$P^*_{j,t+1} = \frac{1}{1-\mathcal{C}}P_{j,t+1} - \frac{\mathcal{C}}{1-\mathcal{C}}\left\{P_{j,t} + \tilde{\pi}_{t+1}\right\} = \frac{1}{1-\mathcal{C}}\pi_{j,t+1} + P_{j,t} - \frac{\mathcal{C}}{1-\mathcal{C}}\tilde{\pi}_{t+1}$$

using this in the optimal price

$$\begin{aligned} P^*_{j,t} = &\left(1-\mathcal{C}\,\beta\right)\left\{MC_{j,t} - \frac{1}{\lambda_j - 1}\lambda_{j,t} - \mathcal{C}\,\beta\sigma_{ind,t}\right\} \\ &+ \mathcal{C}\,\beta\mathbb{E}_t\left\{\frac{1}{1-\mathcal{C}}\pi_{j,t+1} + P_{j,t} - \frac{\mathcal{C}}{1-\mathcal{C}}\tilde{\pi}_{t+1}\right\} \end{aligned}$$

and using this back in the price index

$$\begin{aligned} P_{j,t} = \mathcal{C}\left\{P_{j,t-1} + \tilde{\pi}_t\right\} + \left(1-\mathcal{C}\right)\Bigg\{&\left(1-\mathcal{C}\,\beta\right)\left\{MC_{j,t} - \frac{1}{\lambda_j - 1}\lambda_{j,t} - \mathcal{C}\,\beta\sigma_{ind,t}\right\} \\ &+ \mathcal{C}\,\beta\mathbb{E}_t\left\{\frac{1}{1-\mathcal{C}}\pi_{j,t+1} + P_{j,t} - \frac{\mathcal{C}}{1-\mathcal{C}}\tilde{\pi}_{t+1}\right\}\Bigg\} \end{aligned}$$

or subtracting $P_{j,t-1}$ on both sides we obtain:

$$\pi_{j,t} = \beta\mathbb{E}_t\pi_{j,t+1} + \tilde{\pi}_t - \mathcal{C}\,\beta\mathbb{E}_t\tilde{\pi}_{t+1} + \frac{\left(1-\mathcal{C}\right)\left(1-\mathcal{C}\,\beta\right)}{\mathcal{C}}\left\{mc_{j,t} - \frac{1}{\lambda_j - 1}\lambda_{j,t} - \mathcal{C}\,\beta\sigma_{ind,t}\right\}$$

where $mc_{j,t} := MC_{j,t}/P_{j,t}$.

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Reassessing the Effects of Foreign Monetary Policy on Output: New Evidence from Structural and Agnostic Identification Procedures

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Andrés Yany

Abstract

We investigate the propagation of a foreign monetary policy shock over a small open economy, in particular over the Chilean economy. Our motivation is based on the ongoing period of monetary normalization already started by the Fed. We follow Canova (2007) and compare the impulse response functions of structural VAR models and a DSGE model tailored for the Chilean economy. We use the recursive VAR model of Sims (1980) and an extension of the agnostic *VAR model of Uhlig (2005) and Arias et al. (2014) for small open economies following Koop and Korobilis (2010). The results suggest that the recursive VAR model does not properly identify the shock, and its implications are counterintuitive. On the contrary, beyond the quantitative differences, we find that the responses of the* agnostic *VAR model are qualitatively in line with those of the DSGE model except for output. However, the transmission of the shock to the local economy is limited but more persistent according to the*

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DSGE model. Finally, we spot different policy implications arising from both models. According to the agnostic *VAR model, the central bank does not need to raise its policy rate because the drop in activity offsets any jump in inflation; whereas in the DSGE model the rise in prices is partially accommodated by an increase in the policy rate. Thus, this comparison motivates an interesting discussion for the policymaker.*

Keywords: monetary policy shocks; small open economies; structural VAR; VAR identification; sign restrictions, DSGE model.

JEL classification: E32; F41.

1. INTRODUCTION

In December 2008, the federal funds rate dropped to the zero lower bound, and since then unconventional monetary policies have dominated the scene.[1] It took almost six years for the Fed to raise its policy rate and the zero lower bound was finally abandoned by the end of 2015. The ongoing period of monetary normalization combines two signals: *i)* concrete policy measures and *ii)* forward guidance. Currently, several central banks are evaluating the likely effects that US monetary normalization may have on their economies in order to inform policy decisions and assess potential risks since the propagation of that shock activates different channels (interest rate spread, exchange rate depreciation, problems of excessive debt burden if debt is denominated in dollars, etc.) that affect their economies in different dimensions. For example, private debt may have increased significantly due to lower interest rates and thus an increase in foreign rates can generate a domestic depreciation that amplifies the burden of foreign debt in domestic currency. Moreover, the current poor performance in many of these economies could further amplify the impact of the shock on debtors and the overall economy.[2]

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[1] The Fed had strong reasons to intervene based on historical reasons; fears of a liquidity crisis that could lead the economy to another great depression.

[2] Consider another example to motivate the discussion further. The pass-through of exchange rate to inflation can trigger an increase in domestic interest rates to contain inflation. However, at the same time higher foreign rates can be associated with more adverse external conditions. They can have a negative impact on output, which in turn could help

Thus, this paper investigates the propagation of a foreign monetary policy shock over a small open economy, in particular over the Chilean economy. We use a comprehensive methodological framework that compares the impulse response functions (henceforth IRFs) of three models: two structural VAR models and a DSGE model tailored for the Chilean economy.[3] We follow this approach because according to Canova (2007), structural VAR models can be used to judge and validate the responses from DSGE models. Therefore, this comparison sheds new light and provides insights on the propagation of a foreign monetary policy shock over the Chilean economy, and in addition, it assesses the suitability of the micro-founded structure behind the DSGE model (i.e., the theoretical model). To this end, we use the recursive VAR model of Sims (1980) in which identification of structural shocks is based on a particular order of the variables in the system, along with an extension of the *agnostic* VAR model of Uhlig (2005) and Arias et al. (2014) for small open economies following Koop and Korobilis (2010). In this identification scheme, structural shocks are identified by imposing restrictions directly on the IRF.

Our findings can be summarized as follows. *1)* Consistent with several studies such as Bernanke et al. (2005), Mojon (2008) and Castelnuovo (2016) our analysis of IRFs lead us to conclude that identification of foreign monetary shocks is not straightforward in recursive VAR models. Therefore, the recursive VAR model fails to provide an informative benchmark to judge the plausibility of results from structural micro-founded models. *2)* On the contrary, the *agnostic* VAR model provides IRFs with dynamics that are broadly consistent with macroeconomic theory; hence, in our view results provide an informative benchmark for micro-founded models. *3)* Beyond the quantitative differences, we find that the IRFs of the *agnostic* VAR model are qualitatively in line with those of the DSGE model except for output. The DSGE model shows an initial increase in activity, which is explained by the improvement of the current account due to the real and nominal exchange rate depreciation, whereas the

to mitigate the hike in inflation and the central bank's response. Thus, we draw an interesting policy implication from this analysis.

3 A standard dynamic stochastic general equilibrium (DSGE) model for a small open economy with nominal and real rigidities that is closely related to models developed by Christiano et al. (2005) and Smets and Wouters (2003, 2007).

agnostic VAR infers a significant drop in output. *4)* The transmission of the shock to the domestic economy in the DSGE model is limited but persistent. At least two reasons may explain this. First, by construction, there are many micro-founded restrictions in the model that increase the persistency of the shock (habit formation in consumption, quadratic adjustment cost for investment, etc.). Second, there is an excessive simplification in the definition of exogenous processes for foreign variables (e.g. foreign interest rates follow an AR(1) process). *5)* Finally, we spot different policy implications arising from both models. According to the *agnostic* VAR model, the central bank does not need to raise its policy rate because the drop in activity offsets any jump in inflation; whereas in the DSGE model the rise in prices is partially accommodated by an increase in the policy rate. Thus, this comparison enriches the discussion for the policymaker.

The results for the recursive VAR model are not new and have been documented many times before in the literature. The identification of monetary policy shocks in this setting has always been a subject of debate, and different specifications and models may lead to different responses. Bernanke et al. (2005) provided several reasons to understand this result:

1) The policy shock is not properly identified in the VAR system;

2) Variables of the VAR do not represent the real state of the economy;

3) The impulse response functions are biased because only a subset of the state variables of the economy are used to identify the shocks.

Similarly, Weber et al. (2009) argue that structural breaks may be crucial to understand the monetary transmission process. They found two structural breaks in their sample using data for the euro area. They report evidence in favor of an *atypical* interim period 1996-1999, but for the rest of the sample, the monetary transmission process remains adequate.

The *agnostic* VAR model of Uhlig (2005) imposes sign restrictions for a subset of the IRFs which in turn imply nonlinear constraints in the structural parameters of the model. In this paper, the author studies the impact of a monetary policy shock on output for the US economy by imposing a set of sign restrictions on all of the variables but leaving the response of output unrestricted. Thus, he refers to this method as an *agnostic* identification scheme.[4] Studies that follow this methodology are Canova and Nicoló (2002), Uhlig (2005), Rubio-Ramírez, Waggoner and Zha (2010) and Arias et al. (2014). These papers extended the VAR framework to also accommodate zero restrictions.

More recently, unconventional monetary policies in the US and the eurozone have encouraged the use of different frameworks to evaluate the impacts of these shocks (including SVARs, Bayesian VARs, DSGE, etc.), such as Carrera et al. (2015), Baumeister and Benati (2013), Castelnuovo (2012), Christensen and Rudebusch (2012), and Kapetanios et al. (2012), among others. Normally, the choice of restrictions is proposed by the researcher after a careful analysis based on economic theory. For example, if the interest rate differentials increase, then exchange rates are expected to rise due to adjustments one can anticipate from the uncovered power parity relation. This expected response might be questioned from several angles (e.g. UIP does hold). However, our choice is justified with sound economic theory. Other related applications are presented in Baumeister and Benati (2013), which analyzes the effects of unconventional policies with a time varying structural VAR, while Castelnuovo (2012, 2016) use a micro-founded DSGE approach to assess the macroeconomic impacts of an increase in interest rates. Finally, Carrera et al. (2015) have studied the impact of quantitative easing policies on small open economies (a subset of Latin American countries). That piece of research is a very close application to our paper because it uses similar identification methodology, but differs in the details of the posterior distribution calculation.[5]

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4 The key result from this paper is that neutrality of monetary policy is not inconsistent with the US data. More recently, Castelnuovo (2016) addresses this point for the euro area and analyzes the neutrality of monetary policy on inflation. He reports that the neutrality of VAR models may be due to a deficient identification of the policy shock, omitted variables or structural breaks.

5 The main difference of Carrera et al. (2015) and our approach is that they estimate the parameters of the blocks of the reduced-form VAR model with block exogeneity independently, whereas our approach remains closer to the original framework of Arias et al. (2014) since we estimate the parameters jointly.

The rest of the paper is organized as follows. The next section presents the VAR models. Section 3 briefly describes the structural DSGE model economy. Section 4 reports impulse response functions for each model. Finally, Section 5 concludes.

2. STRUCTURAL VAR MODELS AND IDENTIFICATION SCHEMES

Structural VAR models were introduced in the seminal paper of Sims (1980) as an alternative methodology to large-scale macroeconomic models of dynamic equations systems. A complete review of this literature is far beyond the scope of this paper, but the interested reader may refer to Kilian (2013) and Lütkepohl (2011) for a comprehensive analysis of it.

According to Canova (2007) structural VAR models can be used to judge and validate theoretical models, such as DSGE models, because VAR models are able to characterize the joint dynamics of several economic variables with only a few assumptions, whereas theoretical models rely heavily on a micro-founded structure to identify the dynamics between the variables of the system. Thus, the comparison of both methodologies enables us to assess the suitability of the micro-founded structure behind a theoretical model if and only if the structural VAR model is properly identified.

The structural VAR model for an SOE with block exogeneity (henceforth SVAR-SOE) is defined as:

$$\begin{bmatrix} y_t^{*\prime} & y_t' \end{bmatrix} \begin{bmatrix} A_{01} & 0 \\ A_{03} & A_{04} \end{bmatrix} = \sum_{l=1}^{p} \begin{bmatrix} y_{t-l}^{*\prime} & y_{t-l}' \end{bmatrix} \begin{bmatrix} A_{l1} & 0 \\ A_{l3} & A_{l4} \end{bmatrix} + c + \begin{bmatrix} \varepsilon_t^{*\prime} & \varepsilon_t' \end{bmatrix}. \quad (1)$$

The zero blocks in the system reflect the block exogeneity assumption of the model in the spirit of Zha (1999). The $n\times 1$ vector y_t contains the endogenous variables for the domestic block (i.e., small open economy), whereas the $n^{*}\times 1$ vector y_t^{*} contains the endogenous variables for the foreign block. The A_i matrices and the vector of constants c are the structural parameters, whereas p denotes the lag order of the model. The inclusion of exogenous variables is straightforward, but they are excluded to simplify the notation. Finally, the vectors ε_t and ε_t^{*} are

Gaussian with a mean of zero and variance-covariance matrix I_{n+n^*} (the $n+n^*$ dimensional identity matrix).

The model can be compactly written as:

$$Y_t' A_0 = X_t' A_+ + \xi_t' , \tag{2}$$

where $Y_t' = \left[y_t^{*\prime} \; y_t' \right]$, $X_t' = \left[Y_{t-1}' \ldots Y_{t-p}' \; 1 \right]$, $A_t' = \left[A_1' \ldots A_p' \; c' \right]$, and the reduced-form is defined as:

$$Y_t' = X_t' B + u_t', \tag{3}$$

where $B = A_+ A_0^{-1}$, $u_t' = \varepsilon_t' A_0^{-1}$ and $E\left[u_t u_t' \right] = \Sigma = (A_0 A_0')^{-1}$. The estimation of SVAR models requires the identification of the structural shocks. Several alternative methodologies are available for the estimation and identification of these types of models. In particular, the most widely used methodologies can be grouped into three categories: recursive identification schemes, nonrecursive identification schemes and sign restriction schemes; in this paper we explore two of these identification schemes. The next two subsections explain the details of each approach.

2.1. Recursive Identification Scheme

The recursive identification scheme (henceforth recursive scheme or recursive VAR) was introduced in the seminal work of Sims (1980) and has become the conventional benchmark used in applied macroeconomics to validate responses of micro-founded structural models. The structural model is identified in four steps. First, the variables of the system are ordered in a specific way, the first variable being the most exogenous and the last one the most endogenous of the system. Second, the reduced-form model is estimated. Third, the structural innovations are recovered using a Cholesky decomposition over the variance-covariance matrix of the residuals of the reduced-form model (i.e., $\Sigma_\epsilon = PP'$). Finally, the structural parameters are estimated using the map of the reduced-form parameters to the structural parameters defined in the previous subsection:

$$B = A_+ A_0^{-1} \quad u_t' = \xi_t' A_0^{-1} \quad \Sigma_\epsilon = PP' = (A_0 A_0')^{-1}.$$

Note that the P matrix depends on the order of variables and hence is not unique, thus the econometrician needs to rely on some theoretical argument to justify his identification scheme. One of the main drawbacks of this approach is that economic theory cannot be incorporated directly into the model. Moreover, even in those cases in which the theory is able to suggest a particular order of causality among the variables of the system, the model can still generate IRFs that are counterintuitive or yield puzzling results.[6]

The block exogeneity assumption for the recursive VAR model for SOE implies that the reduced-form model cannot be estimated equation by equation using OLS. Instead, the estimation is performed by quasi-maximum likelihood; see Hamilton (1994) for a comprehensive discussion of this methodology.

2.2. Identification with Sign and Zero Restrictions

The sign restriction scheme follows a different approach to identify the structural shocks of the model. In this setting, the IRFs of the model are restricted directly according to economic theory. For instance, the contemporaneously dynamic response of inflation is set to be less than zero to a positive monetary policy shock as well as to the first periods following the shock. The methodology imposes linear and nonlinear constraints in the structural parameters of the model. In addition, the methodology does not require the complete identification of the full set of structural shocks of the model as in the recursive scheme. However, in this case the identification of the subset of structural shocks can be contaminated with other structural shocks that look alike. Thus, the full identification of the shocks should generate narrower confidence intervals for the IRFs of the system. Alternatively, the researcher can increase the number of restrictions to try to minimize the aforementioned problem.[7]

There are several ways in which sign restrictions can be introduced in VAR models. For instance, Blanchard and Quah (1989) developed an algorithm to restrict the long-run response of a set of variables

[6] Sims (1980) defines a puzzle as a situation in which the impulse response functions from an identification scheme do not match conventional wisdom from theoretical models.

[7] Unfortunately, there is little guide to assess the potential gains from this approach. However, further research may help to understand the trade-off between these two approaches.

after a structural shock. Other authors have restricted the joint dynamics of the variables after a structural shock, as in Canova and De Nicoló (2002). A different approach is used in Uhlig (2005) to study the impact of a monetary policy shock on output for the US economy by imposing a set of sign restrictions in all of the variables but leaving the dynamic response of output unrestricted. The author referred to this method as an *agnostic* identification scheme since no assumptions were made with respect to the response of output. In this setting the restrictions are imposed directly over the dynamics of each variable of the system. More recently, extensions to these approaches can be found in Mountford and Uhlig (2009), Rubio-Ramírez et al. (2010) and Arias et al. (2014) (henceforth ARW). In particular, ARW expands Uhlig's methodology by incorporating zero restrictions; thus the dynamic responses of the variables after a shock can be set to zero, less than zero or greater than zero. In addition, the methodology allows the combination of these types of restrictions simultaneously in the dynamic response of the variables, which in turn should improve the identification of the structural shocks.[8]

In this paper we extend the methodology of Arias et al. (2014) for SOE; for ease of exposition we borrow Uhlig's definition and refer to this method as *agnostic* scheme or *agnostic* VAR. The block exogeneity assumption implies that the number of independent variables is not the same between the blocks of the model, and thus we follow Koop and Korobilis (2010) to use a more general framework to estimate VAR models. The implications of this identification scheme have not been explored comprehensively in the literature for SOE. This approach enables us to specify an alternative VAR model in which the identification of structural shocks is based on a set of restrictions that are driven by theory (or by stylized facts of the data) and not just by a particular order of the variables as in the recursive scheme. Thus, this method could potentially provide an interesting benchmark to evaluate and validate the responses of theoretical models.

In this setting, the identification of the structural shocks relies on Bayesian methods, and the algorithm can be summarized as follows:

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8 More precisely, the inclusion of zero restrictions to Uhlig's method was developed in Mountford and Uhlig (2009) using a penalty function approach. However, according to ARW the method imposes additional sign restrictions in unrestricted variables, which generate narrower confidence intervals for the responses of the variable. Thus, ARW shows a new framework to combine the two types of restrictions.

1) Draw $(B;\Sigma)$ from the posterior of the reduced-form parameters.

2) Generate $(A_0^*;A_+^*)$ by using a mapping between the reduced-form and the structural parameters.[9]

3) Draw an orthogonal matrix Q such that $(A_0^*Q;A_+^*Q)$ satisfies the zero restrictions.[10]

4) Keep the draw if sign restrictions are satisfied.

5) Repeat 1 to 4 until the desired number of simulations is reached.

6) Compute the median and confidence bands for the full set of IRFs that satisfy the restrictions.

If no restrictions are imposed over the blocks of the SVAR-SOE, then each equation of the model has the same number of variables. In this case, the draws from the posterior of the reduced-form parameters can be obtained using the normal-Wishart prior (conjugate prior) and the posterior of the parameters are given by:[11]

$$b|\Sigma,y \sim N\left(\overline{B},\overline{\Sigma}\otimes\overline{V}\right) \text{ and } \Sigma^{-1}|y \sim W\left(\overline{S}^{-1},\overline{v}\right),$$

and:

$$\overline{S}=S+\underline{S}+\hat{B}'X'X\hat{B}+\underline{B}'\underline{V}^{-1}\underline{B}-\overline{B}'\left(\underline{V}^{-1}+X'X\right)\overline{B}.$$

The normal-Wishart prior imposes a Kronecker structure on

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9 The mapping between structural and reduced-form parameters can be implemented by using a function $h()$ such that $h(X)'h(X)=X$, i.e. Cholesky decomposition: $(A_0^*;A_+^*)=\left(h(\Sigma)^{-1};Bh(\Sigma)^{-1}\right)$.

10 Using the QR decomposition $(X=QR)$ which holds for any $n\times n$ random matrix in which each element is *i.i.d.* from a $N(0,1)$. In addition, ARW describes an algorithm to obtain recursively each column of Q, which improves the efficiency of the algorithm significantly when the researcher is interested in identifying more than one structural shock.

11 Where $\overline{v}=T+\underline{v}$; $b=vec\left(\overline{B}\right)$ and $\hat{B}$ is the OLS estimator of B; $\overline{V}=\left[\underline{V}^{-1}+X'X\right]^{-1}$ and $\overline{B}=\overline{V}\left[\underline{V}^{-1}\underline{B}+X'X\hat{B}\right]^{-1}$; the hyperparameters $\underline{\alpha}$, $\underline{V}$, and $\underline{S}$ characterize the prior distributions of the parameters: $b|\Sigma,y\sim N\left(\underline{B},\underline{\Sigma}\otimes\underline{V}\right)$ and $\Sigma^{-1}|y\sim W\left(\underline{S}^{-1},\underline{v}\right)$.

the variance-covariance matrix of b which in turn implies that for each element of b, say b_i the $\text{cov}(b_i, b_j) \neq 0$ for all $i \neq j$. Unfortunately, the block exogeneity assumption requires a block of zeros in the reduced-form model which means that this set of parameters must be independent from the rest of the parameters. Therefore, the normal-Wishart prior is not suitable to estimate the SVAR-SOE model. Instead, we need to specify a prior that breaks the Kronecker structure in the variance-covariance matrix of b.

Following Koop and Korobilis (2010), we use the independent normal-Wishart prior that defines the posterior of the parameters as follow:[12]

$$b|\Sigma, y \sim N(\overline{B}, \overline{V}) \text{ and } \Sigma^{-1}|y, b \sim W(\overline{S}^{-1}, \overline{v})$$

and:

$$\overline{S} = \underline{S} + \sum_{t=1}^{T} (y_t - Z_t b)(y_t - Z_t b)'.$$

Thus, the main methodological contribution of this paper is to combine the methods of Koop and Korobilis (2010) and Arias et al. (2014) to identify the SVAR-SOE model. In this setting, the model needs to be redefined in the following way. First, rewrite 3 as:

$$y_{mt} = z'_{mt} b_m + \varepsilon_{mt}.$$

Where t is the time index and m indicates the variable (i.e., equation); y_{mt} specifies the t^{th} observation of the m^{th} variable and z_{mt} is a vector that contains the explanatory variables for the m^{th} equation at time t. Second, define b_m as the vector that contains the parameters of the m^{th} equation and M as the total number of equations. Note that in this case the z_{mt} vector can vary across equations or blocks of the model. Third, stack the b_i vectors and z'_{mt} matrices as:

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[12] Where: $\overline{v} = T + \underline{v}$, $\overline{B} = \overline{V}\left[\underline{V}^{-1}\underline{B} + \sum_{t=1}^{T} Z_t'\Sigma^{-1} y_t\right]$, and $\overline{V} = \left[\underline{V}^{-1} + \sum_{t=1}^{T} Z_t'\Sigma^{-1} Z_t\right]^{-1}$; the hyperparameters $\underline{\alpha}$, $\underline{V}$, and $\underline{S}$ characterize the prior distributions of the parameters: $b \sim N(\underline{B}, \underline{V})$ and $\Sigma^{-1} \sim W(\underline{S}^{-1}, v)$ with $p(b, \Sigma^{-1}) = p(b)p(\Sigma^{-1})$.

$$b=\begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_M \end{pmatrix} \qquad Z_t=\begin{pmatrix} z'_{1t} & 0 & \cdots & 0 \\ 0 & z'_{2t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & z'_{Mt} \end{pmatrix}.$$

Next, define $y_t=\left(y_{1t},\ldots,y_{Mt}\right)'$, $\varepsilon_t=\left(\varepsilon_{1t},\ldots,\varepsilon_{Mt}\right)'$ and write the model more compactly as:

$$y_t=Z_t b+\varepsilon_t.$$

The total number of parameters is given by $k=\sum_{j=1}^{M}k_j$ and $\varepsilon_t\sim N\left(0,1\right)$. Note that b is a $k\times 1$ vector and Z_t is an $M\times k$ matrix. Finally, stack y_t, ε_t and Z_t as column vectors and define $\varepsilon\sim N\left(0,I\otimes\Sigma\right)$ to write the model as:

4 $$y=Zb+\varepsilon.$$

The notation in equation 4 is consistent with the notation of Koop and Korobilis (2010) for the independent normal-Wishart prior. Note that the posterior of Σ is not independent from the draw of b and hence direct sampling from the posterior is not feasible. Instead, a sequential algorithm can be used in which sequential draws are taken from the conditional posterior distributions of $p\left(b\middle|y,\Sigma\right)$ and $p\left(\Sigma^{-1}\middle|y,b\right)$, i.e., a Gibbs sampling algorithm.[13]

3. A DSGE MODEL FOR CHILE

In this section, we briefly describe the DSGE model for Chile. We use the model of Medina and Soto (2007a) to compute the impulse response to a 1% foreign monetary policy shock. The model is a new

[13] We use a burn-in period to achieve convergence to the posterior distribution. In particular, we made 5,500 simulations and burned the first 500 simulations. We also tried with a different number of simulations but the results did not change significantly. In addition, we discard the draws for which the eigenvalues of the companion of the VAR model were greater than one in absolute value.

Keynesian small open economy model, which is closely related to the framework of Christiano et al. (2005) and Smets and Wouters (2003, 2007). However, it has additional and specific features to describe the Chilean economy, such as a representative commodity-exporting firm, a *structural* fiscal policy rule, and a monetary policy rule that responds to changes in headline CPI inflation (we refer to Medina and Soto, 2007a, for a more detailed description of the model).

This model has been extended in several directions to address specific questions and has also been re-estimated to take advantage of recent data. Examples are the learning extension to replicate the current account dynamics of Chile as Fornero and Kirchner (2014) and Fornero et al. (2015) conduct several policy experiments simulating a copper price shock. In the current version, we abstract from these additions.[14]

A full description of the model is beyond the scope of this paper. Therefore, in the remainder of the section, we briefly describe its main features. The domestic economy is composed of a continuum of households, a fraction of which are non-Ricardian without access to the capital market. These non-Ricardian households consume their entire wage income. The remaining Ricardian households make intertemporal consumption-savings decisions in a forward-looking manner, to maximize the present value of utility.

There are three types of sectors in the domestic economy. First, there is a continuum of firms producing differentiated varieties of intermediate tradable goods, with monopoly power and sticky prices à la Calvo (1983). These firms use labor, capital and oil as inputs and sell their goods to competitive assemblers that produce final domestic goods, which are sold in the domestic and foreign market. There is a representative capital goods producer that rents capital goods to the intermediate goods producing firms. The optimal investment composition is determined through cost minimization, where we assume costs of adjusting investment, following Christiano et al. (2005). All firms are owned by Ricardian households. Second, there is an imported goods sector with a continuum of retail firms that repackage a homogenous good from abroad into differentiated

[14] Robustness exercises were done using the model of Fornero and Kirchner (2014) and Fornero et al. (2015) and we did not find any relevant advantage of adding an endogenous commodity-exporting sector in order to compute the IRFs to a foreign monetary policy shock.

imported varieties. There is a large set of firms that use a CES technology to assemble final imported goods from imported varieties. These firms also have monopoly power and set their prices infrequently. All firms are also owned by Ricardian households. Third, there is an exogenous commodity-producing sector composed of a unique representative firm. The entire production is exported abroad and the international price of the commodity is taken as given. The government owns a fraction of the assets of that firm, and foreign investors own the remaining fraction, where the revenue is shared accordingly.

The central bank conducts the monetary policy through a simple Taylor-type feedback rule for the nominal interest rate and responds to headline CPI. The fiscal policy follows a structural balance fiscal rule, where government expenditure (government consumption and transfers to households) depends on cyclical adjustments of commodity price and output gap. In addition, the model includes distortional taxes in consumption, income, and capital gains.

There is a foreign sector composed of five exogenous variables (GDP, inflation, interest rate, oil price, and commodity price). We assume that the dynamics of these foreign variables are described by independent autoregressive processes of order one, AR(1), as in Medina and Soto (2007a) and Fornero and Kirchner (2014). We choose this framework instead of a foreign SVAR block (as in Fornero et al., 2015) to avoid selecting a SVAR identification scheme in the DSGE model.[15]

Finally, the model is parameterized using estimates from Bayesian estimation techniques with quarterly data covering the period 2001Q3-2007Q4 and 2001Q3-2014Q4 to analyze the robustness of the results. We use their posterior mean to compute the impulse responses to a foreign interest rate shock.[16]

[15] In this case, the identification scheme chosen for the foreign SVAR block would influence the impulse responses computed by the DSGE.

[16] Details of the Bayesian estimation are available on request. In particular, the persistence of the shock is calibrated to 0.87 following Medina and Soto (2007a). This value arises when the AR(1) process is estimated with a sample that ends before the subprime crisis.

4. RESULTS

This section is divided into four parts for ease of exposition. The first part describes the data used to estimate the VAR models along with the set of identified assumptions behind the recursive and *agnostic* schemes. The second part shows the comparison of the IRFs for both identification schemes and highlights their similarities and differences. The third part shows the IRF from the DSGE model for the Chilean economy. Finally, the last part compares the IRFs of the VAR and DSGE models. Thus, this comparison between models sheds new light and provides insights on the propagation of a foreign monetary policy shock over the Chilean economy, while it also assesses the suitability of the DSGE model (i.e., the theoretical model).

4.1 Data and Identification Schemes for SVAR-SOE Models

The data are monthly observations covering the period from January 1996 to December 2007[17] (1996m01-2007m12). Both recursive and *agnostic* identification schemes use the same data set. Table 1 shows the variables for each block of the SVAR-SOE model.

We transform price indexes in nominal US dollar terms (original sources) to real prices by dividing (deflating) by an external price index constructed to reflect the foreign Chilean trade structure. Domestic real GDP, investment, and price indexes are seasonally adjusted using the Census X-12 procedure when they are not available in seasonally adjusted form from the original source. The interest rates are defined in levels and the rest of the variables in logs. We choose a two-month lag based on standard information criteria and also following the recommendation of Castelnuovo (2016).

[17] The data after December 2008 is excluded because we want to isolate the propagation of the shock during a *normal* monetary regime, and clearly this was not the case after December 2008 since the federal funds rate experienced a unique path compared to its historical behavior (from September 2007 to April 2008, the policy rate decreased from 5.25% to 2%). However, we also estimate the models using the implicit foreign interest rate (shadow federal funds rate) covering the period from January 1996 to December 2014 to analyze the robustness of our results since this rate is not bounded below by zero.

Table 1

SET OF VARIABLES FOR SVAR-SOE MODELS

Foreign block (US)	*Domestic block (Chile)*
Industrial production index (y*)	Index of economic activity (y)
Consumer price index (CPI*)	Real machinery and equipment investment (Ime)
US federal funds rate (r*)	Real construction investment (Ic)
(US shadow federal funds rate)	Core consumer price index (CPIx1)
(Real price of oil)	Nominal monetary policy rate (r)
	Real exchange rate (RER)

Note: We use the Chow Lin procedure to transform quarterly into monthly frequency (e.g. domestic investments). Variables in parentheses in the foreign block are considered only for robustness exercises and not for the baseline model (exercises not reported). For further details concerning variables, sources and transformations see Table 1.A in Appendix A.

We do not include cointegration relations in the SVAR-SOE because we analyze the short-term dynamics and not the long-run behavior of the model. The main drawback of this approach is that we need to rely on simulation methods to make valid inference over the IRFs of the models; see Sims et al. (1990) for a comprehensive discussion of this issue. Finally, we control for the real price of copper and linear time trends, and add a constant term to each equation of the model.

The recursive VAR model is specified as in Fornero et al. (2015); the variables for each block were ordered according to Table 1 (i.e., most exogenous variables from top to bottom). In particular, this setting assumes that the domestic policy rate reacts contemporaneously with the rest of the variables in the system except for the exchange rate. Moreover, it cannot have a contemporaneous impact on the rest of the variables of the domestic block except the exchange rate; whereas the foreign policy rate has a contemporaneous impact over the domestic block but not over the rest of the variables of the foreign block.

Table 2 shows the set of restrictions for the *agnostic* VAR model. In addition, the table also describes two alternative *agnostic* models in order to assess the robustness of the base model. The foreign monetary policy shock is assumed to be positive for at least one month. The

Table 2

SIGN AND ZERO RESTRICTIONS
FOR AGNOSTIC VAR MODELS

	Base model		*Mod A*	*Mod B*
	h = 0	*h > 0*	*h > 0*	*h > 0*
Foreign block				
US federal funds rate (rus)	1	?	?	?
Industrial production index (Yus)	0	−1	−1	−1
Consumer price index (CPIus)	0	−1	−1	−1
Domestic block				
Interest rate (r)	?	?	?	?
Monthly production index (Y)	0	?	?	?
CPI core	?	?	?	?
Investment (I)	0	−2	−1	−3
Real exchange rate (RER)	1	?	?	?

Note: Restrictions are imposed over the monthly IRFs of the model after a positive foreign monetary policy shock. Positive or negative entries indicate the length of the sign restrictions, whereas zero entries indicate zero restrictions. Finally, question marks (?) indicate that no restrictions were imposed over the IRF of the variable at that horizon. We also consider two additional alternative sets of restrictions for the base model, see Table 2.A in Appendix A for more details.

shock does not have a contemporary impact on the foreign block or on domestic output and investment (both types of investment). We remain *agnostic* with respect to the contemporaneous response of the domestic policy rate and CPI, but we assume a real depreciation that lasts for at least one month. Finally, we assume that the variables of the foreign block react to the shock with a lag as well as domestic investment, but we assume a more persistent impact over the latter variable based on empirical data.[18]

[18] A different approach would be to rely on an *agnostic* VAR that heavily restricts the foreign block while minimizing the number of restrictions in the domestic block or in the extreme case leaving it completely unrestricted. However, the short sample of the data available for the Chilean economy makes this approach unsuitable since there is not enough information (data) to unveil the propagation of the shock.

The two alternative *agnostic* VAR models explore the sensitivity of the results to the restrictions imposed over domestic investment, which are perhaps the more controversial of the restrictions. In particular they consider two cases, one in which negative sign restrictions only last one period (Mod A) and a second case in which these restrictions last for at least three periods (Mod B). Thus, the base model lies between these two alternative cases. We also consider two additional alternative models in which we increase the restrictions over foreign monetary policy and the real exchange rate for the base model; see Table 2 of Appendix A for further details of these two cases.

The IFRs for the three cases are computed using monthly data, but we aggregate the monthly responses to quarterly responses in order to make the results comparable to the IRFs of the DSGE model. Alternatively, the IRFs can be estimated using quarterly data directly, but we argue that the identification of the foreign monetary policy shock is more reasonable at monthly frequency, because at quarterly frequency the restrictions constrain the contemporaneous response of the variables, which at the latter time frequency would imply stronger identifying assumptions. The same argument applies to the recursive scheme.

4.2 Results for SVAR-SOE Models

To begin with, we illustrate in Figure 1 the impulse responses of the domestic blocks to a 1% positive shock to the foreign interest rate (100 basis points) for the SVAR-SOE model according to the recursive (left panel) and *agnostic* (right panel) identification schemes.

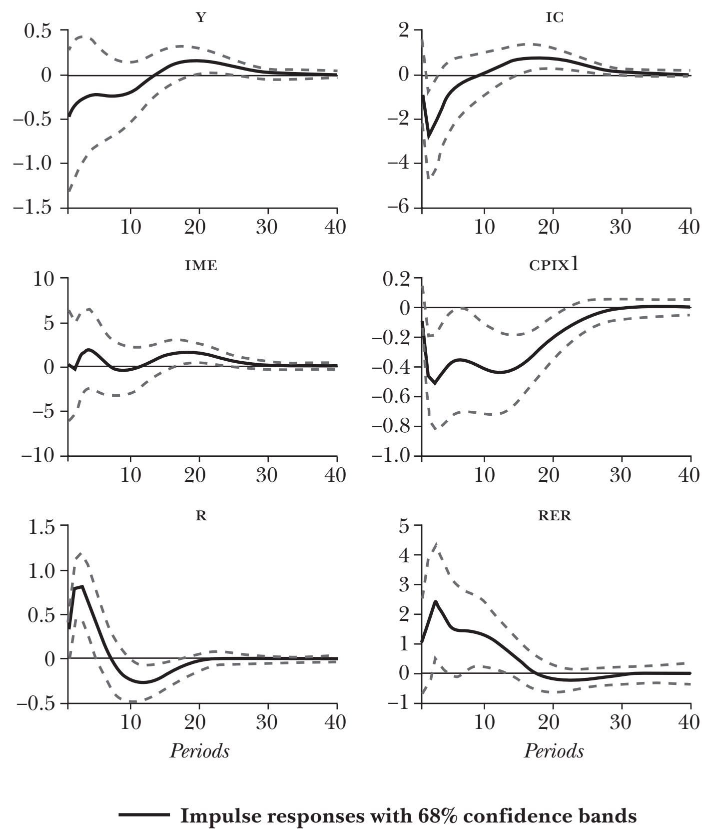
Figure B.1 (Apenddix) shows the responses for the foreign blocks.

In general, the identification of the recursive VAR model yields puzzling responses. In particular, the monetary policy shock is associated with expansionary conditions in the world economy (a boost in trade partners' activity, increases in foreign prices, and in real commodity prices). In the domestic economy, the effect on investment is slightly positive, while at the same time the impact on local activity is not significant. The fluctuations of RER and CPIx1 turn out to behave inconsistently because the appreciation of the real exchange rate should be associated with higher inflation, but the CPI drops. The drop in inflation can be associated to the local response of the interest rate.

Figure 1

IMPULSE RESPONSES FOR THE RECURSIVE AND AGNOSTIC IDENTIFICATION SCHEMES FOR THE DOMESTIC BLOCK TO A FOREIGN MONETARY POLICY SHOCK

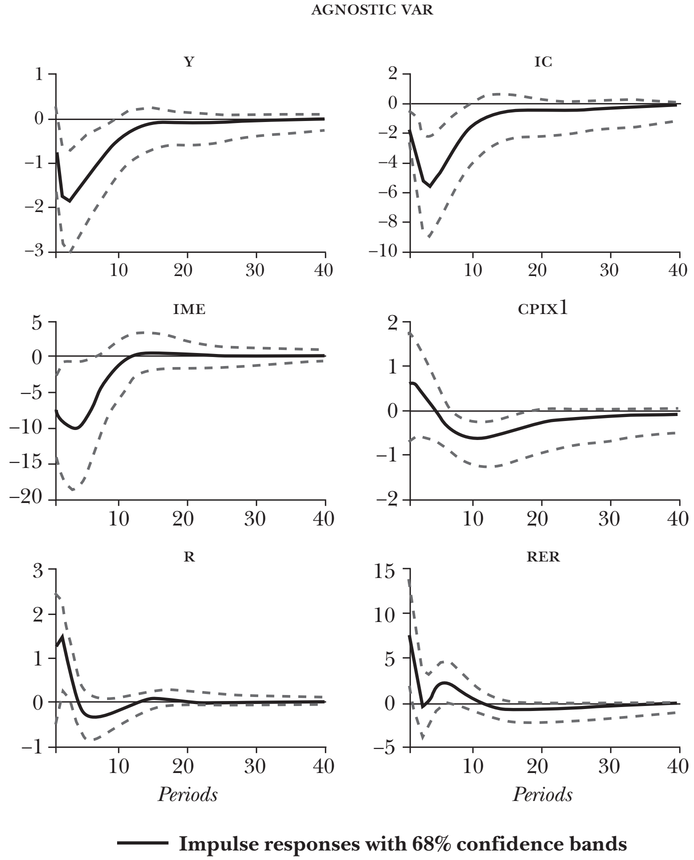
RECURSIVE VAR



Note: The figure shows the quarterly responses to a 1% positive shock to the foreign monetary policy rate at the monthly frequency. The quarterly responses were computed by aggregating the monthly responses of the model.

Figure 1 (cont.)

IMPULSE RESPONSES FOR THE RECURSIVE AND AGNOSTIC IDENTIFICATION SCHEMES FOR THE DOMESTIC BLOCK TO A FOREIGN MONETARY POLICY SHOCK



Note: The figure shows the quarterly responses to a 1% positive shock to the foreign monetary policy rate at the monthly frequency. The quarterly responses were computed by aggregating the monthly responses of the model.

Thus, according to these results the foreign shock has a small and limited impact over the domestic economy. In addition, the identification infers that the central bank reacts aggressively to contain any jump in inflation due to the pass-through of RER to inflation. However, at the same time the recursive identification scheme infers almost no impact over the local activity and investment.[19] There are at least two problems with this interpretation. First, according to the dynamics of the foreign block, the recursive VAR model is not able to identify the shock properly, and thus the previous analysis for the domestic block is not correct. Second, even if we are willing to believe that the model was able to identify the foreign shock, the results suggest that the shock has an extremely limited impact over the domestic economy, which seems unrealistic in light of the magnitude of the shock. Thus, we conclude that in this case, the recursive VAR model fails to provide an informative benchmark to judge and validate the IRFs of our structural micro-founded model.

The results for the *agnostic* VAR model offer a completely different view of the propagation of the shock. Overall, the impulse responses show results in line with macroeconomic theory. They are also statistically significant at conventional levels (with the exception of inflation and the domestic policy rate). The responses for foreign variables show dynamics that are consistent with those expected after a negative policy shock (i.e., a contractionary effect in foreign prices and activity). It is worth noticing that the responses in the foreign block go further beyond the restrictions that were specified in this identification scheme, and thus these results suggest that the shock is properly identified. In the domestic block, the shock has a strong negative impact over output and the two types of investment in the short run (around ten quarters). Moreover, the responses are significant at conventional levels. The fall of investment is mainly due to the large real exchange rate depreciation in line with tighter monetary conditions abroad (capital outflows, etc.). Finally, results show no impact over domestic prices due to the strong drop in the domestic activity that offsets the pass-through of the exchange rate to prices in the short run, which would also explain the lack of response

[19] We explored several alternative specifications to confirm these results. The first exercise consists of changing the order of variables (we assume the interest rate to be the most exogenous variable in the foreign block) and the results are qualitatively very similar.

for the domestic rate. However, there is a small drop in prices in the median-run due to the normalization of the exchange rate and depressed domestic activity.

Therefore, we argue that the *agnostic* VAR model is able to properly identify the foreign monetary policy shock, and the responses from this identification scheme can be used to validate the responses of our DSGE model. The comparison of these two models will enable us to shed new light and provide insights on the propagation of the foreign monetary policy shock over the domestic economy. In particular, we can compare and analyze the different policy implications for the domestic central bank, as well as the short/long-run dynamics and the convergence toward the equilibrium implied by both models in order to better characterize the propagation of the shock.

We consider four alternative sets of sign restrictions to analyze the robustness of the results for this identification scheme; see Table 2 (previous section) and Table A.2 (in the Appendix) for more details. Moreover, Figures B.2 and B.3 depict the IRFs of these four alternative models. In particular, Mod A and B show that restrictions in investment have a significant impact on the real variables, but nominal variables show similar dynamics between the alternative cases and base model. Thus, our conclusions hang on the plausibility of these restrictions. Finally, additional restrictions in foreign policy rate and real exchange rate do not change the responses of the variables significantly with respect to those reported for the base model.

4.3 Results for the DSGE Model

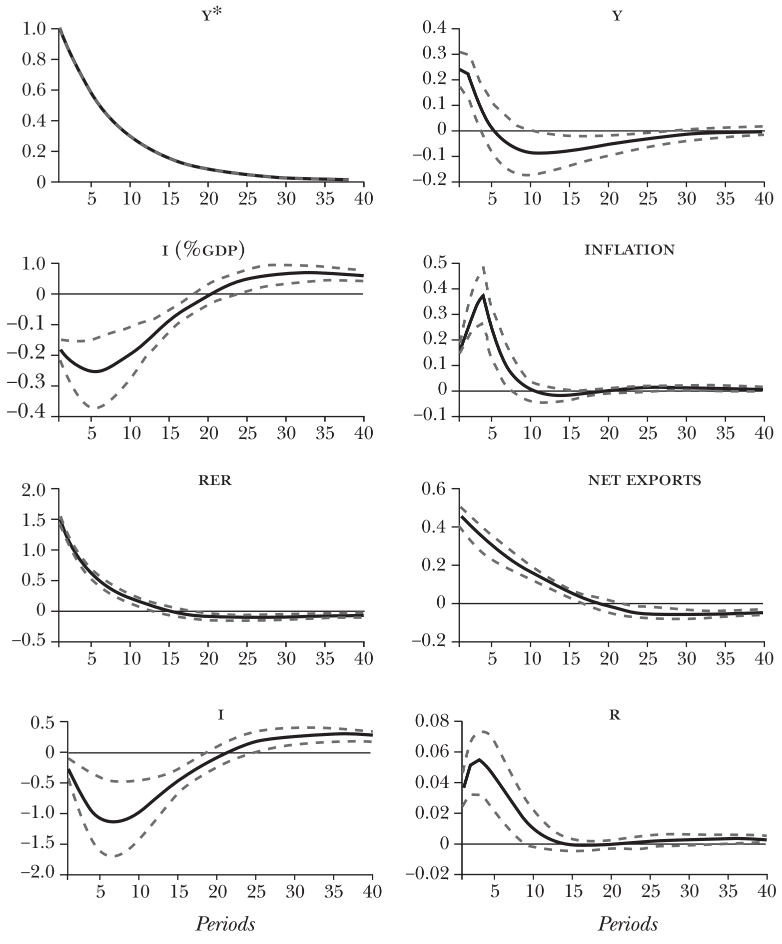
DSGE models are highly parameterized, and thus we estimate the model using data covering the period 2001Q3-2014Q4 in order to improve identification of the parameters of the models. Figure 2 illustrates the responses of the DSGE model to a 1% positive shock (100 basis points) to the foreign interest rate.

The tightening of foreign monetary conditions will lead to capital outflows away from Chile. This will endogenously influence the country risk premium (the debt burden increases if the country is a net borrower). Because of this, there will be a depreciation of the local currency in both nominal and real terms.[20] To fight against in-

[20] Notice that we take a conservative stance regarding the implications of the financial tightening in the US. We can expect additional financial

Figure 2

IMPULSE RESPONSES WITH A DSGE MODEL FOR CHILE
TO A FOREIGN MONETARY POLICY SHOCK



Impulse responses with 90% confidence bands (2001Q3-2014Q4)

Note: the model is parameterized using estimates from Bayesian estimation techniques with quarterly data covering the period 2001Q3-2014Q4. The figure shows the Bayesian impulse responses to a 1% positive shock (100 basis points) to the foreign interest rate. We assume that the dynamics of the foreign variables are described by independent autoregressive processes of order one, AR(1), as in Medina and Soto (2007a) and Fornero and Kirchner (2014).

flationary pressures, the central bank raises the policy rate. The latter causes a large fall in activity, particularly in investment, which decreases slightly more than 1% below its steady-state value

The real exchange rate rises persistently and, during the first periods, roughly depreciates by 1.5%. In consequence, marginal costs increase causing inflationary effects (around 0.2% on impact). As nominal prices are rigid, the inflation reaches its peak at the end of the first year. In addition, the results suggest that the immediate pass-through is 0.18 and increases towards the end of the first year. Moreover, consumption expenses also fall due to the increase in real interest rates (not shown in the figure). Consequently, the model predicts a modest but persistent contraction in output. Notice that the large persistence of the foreign monetary policy shock drives these important fluctuations. Finally, the persistence of the shock contributes to a large improvement of the current account, which explains the initial hike in output.

4.4 Comparing the Results of SVAR-SOE and DSGE Models

The main results from the IRFs analysis showed that the recursive VAR model was not able to identify the foreign monetary policy shock, and thus, the comparison excluded this identification scheme.

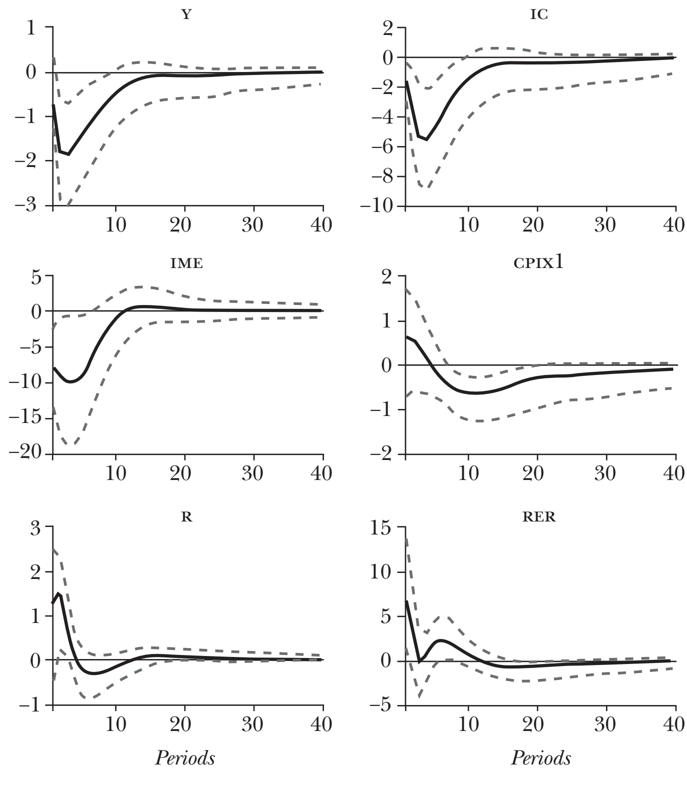
Before jumping into the comparison of the responses between the *agnostic* VAR (Figure 1) and DSGE model (Figure 2), there are two points that we need to address. First, responses for VAR models were constructed by aggregating monthly responses to quarterly frequency and hence their confidence intervals are wider than they should be because variables are smoother at higher frequencies. Thus, the sensitivity of the responses to the restrictions in investment should be reconsidered. Second, the DSGE model uses data from the period after 2008 whereas the VAR models do not, hence the comparison of

distress triggered by larger volatility in emerging economies such as: *i)* an increase of default probabilities of these countries yielding to a boost of country risk premiums; *ii*) the appreciation of the US dollar worldwide leading to unfavorable dynamics in commodity prices and in terms of trade for emerging economies. These further effects can be captured by setting a SVAR for these foreign variables instead of an AR(1) model for each variable. We avoid implementing that SVAR due to the strange implications arising from the Cholesky identification discussed above.

Figure 3

IMPULSE RESPONSES FOR THE AGNOSTIC VAR AND DSGE MODEL
RESPONSES TO A 1% POSITIVE SHOCK TO THE FOREIGN INTEREST RATE

AGNOSTIC VAR

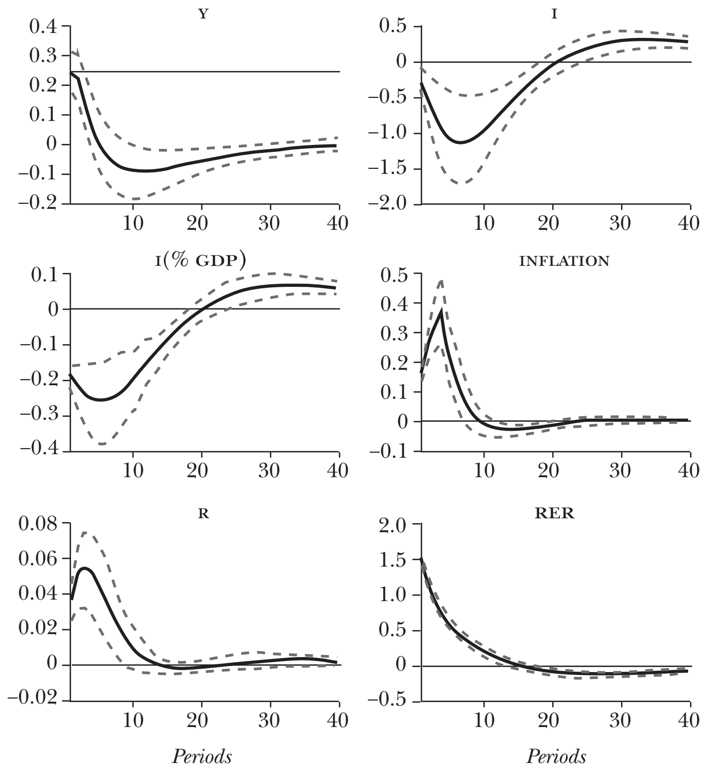


Note: Agnostic VAR, for the baseline model; quarterly responses were computed by aggregating monthly responses. DSGE model, Bayesian impulse responses. The figure shows the 68% and 90% confidence bands for the VAR and DSGE model, respectively.

Figure 3 (cont.)

IMPULSE RESPONSES FOR THE AGNOSTIC VAR AND DSGE MODEL RESPONSES TO A 1% POSITIVE SHOCK TO THE FOREIGN INTEREST RATE

DSGE MODEL



Note: Agnostic VAR, for the baseline model; quarterly responses were computed by aggregating monthly responses. DSGE model, Bayesian impulse responses. The figure shows the 68% and 90% confidence bands for the VAR and DSGE model, respectively.

the results may not be straightforward. We therefore also estimated an alternative DSGE model using a more comparable data set, but the results did not change significantly.[21] Figure 3 summarizes the results for the *agnostic* VAR and DSGE model.

Beyond the quantitative differences, we find that the impulse responses of the *agnostic* VAR model are in line qualitatively with the results of the DSGE model except for output. In the DSGE model, the initial hike is explained by the improving of the current account due to the real and nominal exchange rate depreciation; whereas the *agnostic* VAR infers a drop of almost two percent in output.

There are three key issues in the dynamics of the responses inferred by the DSGE model that we want to highlight. First, the model infers a limited propagation of the shock to the domestic economy, which may seem problematic in light of the size of the shock. Second, the peak of the shock over activity occurs during the second and third year after the shock (impact of the shock accumulates slowly over time). Finally, convergence toward the steady state is reached only in the long run. The last two issues may be due to the many micro-founded restrictions that are included in the model.[22] Ironically, these mechanisms are added to better fit the persistence observed in the data. On the contrary, the *agnostic* VAR offers a slightly different view about the propagation of the shock. In particular, it clearly indicates that the shock is much less persistent, but at the same time, it has a greater impact in the short-run. Finally, policy implications from both models turned out to be different, according to the *agnostic* VAR model, the central bank do not need to rise its policy rate because the drop in activity helps to contain any jump in inflation; whereas in the DSGE model the rise in prices is partially accommodated by the increase in the policy rate.

Of course, both models are approximations and thus we favor the view that the responses will lie between the responses of both models. The main advantage of the DSGE model is that it offers a comprehensive description of the propagation of the shock that enriches policy discussions. However, this comparison enables us to:

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[21] See Figure B.4 (Appendix) for the complete set of responses for this alternative DSGE model. The main difference is that the responses are exacerbated in this case.

[22] One example of these micro-founded restrictions is the delay in domestic consumption because of the assumption of consumption habits.

1) Validate the responses of the theoretical model (i.e., DSGE model) for the Chilean economy;

2) Better understand the propagation of the shock over the domestic economy, in terms of duration, length, and depth;

3) Develop potential improvements to the structure behind the DSGE model in order to address the three key issues outlined in the previous paragraph;

4) Offer a richer policy discussion for the policymaker.

5. CONCLUSIONS AND FURTHER DISCUSSION

This paper investigates the propagation of a foreign monetary policy shock over a small open economy, in particular over the Chilean economy. Our motivation is based on the ongoing period of monetary normalization already started by the Fed. We use a comprehensive methodological framework (i.e., two structural VAR models and a DSGE model tailored for the Chilean economy) in order to shed new light and provide insights on the propagation of the shock. We use this approach because according to Canova (2007), structural VAR models can be used to judge and validate the responses from a DSGE model. This exercise is important because the main advantage of DSGE models is that they provide a comprehensive description of the economy. Our main methodological contribution is to combine the methods of Arias et al. (2014) and Koop and Korobilis (2010) to develop an *agnostic* VAR model for SOE.

The results suggest that the recursive VAR model is not able to identify the shock since some of the responses are counterintuitive (especially for the foreign block). These results are in line with Bernanke et al. (2005), Mojon (2008) and Castelnuovo (2015). Thus, this identification scheme cannot be used to judge the responses of the DSGE model. On the contrary, the *agnostic* VAR model shows results in line with macroeconomic theory. The comparison between the *agnostic* VAR and DSGE model show that both approaches infer similar responses for the economy, except for output. In addition, we identify three points that deserve further attention in the dynamics of the DSGE model: *1)* The impact of the shock; *2)* Peak of the shock;

and *3)* The convergence toward the steady state. Finally, we spot different policy implications arising from both models. According to the *agnostic* VAR model, the central bank does not need to raise its policy rate because the drop in activity offsets any jump in inflation; whereas in the DSGE model the rise in prices is partially accommodated by the increase in the policy rate. Thus, this comparison enriches the discussion for the policymaker.

Our results therefore suggest that there is a gap in the interpretation of the propagation of the foreign monetary policy shock in these models. Further research is needed to develop a better propagation mechanism in the DSGE model to solve or improve the short- and long-run propagation mechanism of the shock. We leave these issues to further work. However, we recognize and propose two potential improvements for the DSGE model. First, significant gains could be made by improving the time series properties of the foreign shocks in these types of models; the DSGE model combines an AR(1) process to describe the foreign interest rate, which is, admittedly, extremely simple. The lack of a foreign propagation mechanism can help to explain the observed responses in this model. Second, the lack of financial restrictions mitigates the propagation of the shock; the model can be improved by including a financial accelerator as in Bernanke (1999). In brief, these improvements provide an opportunity to investigate the causes of the differences between the *agnostic* VAR and DSGE model.

Finally, we recognize that our comparison does not have a real benchmark to judge each model independently. A more elegant approach to performing the comparison would be to specify a more general DSGE model and simulate data from it. We could then compute and compare the responses of each model according to a loss function. However, our approach remains valid since it fosters discussion among policy makers. In addition, the specification of a true model is always a controversial assumption and in this case it would be similar to the DSGE model, meaning the comparison could be biased toward such model.

Appendix A

Table A.1

DATA USED FOR THE ESTIMATION OF THE SVAR MODELS

Variable	*Description*
Log world real GDP	World real GDP index, US indexof industrial production (both SA)
Log foreign price index	Chilean external price index (IPE) and US consumer price index (both SA)
Foreign interest rate	Fed funds rate
Log real copper price	Real copper price
Log real oil price	Real WTI oil price
Log domestic real GDP	Monthly economic activity indicator (IMACEC) (SA)
Log domestic price index	Consumer price index (IPC, 2013=100) (SA)
Log real exchange rate	Multilateral real exchange rate
Domestic interest rate	Monetary policy rate
Log real investment in machinery and equipment	Real gross fixed capital formation in machinery and equipment (SA)
Log real investment in construction	Real gross fixed capital formation in construction (SA)

Sources: Central Bank of Chile and Federal Reserve Economic Data (FRED, Federal Reserve Bank of St. Louis). The log world real GDP was constructed using the Chow-Lin procedure with monthly world production index for the world real GDP index, the log real copper price and oil price were deflated with the international price index (IPE, 2005=100). Finally, an increase in the exchange rate denotes a depreciation.

Table A.2

ALTERNATIVE AGNOSTIC VAR MODELS SIGN AND ZERO RESTRICTIONS

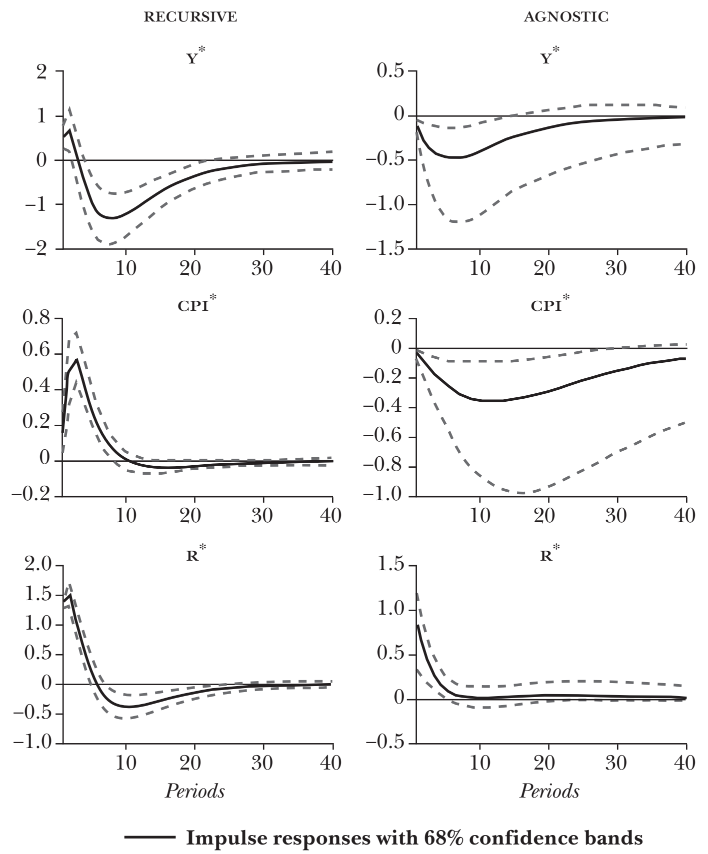
	Base model		*Mod C*	*Mod D*
	h = 0	*h > 0*	*h > 0*	*h > 0*
Foreign block				
US federal funds rate (rus)	1	?	2	2
Industrial production index (Yus)	0	−1	−1	−1
Consumer price index (CPIus)	0	−1	−1	−1
Domestic block				
Interest rate (r)	?	?	?	?
Monthly production index (Y)	0	?	?	?
CPI core	?	?	?	?
Investment (I)	0	−2	−2	−2
Real exchange rate (RER)	1	?	?	2

Restrictions are imposed over the monthly IRFs of the model after a positive foreign monetary policy shock. Positive or negative entries indicate the length of the sign restrictions, whereas zero entries indicate zero restrictions. Finally, question marks (?) indicate that no restrictions were imposed over the IRF of the variable at that horizon. We also consider two additional alternative set of restrictions for the base model; Mod C considers the foreign monetary policy to be positive for at least three months. Mod D considers the foreign monetary policy and the real exchange rate to be positive for at least three months. Thus, these two alternative *agnostic* schemes are incremental cases of the base model.

Appendix B

Figure B.1

IMPULSE RESPONSES FOR THE RECURSIVE AND AGNOSTIC IDENTIFICATION SCHEMES FOR THE FOREIGN BLOCK TO A FOREIGN MONETARY POLICY SHOCK

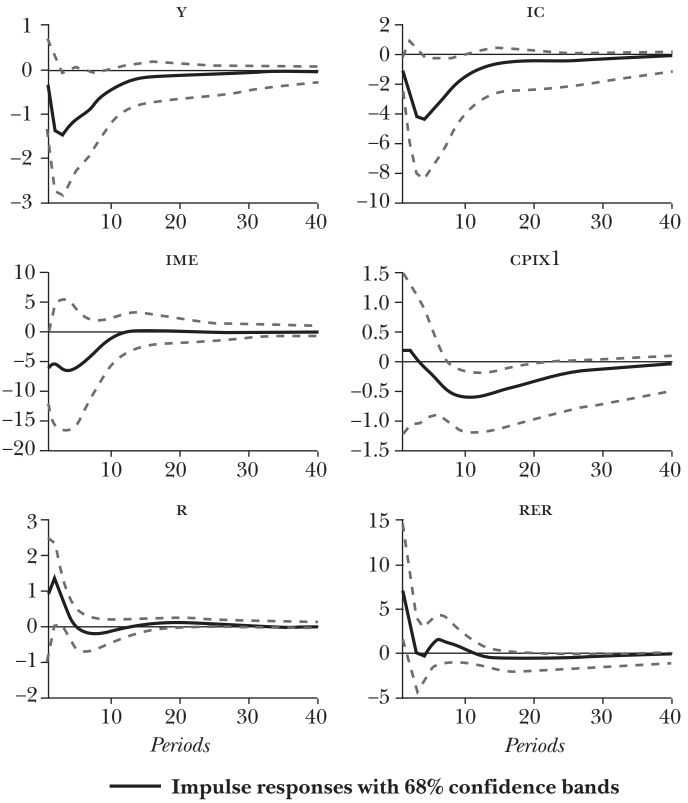


Note: Recursive VAR first column; *agnostic* VAR last column for the base line model. The figure shows the quarterly responses to a 1% positive shock to the foreign monetary policy rate at the monthly frequency. The quarterly responses were computed by aggregating the monthly responses of the model.

Figure B.2

IMPULSE RESPONSES FOR ALTERNATIVE AGNOSTIC VAR MODELS
FOR THE DOMESTIC BLOCK TO A FOREIGN MONETARY POLICY SHOCK

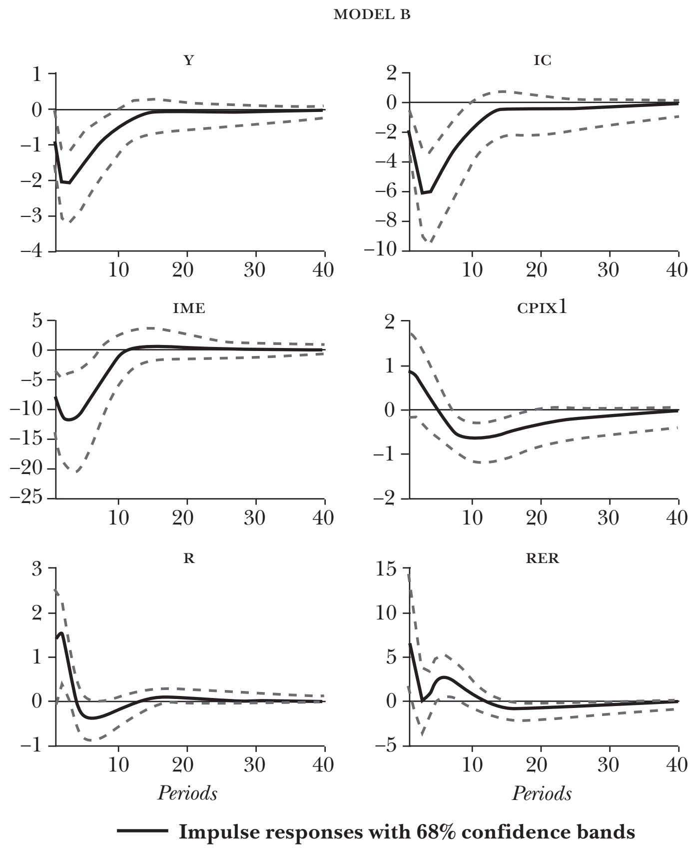
MODEL A



Note: Responses for the alternative restrictions over investment for *agnostic* VAR models: *1)* Mod A: negative sign restrictions only last one month; *2)* Mod B: negative sign restrictions last for three months. The figure shows the quarterly responses to a 1% positive shock to the foreign monetary policy rate at the monthly frequency. The quarterly responses were computed by aggregating the monthly responses of the model. The responses for the foreign blocks do not change in these two cases and thus they are not reported.

Figure B.2 (cont.)

IMPULSE RESPONSES FOR ALTERNATIVE AGNOSTIC VAR MODELS FOR THE DOMESTIC BLOCK TO A FOREIGN MONETARY POLICY SHOCK

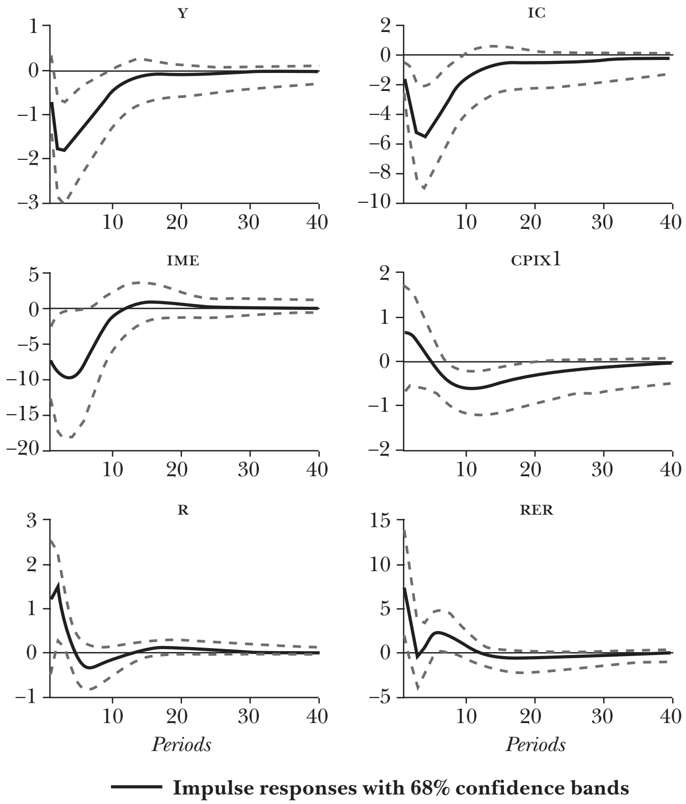


Note: Responses for the alternative restrictions over investment for *agnostic* VAR models: *1)* Mod A: negative sign restrictions only last one month; *2)* Mod B: negative sign restrictions last for three months. The figure shows the quarterly responses to a 1% positive shock to the foreign monetary policy rate at the monthly frequency. The quarterly responses were computed by aggregating the monthly responses of the model. The responses for the foreign blocks do not change in these two cases and thus they are not reported.

Figure B.3

IMPULSE RESPONSES FOR ALTERNATIVE AGNOSTIC VAR MODELS FOR THE DOMESTIC BLOCK TO A FOREIGN MONETARY POLICY SHOCK

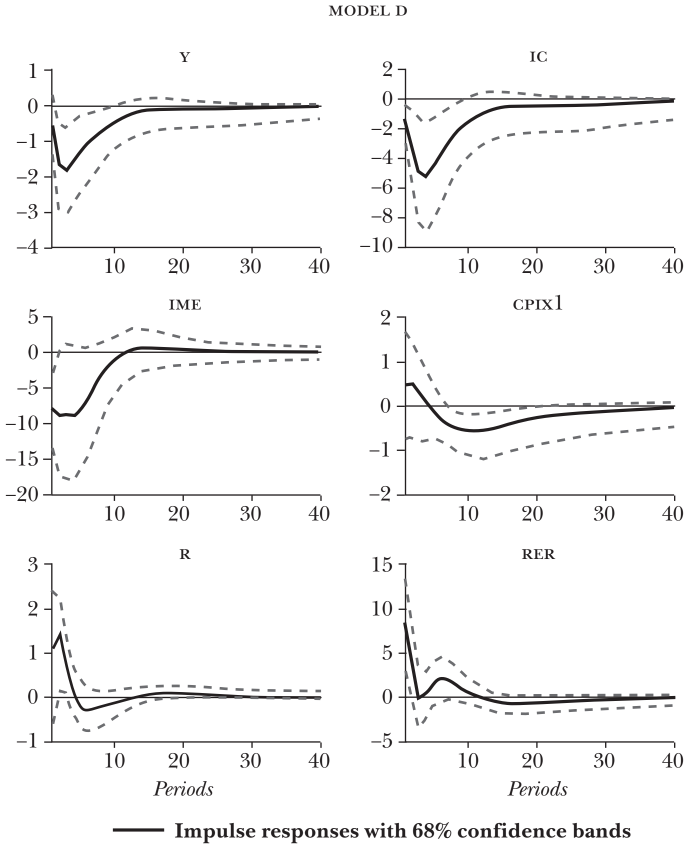
MODEL C



Note: Responses for the alternative agnostic VAR models: *1)* Model C: foreign monetary policy is positive for at least three months; *2)* Model D: foreign monetary policy and real exchange rate are positive for at least three months. Thus, these two alternative agnostic schemes are incremental cases of the base model. The figure shows the quarterly responses to a 1% positive shock to the foreign monetary policy rate at the monthly frequency. The quarterly responses were computed by aggregating the monthly responses of the model. The responses for the foreign blocks are the same as those in the base model and thus they are not reported.

Figure B.3 (cont.)

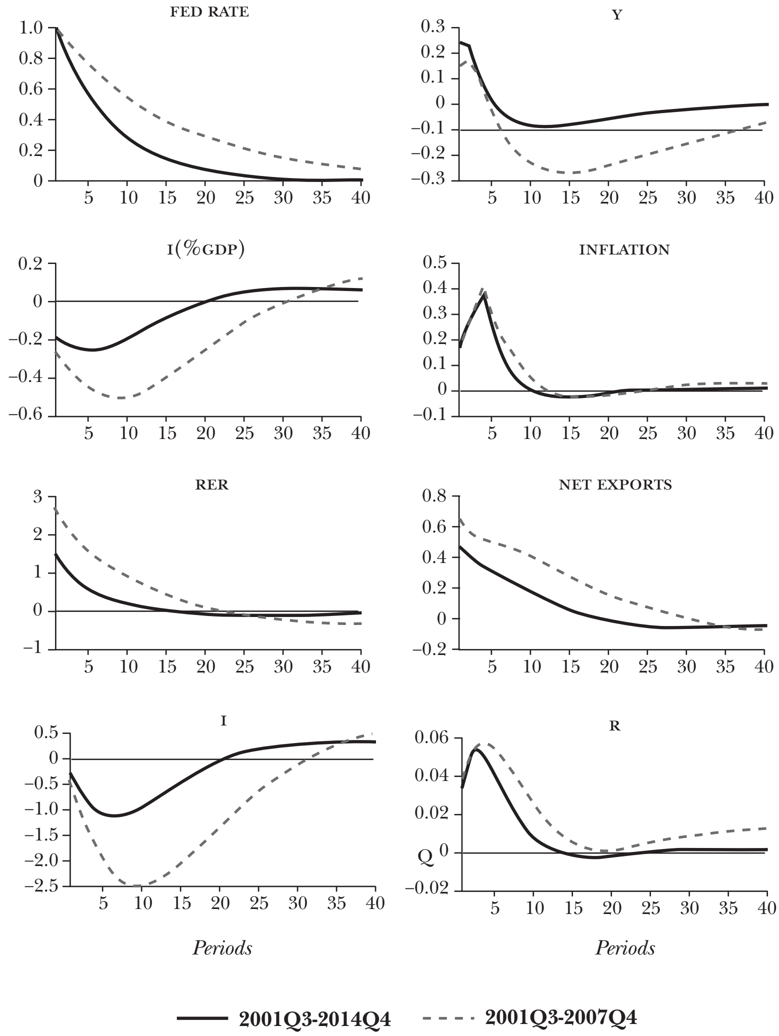
IMPULSE RESPONSES FOR ALTERNATIVE AGNOSTIC VAR MODELS FOR THE DOMESTIC BLOCK TO A FOREIGN MONETARY POLICY SHOCK



Note: Responses for the alternative agnostic VAR models: *1)* Model C: foreign monetary policy is positive for at least three months; *2)* Model D: foreign monetary policy and real exchange rate are positive for at least three months. Thus, these two alternative agnostic schemes are incremental cases of the base model. The figure shows the quarterly responses to a 1% positive shock to the foreign monetary policy rate at the monthly frequency. The quarterly responses were computed by aggregating the monthly responses of the model. The responses for the foreign blocks are the same as those in the base model and thus they are not reported.

Figure B.4

IMPULSE RESPONSES WITH A DSGE MODEL FOR CHILE
TO A FOREIGN MONETARY POLICY SHOCK



Note: Model is parameterized using estimates from Bayesian estimation techniques with quarterly data covering the period 2001Q3-2014Q4 and 2001Q3-2007Q4. The figure shows the Bayesian impulse responses to a 1% positive shock (100 basis points) to the foreign interest rate. We assume that the dynamics of the foreign variables are described by independent autoregressive processes of order one, AR(1), as in Medina and Soto (2007a) and Fornero and Kirchner (2014).

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The Effect of International Monetary Policy Expansions on Costa Rica

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Abstract

This paper studies if the international monetary policy has a major effect on the Costa Rican economy. The analysis is performed estimating a structural Bayesian vector autoregression (SBVAR) and a dynamic stochastic general equilibrium (DSGE) small open economy model estimated with Bayesian maximum likelihood methods using data from 2000 to 2014. The SBVAR estimation provides evidence that shocks to US interest rates, US inflation and US output in conjunction accounts for the following share of fluctuations: 43.2%, of nominal exchange rates; 52.2% of Costa Rican interest rates; 35.1% of Costa Rican inflation; 51.4% of Costa Rican output; 36.7% of exports; and 39.3% of imports. The DSGE model describes the mechanisms through which the local and foreign disturbances affect Costa Rica. An unexpected increase in the local interest rates means that the holding of local assets by the rest of the world increases; and it also incentives savings, which means postponed consumption. Households substitute deposits, local and foreign currency, with government debt. As expected the substitution of savings by government debt means there is no greater investment in the economy due to an increase in the risk premium. Meanwhile, an unexpected expansion in the US interest rate causes an outflow of resources from the economy, which along with the interest rate increase causes a depreciation of the currency and an increase in the local interest rate. Therefore consumption decreases and exports increase.

Keywords: monetary policy, central banks, general equilibrium.
JEL classification: E52, E58.

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1. INTRODUCTION

The expansive international monetary policy that has been in place since 2009, especially in the United States, has had several effects on the Costa Rican economy. The international financial crisis occurs just in the early stages of structural reforms for the monetary and exchange rate policies. In this context, the authorities have adapted to external conditions while taking advantage of them to finally control inflation and make progress in reforming the exchange rate regime. This paper aims to evaluate the effect of the international monetary policy over the local economic conditions.

The first observable consequence of the international monetary policy is the low interest rates prevalent for several years in the international markets. Given this, domestic economic agents were able to access cheap foreign borrowing. In fact, during the years 2012 to 2016 the Costa Rican government placed the equivalent of 8% of 2014 GDP in new foreign debt. On the domestic side, there was pressure on domestic interest rates originated by the need to finance the government deficit that conducted to a higher interest rate differential. These aspects attracted resources to Costa Rica and generated an appreciation pressure of the *colón* (CRC), which along with low commodity prices have been the main forces to reduce inflation.

Under the circumstances, the net international reserves (NIR) balance significantly increased, explained by the capital inflow into the economy and the obligation to defend the lower limit of the exchange rate band system along with the creation of several reserve accumulation programs established by the authorities of the Central Bank of Costa Rica (Banco Central de Costa Rica, BCCR). The following currency appreciation ended facilitating an important objective of the Central Bank, the reduction and stability of inflation and its convergence to that of the major trading partners.

The document is organized as follows. Section 2 provides a brief characterization of the Costa Rican economy. Section 3 uses a Bayesian vector autoregression estimation to study the magnitude of the effects of the international monetary policy over the local economy, especially the period after the recent financial crisis. Section 4 covers the DSGE model and the results of the impulse response functions that allow us to elaborate on the possible effects of changes in the international and local monetary policies, as well as other important international variables. And finally, Section 5 contains some conclusions and remarks.

2. THE COSTA RICAN ECONOMY AND THE INTERNATIONAL MONETARY POLICY[1]

2.1 Costa Rica in Figures

Costa Rica is a small and open economy; its main commercial partner is the United States of America (USA) that counts for 47% of the international trade (imports and exports). From the stock market point of view, Costa Rica is underdeveloped and it is not internationally integrated.

The GDP is about 53 billion dollars (USD) for 2015; and a GDP per capita for 2015 of 10,947 USD. The average real growth for 1991-2008 was 5.1%; as a result of the international financial crisis, the output decreased in 2009 (−1%) a moderated contraction compared with those of some Latin American economies. Since then the economic activity began a recovery process (4.1% from 2010-2015). According to calculations made by Esquivel and Rojas (2006) and updated by the Central Bank, the potential output in Costa Rica is estimated at 4.3 percent.

The country exhibited a large current account deficit, around 6.2% of the GDP for the period 2005-2008. This disequilibrium experienced a correction due to an improvement in terms of trade, a reduction of the value of its imports and a GDP contraction given the international financial crisis, and by the end of 2009 it was 2% of the GDP. For the period between 2010 and 2015, the current account deficit stands for 4.7% of the GDP and was almost entirely financed by foreign direct investment (Table 1).

From 1980 to 2008 the average inflation annual rate was 18.7%; it declined to 3.9% from 2009 to 2015. The Central Bank faces the challenge of consolidating this process to achieve and maintain similar inflation levels to its main trading partners, in the medium term.

In 2006 the BCCR started a slow transition to inflation targeting by introducing more flexibility in its exchange rate regime.

At that time the assessment of the BCCR was that in Costa Rica the implementation of a variation of fixed exchange rate regime (crawling peg) along with the Central Bank losses were a permanent source of money creation which made impossible to pin down inflation from 1982 to 2005.

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1 Based on Barquero and Muñoz (2016).

Table 1

COSTA RICA: MACROECONOMIC INDICATORS

Indicator	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Inflation	10.8	13.9	4.0	5.8	4.7	4.6	3.7	5.1	−0.8
Real rate of growth	7.9	2.7	−1.0	5.0	4.5	5.2	3.4	3.5	2.9
Current account deficit (percent of GDP)	6.3	9.3	2.0	3.5	5.4	5.3	5.0	4.8	4.2
Foreign direct investment (percent of GDP)	6.2	6.9	4.6	4.0	5.1	4.2	4.8	4.0	4.2
Net international reserves (percent of GDP)	15.6	12.7	13.8	12.7	11.5	15.1	14.9	14.6	15.2
Global public sector deficit (percent of GDP)[1]	−0.8	0.4	5.0	5.9	5.6	5.1	6.2	5.3	5.8
Financial wealth dollarization	38.0	43.2	42.9	39.8	36.7	32.9	30.8	32.2	30.4
Credit dollarization	42.4	44.6	42.6	38.7	39.4	41.1	42.1	41.0	41.6

[1] Negative value stands for surplus.
Source: Central Bank of Costa Rica.

In other words, the Central Bank did not have control over its monetary base and Costa Rica was a textbook example of the *impossible trinity.*

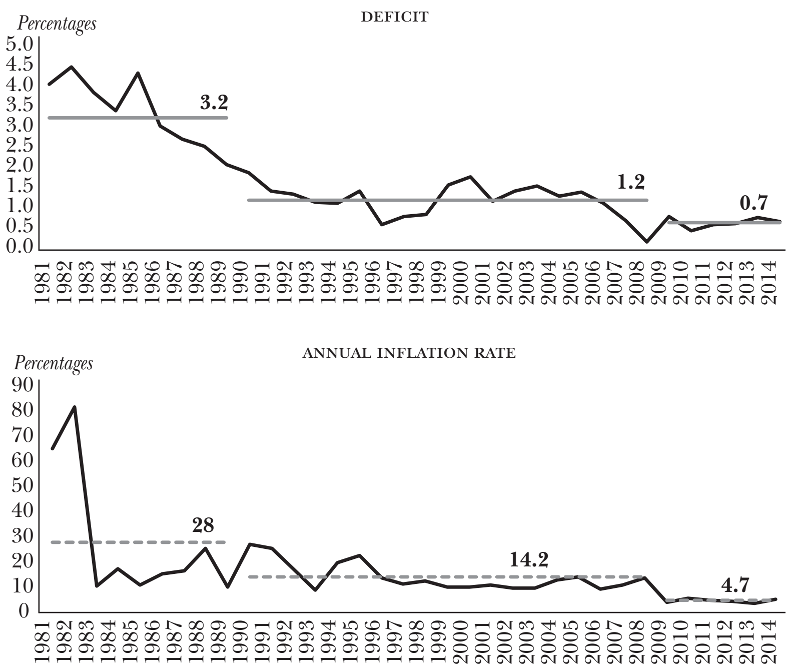
The basic idea was that in the medium and long terms, the inflation was created by the excess of money over its demand. So, by delinking the money creation process from the exchange rate regime that would reduce the sterilization needs of the Central Bank, it will reduce along time the size of the Central Bank deficit (Figure 1 shows this idea). Therefore, the BCCR will gradually take control of its two main sources of monetary expansion (fixed exchange rate regime and losses due to sterilization efforts).

The BCCR purpose was to move gradually from the fixed exchange rate regime to a free float one, in which the market forces are the main determinants of the nominal exchange rate.

Figure 1

BCCR: DEFICIT AND ANNUAL INFLATION RATE

Percentage of GDP



Source: Central Bank of Costa Rica.

During the first 19 months of the new regime the nominal exchange rate appreciated about 6%; however, this was a period in which the Central Bank continued purchasing international reserves and sterilizing the resulting monetary excesses. There was an improvement in its deficit; however, the inflation, in average, during the period 2006-2008 was not different from the previous 23 years, and this could also be partly explained by high inflation expectations generated after almost three decades of double-digit inflation.

2.2 Monetary Policy in Costa Rica

From 1983 to late 2006, the conceptual basis of the BCCR's monetary policy was the monetary approach to the balance of payments, which was run by a financial programming exercise oriented to control monetary aggregates (net domestic assets, M1, M2, total liquidity, total domestic credit), where the monetary policy instruments were basically reserve requirements and open market operations. The monetary approach to the balance of payments operates under a fixed exchange rate system; Costa Rica's exchange rate at the time was a crawling peg which in practice can be considered as fixed.

The fixed exchange rate regime and the opening of the capital account in 1992 actually meant that the BCCR lost monetary control over the economy and thus inflation control. This demonstrated the incompatibility between the monetary system and the exchange rate regime (impossible trinity), that led the country to inflation rates in double digits. Indeed, average inflation for the period 1980-2006 is around 19.3 percent.

In 2005 the Board of Directors of the BCCR decided to gradually advance on the adoption of a monetary policy regime based on inflation targets. As part of this process in October 2006, it decided to leave the exchange rate regime in operation since the early eighties and temporarily moved to a regime of exchange band. This amendment sought not only to provide greater flexibility in determining the nominal exchange rate, but also to strengthen the use of the interest rate transmission mechanism of monetary policy.

In June 2011 the Board redefined the monetary policy rate (*tasa de política monetaria* or TPM, in Spanish) as the reference interest rate used by the BCCR to drive the cost of operations within the integrated liquidity market (MIL). Specifically, the operations are conducted in a corridor formed by the interest rates on its standing facilities of credit and the deposit. Operationally, the Bank implements its monetary policy by influencing the amount of loanable funds and liquidity in the MIL, ensuring that the resulting interest rate approaches the monetary policy.

In February 2015, the Central Bank's Board of Directors makes the decision to migrate to a managed floating exchange rate regime in which the exchange rate is determined by the interaction of supply and demand while the BCCR intervenes to moderate excessive volatility without interfering with the market forces.

The main result of these reforms within an international environment of high liquidity and low interest rates was a sharp decline in the rate of inflation. The rates of inflation, expected inflation, and core inflation decreased from over 12% in 2008 to around 5% by 2010. Since then all these indicators have remained stable and low, allowing the BCCR to achieve a level of inflation that has mostly been within the target announced by the monetary authority and therefore increasing the level of credibility by the economics agents.

However, if the current level of inflation is not sustainable once the international monetary policy changes direction, or at least is not resilient to drastic increases in the exchange rate or the international price of commodities, that should be a source of concern for the Central Bank.

3. STRUCTURED BAYESIAN VECTOR AUTOREGRESSION (VAR) ESTIMATION

In this section, we perform a structured Bayesian vector autoregression (SBVAR)[2] estimation that allows seeing the relation between the main variables in the model. This is performed by checking the effect that the US economy has in the Costa Rican economy estimating a model following Zha (1999), which allows exogenous blocks in the estimation of the VAR in the sense that any variable that is not included in the block does not have an effect (coefficient equal to zero) in the corresponding equations of the exogenous block at time t and in lags. In addition, one can impose some structure in the matrix of contemporaneous coefficients in the left side of the VAR.

Our observable variables vector in this empirical work is given by $Y = [e, r^{CR}, \pi^{CR}, y^{CR}, imp^{CR}, exp^{CR}, r^{US}, \pi^{US}, y^{US}]$, where e is the real exchange rate between Costa Rican currency and US dollar, r is the real interest rate, π is the inflation, Y is the GDP, imp are the imports and exp are the exports. The series contain quarterly data from 2000 first quarter to 2014 third quarter and were transformed by using the Hodrick-Prescott filter.

Partitioning the observables Y_t into Costa Rican nominal, GDP and real variables, and US nominal variables: $Y_t^{e,nom} = [e, r^{CR}, \pi^{CR}]$, $y_t^y = [y^{CR}]$, $Y_t^{CR} = [imp^{CR}, exp^{CR}]$ *and* $Y_t^{\widetilde{nom}} = [r^{US}, \pi^{US}, y^{US}]$ respectively, the four blocks are given by:

$$\begin{bmatrix} TS_3 & A^y_{e,nom} & 0 & A^{\widetilde{nom}}_{e,nom} \\ 0 & I_{1\times 1} & A^{CR}_y & A^{\widetilde{nom}}_y \\ 0 & 0 & I_{2\times 2} & 0 \\ 0 & 0 & 0 & TS_3 \end{bmatrix} \begin{pmatrix} Y_t^{e,nom} \\ y_t^y \\ Y_t^{CR} \\ Y_t^{\widetilde{nom}} \end{pmatrix} = \begin{bmatrix} B^{e,nom}_{e,nom} & B^y_{e,nom} & B^{CR}_{e,nom} & B^{\widetilde{nom}}_{e,nom} \\ B^{e,nom}_y & B^y_y & B^{CR}_y & B^{\widetilde{nom}}_y \\ B^{e,nom}_{CR} & B^y_{CR} & B^{CR}_{CR} & B^{\widetilde{nom}}_{CR} \\ 0 & 0 & 0 & B^{\widetilde{nom}}_{\widetilde{nom}} \end{bmatrix} \begin{pmatrix} Y_{t-1}^{e,nom} \\ y_{t-1}^y \\ Y_{t-1}^{CR} \\ Y_{t-1}^{\widetilde{nom}} \end{pmatrix} + \begin{pmatrix} \varepsilon_t^{e,nom} \\ \varepsilon_t^y \\ \varepsilon_t^{CR} \\ \varepsilon_t^{\widetilde{nom}} \end{pmatrix},$$

where TS_n denotes an upper triangular matrix of dimension $n \times n$. The *structural errors* $\left[\varepsilon_t^{e,nom}, \varepsilon_t^y, \varepsilon_t^{CR}, \varepsilon_t^{nom}\right]$ are orthogonal with unit variance.

2 All the results are reported at the mode of the parameters distribution using maximum likelihood.

The contemporaneous matrix (left) can be seen as an upper triangular matrix of dimension 9x9 and this means that the variable which is on the top e is affected by the greatest number of variables (9), the one below r^{CR} does not receive effect from the first ordered variable e contemporaneously but from the others does it and so on, until the last ordered variable y^{US} is the most exogenous one. In this case, we also impose additional restrictions (zeros) in the model, in the first row the zero means that imports and exports of Costa Rica do not have an impact at time t in $Y_t^{e,nom}$. The other zero (third row) and the use of an identity matrix ($I_{\{2x2\}}$) imply no effect of any variable at time t in Y_t^{CR}.

In the matrix of lags (right), the restrictions are set by the method of estimation and as a consequence, the block of US variables is not affected (not at time t nor in lags) by the domestic variables. We must mention that this method is not equivalent to make two regressions: one with the domestic variables as dependents and all the variables as regressors, and the other with just the US variables as dependents and regressors as well, because this does not take into account the relationship between blocks when, for example, one computes the second moments and the variance decomposition as the other method does.

In the estimation we chose two lags because it gave us the best model fit when we compare the second moments of data and the model (standard deviations and correlations), we report only two tables, one with standard deviations and the correlations of all variables with y^{US} to save space.

As we see the most notable differences come from the correlation table, the first three variables e, r^{CR}, π^{CR} are the ones with more deviations in proportion; however, the signs do not change and the differences are not significant.

Table 1

STANDARD DEVIATIONS

	e	r^{CR}	π^{CR}	y^{CR}	imp^{CR}	exp^{CR}	r^{US}	π^{US}	y^{US}
Data	4.59	0.38	1.49	2.88	3.51	5.56	2.00	0.01	1.17
Model	4.52	0.47	1.49	2.85	4.26	5.14	1.58	0.01	1.05

Table 2

CORRELATIONS WITH y^{US}

	e	r^{CR}	π^{CR}	y^{CR}	imp^{CR}	exp^{CR}	r^{US}	π^{US}	y^{US}
Data	0.02	−0.20	0.44	−0.34	0.50	0.29	0.44	0.52	1.00
Model	0.13	−0.31	0.24	−0.34	0.32	0.21	0.36	0.43	1.00

Our main result in this estimation is the variance decomposition which shows a really big impact from the foreign shocks ξ^r, ξ^π and ξ^y to the domestic and bilateral variables e, r^{CR}, π^{CR}, y^{CR}, imp^{CR} and exp^{CR} with a cumulate effect of 43.2, 52.2, 35.1, 51.4, 36.7 and 39.3 respectively.

Table 3

VARIANCE DECOMPOSITION

	Bilateral	*Costa Rica*					*United States*		
	e	r^{CR}	π^{CR}	y^{CR}	imp^{CR}	exp^{CR}	r^{US}	π^{US}	y^{US}
ξ^e	33.6	7.0	9.1	5.0	7.9	5.7	0.0	0.0	0.0
$\xi^{\tilde{r}}$	7.7	10.5	4.4	2.7	4.8	3.5	0.0	0.0	0.0
$\xi^{\tilde{\pi}}$	4.6	11.6	26.3	4.1	5.3	10.6	0.0	0.0	0.0
$\xi^{\tilde{y}}$	1.9	6.0	10.1	16.4	5.4	4.4	0.0	0.0	0.0
$\xi^{\widetilde{imp}}$	2.7	4.4	11.0	1.8	14.9	3.8	0.0	0.0	0.0
$\xi^{\widetilde{exp}}$	6.4	8.2	3.9	18.8	25.0	32.5	0.0	0.0	0.0
ξ^r	4.5	23.4	7.8	10.4	6.8	9.1	77.1	19.1	23.7
ξ^π	19.6	3.3	14.8	7.0	2.7	6.7	11.4	79.9	2.6
ξ^y	19.1	25.5	12.5	34.0	27.2	23.5	11.6	1.0	73.7

The volatility of the real exchange rate is more affected by the inflation and product from USA and in almost the same quantity, while the domestic monetary policy gets the biggest effect from the interest rate and product, the domestic GDP gets the greatest impact of all the shocks precisely from the foreign GDP, and imports and exports are more influenced by the foreign product. The block of zeroes is brought because USA is the exogenous block, so nondomestic variable has an effect on its variables. To further investigate the mechanisms through which domestic and international shocks affect the Costa Rican economy, we then develop and estimate a DSGE model that characterizes the main elements of that economy.

4. THE EFFECT OF LOCAL AND INTERNATIONAL MONETARY POLICY ON COSTA RICA

4.1 DSGE Model

The DSGE model[3] for Costa Rica used in this paper is a new Keynesian model with price and wage frictions that includes a wide set of economic agents, among them households that receive income from their holdings of financial assets and also wages from labor. Additionally, they receive the profits from the firms that produce intermediate goods and direct transfers from the government. This income is used to buy consumption goods, pay taxes and buy financial assets for the next period.

The model also includes entrepreneurs that produce a homogeneous good using as inputs capital and labor. The production process requires the entrepreneur to buy capital at the beginning of the period. However its net wealth is not enough to buy the amount of capital required, thus it asks the financial sector for loans. These loans are funded with deposits from the households and foreign debt contracted by the banks.

The entrepreneurs sell their homogeneous good to firms that produce intermediate goods, which differentiate the homogeneous good at a zero cost. These firms pick a price that maximizes their profits even though they face a quadratic cost adjustment in price changes following Rotemberg (1982), creating this way price rigidity in the model.

3 Based on Alfaro et al. (2015).

The firms that produce intermediate goods sell them to the firms that produce final goods, which used the intermediate goods as inputs and then sell the aggregate product to the households as a consumption good, to the foreign sector as exports and to the firms that are capital producers as investment goods or capital input.

Finally, there is a monetary authority that sets the nominal interest rate according to a Taylor rule, and a government that issues debt, charges taxes on capital rents, wages, and consumption, and expends in investment and operating costs using a fiscal rule. A more detailed explanation of the model follows next.

4.1.1 Households

There is a number of identical households and a continuum of household members, where $z \in (0,1)$ represents the labor type offered by each household member, and $S \in (0,1)$ is the disutility of labor for each member (S) that represents the aversion to labor. Labor is indivisible, which means that the market labor adjustment takes place through the number of household members working and not through the amount of hours supplied.

Each employed household member utility is represented as

$$U = E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{(c_{t+i})^{1-\sigma_r}}{1-\sigma_r} - \chi s^\eta \right].$$

And the utility of unemployed members is

$$U = E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{(c_{t+i})^{1-\sigma_r}}{1-\sigma_r} \right].$$

The aggregate utility function for the household looks like:

$$U = E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{(c_{t+i})^{1-\sigma_r}}{1-\sigma_r} - \chi \int_0^1 \int_0^{n_{z,t+i}^d} s^\eta \, ds dz \right].$$

Or,

$$U = E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{(c_{t+i})^{1-\sigma_r}}{1-\sigma_r} - \chi \int_0^1 \frac{\left(n_{z,t+i}^d\right)^{1+\eta}}{1+\eta} dz \right].$$

Integrating among all kind of labor the household disutility of labor is found $\int_0^1 \frac{\left(n_{z,t+i}^d\right)^{1+\eta}}{1+\eta} dz$.

The household problem can be divided into two parts, the first chooses the consumption path $\{c_{t+i}\}_{i=0}^{\infty}$, real stocks of government bonds $\{b_{t+i}\}_{i=0}^{\infty}$, and deposits in local and foreign currency at the financial system $\{d_{t+i}, d_{t+i}^*\}_{i=0}^{\infty}$ in order to maximize the utility subject to the income constraint. In the second stage, the labor wage $w_{z,t}$ is determined by the labor kind z.

Utility Maximization Problem

The first optimization problem would be

$$\max_{\{c_{t+i}, b_{t+i}, d_{t+i}, d_{t+i}^{*}\}_{i=0}^{\infty}} U = E_t \sum_{i=0}^{\infty} \beta^i \left[\frac{(c_{t+i})^{1-\sigma_r}}{1-\sigma_r} - \chi \int_0^1 \frac{\left(n_{z,t+i}^d\right)^{1+\eta}}{1+\eta} dz \right],$$

subject to

1 $$\left(1+\tau_{t+i}^c\right)c_{t+i} + b_{t+i} + d_{t+i} + \frac{s_{t+i} p_{t+i}^*}{p_{t+i}^c} d_{t+i}^* = \left(1-\tau_{t+i}^L\right)\int_0^1 w_{z,t+i} n_{z,t+i}^d dz + \frac{i_{t+i-1}}{\pi_{t+i}^c} b_{t+i-1} + + \frac{i_{t+i-1}^d}{\pi_{t+i}^c} d_{t+i-1} + \frac{i_{t+i-1}^{d^*}}{\pi_{t+i}^*} \frac{s_{t+i} p_{t+i}^*}{p_{t+i}^c} d_{t+i-1}^* + + \xi_{t+i} + \xi_{t+i}^b - tr_{t+i}^G.$$

The household receives income from the wages of all the employed members $\int_0^1 w_{z,t} n_{z,t}^d dz$, it also receives the returns and the face value of the holdings of financial assets, for government bonds receives, i_{t-1} for deposits in local and foreign currency receives i_{t-1}^d and i_{t-1}^{d*}. Additionally, receives profits from the firms ξ_t and from the banks ξ_t^b. The household then buys consumption goods c_t, financial assets in local currency b_t, d_t and foreign currency d_t^* (valued using the real exchange rate $s_t p_t^* / p_t^c$). Finally, it pays taxes over consumption τ_t^c and labor τ_t^L and receives transfers for tr_t^G. Local inflation is π_t and foreign inflation π_t^*.

Optimality conditions are:

2 $$\lambda_t = \beta E_t \left(\lambda_{t+1} \frac{i_t}{\pi_{t+1}^c} \right)$$

$$\lambda_t = \beta E_t\left(\lambda_{t+1}\frac{i_t^d}{\pi_{t+1}^c}\right) \tag{3}$$

$$\lambda_t = \beta E_t\left(\lambda_{t+1}\frac{s_t p_{t+1}^*}{p_t^c}\frac{i_t^{d^*}}{\pi_{t+1}^*}\right) \tag{4}$$

$$\left(1+\tau_t^c\right)\lambda_t = c_t^{\left(-\sigma_r\right)} \tag{5}$$

Simultaneously the consumption basket composition between local and imported goods is determined to minimize its costs.

$$\min_{c_t^h, c_t^f} G = \frac{p_t^h}{p_t^c}c_t^h + \frac{p_t^f}{p_t^c}c_t^f ,$$

subject to

$$c_t = \left(\left(1-\alpha_c\right)^{\frac{1}{\eta_c}}\left(c_t^h\right)^{\frac{\eta_c-1}{\eta_c}} + \left(\alpha_c\right)^{\frac{1}{\eta_c}}\left(c_t^f\right)^{\frac{\eta_c-1}{\eta_c}}\right)^{\frac{\eta_c}{\eta_c-1}} \tag{6}$$

$$c_t^h = \left(1-\alpha_c\right)\left(\frac{p_t^h}{p_t^c}\right)^{-\eta_c} c_t \tag{7}$$

$$c_t^h = \left(1-\alpha_c\right)\left(\frac{p_t^h}{p_t^c}\right)^{-\eta_c} c_t \tag{8}$$

Optimal Wage and Labor Supply

The wage from labor z is $w_{z,t}$ and total labor supply $n_{z.t}^d$ is determined by the labor demanding aggregator firms.

Labor aggregator: The labor aggregator firm solves

$$\min_{n_{z,t}^d}\int_0^1 w_{z,t} n_{z,t}^d dz$$

$$s.t\, n_t^d \leq \int_0^1\left[\left(n_{z,t}^d\right)^{\frac{\theta^w-1}{\theta^w}} dz\right]^{\frac{\theta^w}{\theta^w-1}}$$

From which the labor demand can be derived

$$n_{z,t}^{d}=\left(\frac{w_{z,t}}{w_{t}}\right)^{-\theta^{w}}n_{t}^{d},$$

where the aggregate wage is

$$w_{t}=\left(\int_{0}^{1}w_{z,t}^{1-\theta^{w}}dz\right)^{\frac{1}{1-\theta^{w}}}.$$

Given the labor demand, household members determine the wage that maximizes the household utility taking into account there is a chance ε^{w} of not adjusting their wages in the next period.

$$\max_{w_{z,t}}E_{t}\sum_{i=0}^{\infty}\left(\beta\varepsilon^{w}\right)^{i}\left(\frac{\left(c_{t+i}\right)^{1-\sigma_{r}}}{1-\sigma_{r}}-\chi\int_{0}^{1}\frac{\left(n_{z,t+i}^{d}\right)^{1+\eta}}{1+\eta}dz\right),$$

subject to:

$$\left(1-\tau_{t+i}^{L}\right)\int_{0}^{1}w_{z,t+i}n_{z,t+i}^{d}dz+\frac{i_{t+i-1}}{\pi_{t+i}^{c}}b_{t+i-1}+\frac{i_{t+i-1}^{d}}{\pi_{t+i}^{c}}d_{t+i-1}+\frac{s_{t+i}p_{t+i}^{*}}{p_{t+i}^{c}}d_{t+i-1}^{*}\frac{i_{t+i-1}^{d^{*}}}{\pi_{t+i}^{*}}+\xi_{t+i}+\xi_{t+i}^{b}-tr_{t+i}^{G}=$$

$$\left(1+\tau_{t+i}^{c}\right)c_{t+i}+b_{t+i}+d_{t+i}+\frac{s_{t+i}p_{t+i}^{*}}{p_{t+i}^{c}}d_{t+i}^{*}$$

$$n_{z,t+i}^{d}=\left(\frac{w_{z,t+i}}{w_{t+i}}\right)^{-\theta^{w}}n_{t+i}^{d}$$

$$w_{z,t+i}=w_{z,t}$$

The FOC for optimal wage:

9
$$\left(1-\tau_{t}^{L}\right)w_{t}^{opt}=\frac{\theta_{w}}{\theta_{w}-1}\frac{Num_{w_{t}}}{Den_{w_{t}}}$$

10
$$Num_{w_{t}}=\chi_{r}\left(n_{t}^{d}\left(\frac{w_{t}^{opt}}{w_{t}}\right)^{(-\theta_{w})}\right)^{1+\gamma_{r}}+\beta\varepsilon_{w}\left(\left(\frac{w_{t}^{opt}}{w_{t+1}^{opt}}\right)^{(-\theta_{w})}\right)^{1+\gamma_{r}}Num_{w_{t+1}}$$

11
$$Den_{w_{t}}=\lambda_{t}n_{t}^{d}\left(\frac{w_{t}^{opt}}{w_{t}}\right)^{(-\theta_{w})}+\beta\varepsilon_{w}\left(\frac{w_{t}^{opt}}{w_{t+1}^{opt}}\right)^{(-\theta_{w})}Den_{w_{t+1}}$$

Aggregate wage is defined by

12 $$\left(w_t\right)^{1-\theta_w} = \varepsilon_w\left(w_{t-1}\right)^{1-\theta_w} + \left(1-\varepsilon_w\right)\left(w_t^{opt}\right)^{1-\theta_w}.$$

Unemployment: Labor participation by each household member is

$$\left(1-\tau_t^L\right)w_{z,t} \geq \frac{\chi s^\eta}{\lambda_t}$$

And the unemployment rate is

14 $$ur_t = \frac{l_t - n_t^d}{l_t},$$

which means that

$$\int_0^1 w_{z,t} n_{z,t}^d dz = w_t n_t^d .$$

4.1.2 Capital Goods Producers

These firms operate under perfect competition and each period buy capital and new investment goods in order to produce capital goods that are sold to entrepreneurs.

$$\max_{\{k_{t+i},x_{t+i}\}_{i=0}^{\infty}} \xi_t^{CP} = E_t \sum_{i=0}^{\infty}\left(\beta\frac{\lambda_{t+i}}{\lambda_t}\right)^i\left(\mu_{t+i}^K k_{t+i} - \frac{p_{t+i}^x}{p_{t+i}^c}x_{t+i} - (1-\delta)\mu_{t+i}^K k_{t+i-1}\right),$$

subject to:

15 $$k_{t+i} = x_{t+i}\left(1-s\left(\frac{x_{t+i}}{x_{t+i-1}}\right)\right) + (1-\delta)k_{t+i-1},$$

The optimality condition is

16 $$\frac{p_t^x}{p_t^c} = \mu_t^K\left(1-s\left(\frac{x_t}{x_{t-1}}\right) - \frac{x_t}{x_{t-1}}s'\left(\frac{x_t}{x_{t-1}}\right)\right) + \beta E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\mu_{t+1}^K s'\left(\frac{x_{t+1}}{x_t}\right)\left(\frac{x_{t+1}}{x_t}\right)^2\right),$$

where μ_t^k is the price of capital and $\frac{p_t^x}{p_t^c}$ is the price of investment goods. Production technology has adjustment costs a la Christiano et al. (2011), where

$$s\left(\frac{x_t}{x_{t-1}}\right)=\frac{1}{2}\left(e^{\sqrt{a}\left(\frac{x_t}{x_{t-1}}-1\right)}+e^{\left(-\sqrt{a}\right)\left(\frac{x_t}{x_{t-1}}-1\right)}-2\right)$$

$$s'\left(\frac{x_t}{x_{t-1}}\right)=\frac{\sqrt{a}}{2}\left(e^{\sqrt{a}\left(\frac{x_t}{x_{t-1}}-1\right)}-e^{\left(-\sqrt{a}\left(\frac{x_t}{x_{t-1}}-1\right)\right)}\right)$$

$$s'\left(\frac{x_{t+1}}{x_t}\right)=\frac{\sqrt{a}}{2}\left(e^{\sqrt{a}\left(\frac{x_{t+1}}{x_t}-1\right)}-e^{\left(-\sqrt{a}\left(\frac{x_{t+1}}{x_t}-1\right)\right)}\right)$$

The aggregate investment good is obtained as a combination of goods produced locally and imported,

17 $$x_t=\left(\left(1-\alpha_x\right)^{\frac{1}{\eta_x}}\left(x_t^h\right)^{\frac{\eta_x-1}{\eta_x}}+\left(\alpha_x\right)^{\frac{1}{\eta_x}}\left(x_t^f\right)^{\frac{\eta_x-1}{\eta_x}}\right)^{\frac{\eta_x}{\eta_x-1}}.$$

Then the optimal demand for investment goods is

18 $$x_t^h=\left(1-\alpha_x\right)\left(\frac{p_t^h}{p_t^x}\right)^{-\eta_x}x_t$$

19 $$x_t^f=\alpha_x\left(\frac{p_t^f}{p_t^x}\right)^{-\eta_x}x_t$$

where

20 $$\frac{p_t^h}{p_t^x}=\frac{p_t^h}{p_t^c}\Big/\frac{p_t^x}{p_t^c}$$

21 $$\frac{p^f}{p_t^x}=\frac{p_t^f}{p_t^c}\Big/\frac{p_t^x}{p_t^c}.$$

4.1.3 Entrepreneurs

Demand labor $\left(n_t^d\right)$ and supply labor $\left(n_t^e\right)$ acquire capital from the firm's producers of capital and for this use their resources $\left(nw_t\right)$ and acquire debt from the financial system for $\left(cr_t^{tot}\right)$.

22 $$cr_t^{tot}=\mu_t^K k_t-nw_t.$$

Finalized the productive process they sell the homogeneous good $y_t^{h^s}$ to the firms producers of intermediate goods. During the production process these firms face idiosyncratic shocks (z_t) that affect their productivity and that might make that the entrepreneur cannot be able to pay its debts. In this case the banks obtain a fraction of the capital owned by the entrepreneur:

23 $$y_t^{h^s} = z_t\left(\left(n_t^d\right)^{\Omega_n}\left(n_t^e\right)^{(1-\Omega_n)}\right)^{(1-\alpha)}\left(k_{t-1}\right)^{\alpha}\left(k_{t-1}^G\right)^{\alpha^G}.$$

The demand for household labor is determined by

24 $$w_t = \frac{p_t^w}{p_t^c}\Omega_n\left(1-\alpha\right)\frac{y_t^{h^s}}{n_t^d}.$$

Remuneration is

25 $$w_t^e = \frac{p_t^w}{p_t^c}\left(1-\Omega_n\right)\left(1-\alpha\right)\frac{y_t^{h^s}}{n_t^e}.$$

The demand for capital depends on the expected return

26 $$E_t\left(R_{t+1}^K\right) = E_t\left(\frac{r_{t+1}^k\left(1-\tau_{t+1}^K\right)+\mu_{t+1}^K\left(1-\delta\right)}{\mu_t^K}\right),$$

where the marginal product of capital is:

27 $$r_t^k = \frac{p_t^w}{p_t^c}\alpha\frac{y_t^{h^s}}{k_{t-1}}$$

and the entrepreneur's wealth then evolves according to

28 $$nw_t = \phi V_t + n_t^e w_t^e,$$

where

29 $$V_t = R_t^K\mu_{t-1}^K k_{t-1} - E_{t-1}\left(R_t^K\right)cr_{t-1}^{tot}$$

are the net returns for unit of capital. Finally, the entrepreneurs consume

30 $$\frac{p_t^h}{p_t^c}c_t^e = \left(1-\phi\right)V_t.$$

4.1.4 Intermediate Goods Producers

The firms buy the good produced by the entrepreneur at price p_t^w, it is differentiated at zero cost, and it is sold to the final good producers at price $p^h_{j,t}$. They face imperfect competition with quadratic adjustment costs.

$$\max_{p^h_{j,t}} \left(\xi^{nom}_{j,t}\right) = E_t \sum_{i=0}^{\infty} \left(\beta \frac{\lambda_{t+i}}{\lambda_t}\right)^i \left(\left(p^h_{j,t+i} - p^w_{t+i}\right) y^{h^d}_{j,t+i} - p^h_{t+i} \frac{\Psi}{2} \left(\frac{p^h_{j,t+i}}{p^h_{j,t+i-1} \left(\pi^h_{t-1}\right)^{\iota_n} \left(\bar{\pi}\right)^{1-\iota_n}} - 1\right)^2 \right)$$

subject to:

$$y^{h^d}_{j,t+i} = \left(\frac{p^h_{j,t+i}}{p^h_{t+i}}\right)^{-\theta} y^{h^d}_{t+i} .$$

The optimal price condition is:

$$0 = y^{h^d}_t \frac{p^h_t}{p^c_t}(1-\theta) + y^{h^d}_t \frac{p^w_t}{p^c_t}\theta - \tilde{c}\left(\frac{\pi^h_t}{\pi^h_{t-1}}\right)\Psi\left(\tilde{c}\left(\frac{\pi^h_t}{\pi^h_{t-1}}\right) - 1\right)\frac{p^h_t}{p^c_t}$$
$$+\beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t}\tilde{c}\left(\frac{\pi^h_{t+1}}{\pi^h_t}\right)\left(\tilde{c}\left(\frac{\pi^h_{t+1}}{\pi^h_t}\right) - 1\right)\frac{p^h_t}{p^c_t}\pi^h_{t+1}\right)$$

32

$$\xi_t = \left(\frac{p^h_t}{p^c_t} - \frac{p^w_t}{p^c_t}\right) y^{h^d}_t - \frac{p^h_t}{p^c_t}\Psi\left(c\left(\frac{\pi^h_t}{\pi^h_{t-1}}\right)\right)^2 ,$$

where

$$c\left(\frac{\pi^h_t}{\pi^h_{t-1}}\right) = \frac{\pi^h_t}{\left(\pi^h_{t-1}\right)^{\iota_n}\left(\bar{\pi}\right)^{1-\iota_n}} - 1$$

$$\tilde{c}\left(\frac{\pi^h_t}{\pi^h_{t-1}}\right) = \frac{\pi^h_t}{\left(\pi^h_{t-1}\right)^{\iota_n}\left(\bar{\pi}\right)^{1-\iota_n}}$$

$$\tilde{c}\left(\frac{\pi^h_{t+1}}{\pi^h_t}\right) = \frac{\pi^h_{t+1}}{\left(\pi^h_t\right)^{\iota_n}\left(\bar{\pi}\right)^{1-\iota_n}} .$$

Finally, it is possible to find the relationship between the Rotemberg (1982) adjustment cost and the Calvo (1983) price adjusting probability, following $\Psi = \frac{\varepsilon(\theta-1)}{(1-\varepsilon)(1-\beta\varepsilon)}$.

4.1.5 Final Good Producers

This firm maximizes its benefit through the determination of the optimal demand for inputs produced by the intermediate goods producers. The firm profit maximization problem is:

$$\max_{y_{j,t}^{h^d}} \xi_t = p_t^h y_t^{h^d} - \int_0^1 p_{j,t}^h y_{j,t}^{h^d} dj \ ,$$

where y_t^d are total final goods, $p_{j,t}^h$ price of each intermediate good and $y_{j,t}^{h^d}$ is its demand.

The maximization is subject to

$$y_t^{h^d} = \left(\int_0^1 \left(y_{j,t}^{h^d} \right)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} ,$$

where θ represents the degree of substitutability among the different inputs.

The demand for intermediate goods for final goods is

$$y_{j,t}^{h^d} = \left(\frac{p_{j,t}^h}{p_t^h} \right)^{-\theta} y_t^{h^d} \ .$$

The local goods price is

$$p_t^h = \left(\int_0^1 \left(p_{j,t}^h \right)^{1-\theta} dj \right)^{\frac{1}{1-\theta}} .$$

In equilibrium supply and demand of final goods should equal and then follow this condition:

33 $$y_t^{h^s} = y_t^{h^d} \ .$$

4.1.6 Financial System

The financial system of the economy operates under perfect competition and banks are owned by the households. They make loans to the entrepreneurs by taking deposits from the household and loans from abroad.

34 $$cr_t^{tot} = cr_t + cr_t^* \ .$$

Loans in local currency come from household deposits

35 $$cr_t = d_t \, .$$

Loans in foreign currency are funded with deposits in foreign currency from the households and foreign debt (loans).

36 $$cr_t^* = \frac{s_t p_t^*}{p_t^c} d_t^* + \frac{s_t p_t^*}{p_t^c} b_t^* \, .$$

Total household deposits are

37 $$d_t^{tot} = d_t + \frac{s_t p_t^*}{p_t^c} d_t^* \, .$$

Deposits in foreign currency are a ratio of total deposits.

38 $$\frac{s_t p_t^*}{p_t^c} d_t^* = \alpha_d \left(d_t^{tot} \right) .$$

Given the banks can observe the idiosyncratic shock suffered by the entrepreneurs only if they incur in monitoring costs, the optimal contract offered by the bank stipulates jointly the amount of the loan and the interest rate to be paid. This friction in the intermediation process implies the loan interest rate includes a margin $\left(sp_t \right)$ that depends on the value of the loan and the net wealth of the entrepreneurs,

39 $$R_{t+1}^K = sp_{t+1} \frac{i_t}{\pi_{t+1}^c}$$

40 $$sp_t = \left(\frac{k_{t-1} \, \mu_{t-1}^K}{nw_{t-1}} \right)^{\nu} \, .$$

The cost of funds follows the parity condition given by

41 $$\frac{i_t}{\pi_{t+1}^c} = \left(\frac{s_t p_t^*}{p_t^c} \Big/ \frac{s_{t-1} p_{t-1}^*}{p_{t-1}^c} \right) \frac{i_t^*}{\pi_{t+1}^*} \, .$$

Bernanke et al, (1999) show that the optimal contract guarantees the zero profit condition for the banks:

42 $$\xi_t^b = R_t^K cr_{t-1}^{tot} - \frac{i_{t-1}^d}{\pi_t^c} d_{t-1} - \frac{s_t p_t^*}{p_t^c} \left(\frac{i_{t-1}^{d^*}}{\pi_t^c} d_{t-1}^* - \frac{i_{t-1}^*}{\pi_t^*} b_{t-1}^* \right) .$$

4.1.7 Central Bank and Government

Central Bank: The Central follows this rule to achieve a the inflation objective

$$i_i = \left(i_{t-1}\right)^{\rho_s} \left(\bar{i} \left(\frac{\pi_t^c}{\bar{\pi}} \right)^{\rho_\pi} \right)^{1-\rho_s} \varepsilon_t^i . \tag{43}$$

Total inflation can be derived from relative prices

$$\frac{\pi_t^h}{\pi_t^c} = \frac{\dfrac{p_t^h}{p_t^c}}{\dfrac{p_{t-1}^h}{p_{t-1}^c}} . \tag{44}$$

Government: The government collects taxes, issues bonds and has expenditures represented by g_t , and makes transfers to the households. Government collects taxes from consumption, income and capital returns and follows a countercyclical fiscal policy with automatic stabilizers, to ensure a stable debt to GDP ratio. The balance is given by:

$$b_t + Tax_t = b_{t-1} \frac{i_{t-1}}{\pi_t^c} + \frac{p_t^h}{p_t^c} g_t - tr_t^G . \tag{45}$$

Taxes are

$$Tax_t = t_t^K + t_t^C + t_t^L \tag{46}$$

given

$$t_t^C = \tau_t^c c_t \tag{47}$$

are consumption taxes,

$$t_t^L = \tau_t^L n_t^d w_t \tag{48}$$

labor taxes

$$t_t^K = \tau_t^K r_t^k k_{t-1} \tag{49}$$

and capital return taxes. Total expenditure includes operating costs and investment

$$g_t = c_t^G + x_t^G . \tag{50}$$

The investment expenditure is transformed into public capital that affects the entrepreneurs' productivity,

51 $$k_t^G = x_t^G + \left(1 - \delta^G\right) k_{t-1}^G .$$

Finally, it has a set of instruments (expenditure options and tax rates) that guarantee the fulfillment of $b_t = \bar{b}$. This rule follows Leeper et al. (2010b and 2010a). Additionally, the rule also includes a countercyclical response by the government $pib_t > \overline{pib}$.

52 $$\Theta_{tr_t^G} = \overline{tr}^G \left(\frac{b_t}{b_t^s} \right)^{\gamma^{tr^G}} \varepsilon_t^{tr^G} ,$$

53 $$\Theta_{c_t^G} = \left(\frac{pib_t}{\overline{\overline{pib}}} \right)^{\left(-\psi^{c^G}\right)} \left(\overline{c}^G \right)^{1-\rho^{c^G}} \left(\frac{b_t}{\overline{b}} \right)^{\left(-\gamma^G\right)} \left(c_{t-1}^{G^s} \right)^{\rho^{c^G}} \varepsilon_t^{c^G} ,$$

54 $$\Theta_{x_t^G} = \left(\frac{pib_t}{\overline{\overline{pib}}} \right)^{\left(-\psi^{x^G}\right)} \left(\overline{x}^G \right)^{1-\rho^{x^G}} \left(\frac{b_t}{\overline{b}} \right)^{\left(-\gamma^{x^G}\right)} \left(x_{t-1}^{G^s} \right)^{\rho^{x^G}} \varepsilon_t^{x^G} ,$$

55 $$\tau_t^K = \left(\frac{pib_t}{\overline{\overline{pib}}} \right)^{\psi^K} \left(\overline{\tau}^K \right)^{1-\rho^{z^{tk}}} \left(\frac{b_t}{\overline{b}} \right)^{\gamma^{tk}} \left(\tau_{t-1}^K \right)^{\rho^{z^{tk}}} \varepsilon_t^{z^{tk}} ,$$

56 $$\tau_t^L = \left(\frac{pib_t}{\overline{\overline{pib}}} \right)^{\psi^L} \left(\overline{\tau}^L \right)^{1-\rho^{z^{tl}}} \left(\frac{b_t}{\overline{b}} \right)^{\gamma^L} \left(\tau_{t-1}^L \right)^{\rho^{z^{tl}}} \varepsilon_t^{z^{tl}} ,$$

57 $$\tau_t^c = \left(\frac{pib_t}{\overline{\overline{pib}}} \right)^{\psi^c} \left(\overline{\tau}^c \right)^{1-\rho^{z^{tc}}} \left(\frac{b_t}{\overline{b}} \right)^{\gamma^c} \left(\tau_{t-1}^c \right)^{\rho^{z^{tc}}} \varepsilon_t^{z^{tc}} ,$$

where

58 $$pib_t = \frac{p_t^h}{p_t^c} y_t^{h^d} .$$

4.1.8 Rest of the World and Aggregate Restrictions

Price of imported goods follows PPP, where the relative price of an imported good in foreign currency $\frac{p_t^{f^*}}{p_t^*}$ is assumed exogenous

59 $$\frac{p_t^f}{p_t^c} = \frac{s_t p_t^*}{p_t^c} \frac{p_t^{f^*}}{p_t^*} .$$

Exports depend on global consumption

60 $$\exp_t = \left(\frac{\frac{p_t^h}{p_t^c}}{\frac{s_t p_t^*}{p_t^c}} \right)^{(-\mu)} c_t^* \cdot$$

The interest rate charged on foreign debt depends on the risk-free rate $\bar{i}^*$, a risk premium shock $z_t^{i^*}$, through which are transmitted the changes in international monetary policy, and the relative size of the stock of debt with respect to its long-term level $\left(b_t^*\right)$.

61 $$i_t^* = \bar{i}^* z_t^{i^*} + \varphi^b e^{\left(\left(b_t^* - \bar{b}^*\right) - 1\right)}$$

Nominal exchange rate variation is defined by the real exchange rate

62 $$\frac{\frac{s_t p_t^*}{p_t^c}}{\frac{s_{t-1} p_{t-1}^*}{p_{t-1}^c}} = \frac{\pi_t^* dev_t}{\pi_t^c} \cdot$$

Finally, a condition that guarantees the local production demand and supply is imposed.

63 $$y_t^{hd} = c_t^e + g_t + \exp_t + c_t^h + x_t^h \cdot$$

4.1.9 Exogenous Variables

64 $$z_t = \rho_z z_{t-1} + (1 - \rho_z) \log(\bar{z}) + \varepsilon_t^z \cdot$$

65 $$c_t^* = \rho^{c^*} c_{t-1}^* + \left(1 - \rho^{c^*}\right) \log\left(\bar{c}^*\right) + \varepsilon_t^{c^*} \cdot$$

66 $$z_t^{i^*} = \rho^{z^{i^*}} z_{t-1}^{i^*} + \varepsilon_t^{i^*} \cdot$$

67 $$\frac{p_t^{f^*}}{p_t^*} = \rho^{p^{f^*}} \frac{p_{t-1}^{f^*}}{p_{t-1}^*} + \left(1 - \rho^{p^{f^*}}\right) \log\left(\overline{\frac{p^{f^*}}{p^*}}\right) + \varepsilon^{p^{f^*}} \cdot$$

68 $$\pi_t^* = \rho^{\pi^*} \pi_{t-1}^* + \left(1 - \rho^{\pi^*}\right) \log\left(\bar{\pi}^*\right) + \varepsilon_t^{\pi^*} \cdot$$

4.1.10 Product Ratios and Definitions

The following are product ratios.

69
$$\Theta_{tax} = \frac{Tax_t}{pib_t}$$

70
$$\Theta_{tr_t^G} = \frac{tr_t^G}{pib_t}$$

71
$$\Theta_{g_t} = \frac{\frac{p_t^h}{p_t^c} g_t}{pib_t}$$

72
$$\Theta_{c_t^G} = \frac{\frac{p_t^h}{p_t^c} c_t^G}{pib_t}$$

73
$$\Theta_{x_t^G} = \frac{\frac{p_t^h}{p_t^c} x_t^G}{pib_t}$$

74
$$\Theta_{t_t^C} = \overline{\tau}^C \left(\frac{c_t}{pib_t} \right)$$

75
$$\Theta_{t_t^L} = \overline{\tau}^L \left(\frac{w_t n_t^d}{pib_t} \right)$$

76
$$\Theta_{t_t^K} = \overline{\tau}^K \left(\frac{r_t^k k_t}{pib_t} \right)$$

77
$$\Theta_{cr_t^{tot}} = \frac{cr_t^{tot}}{pib_t^{anual}}$$

78
$$\Theta_{d_t^{tot}} = \frac{d_t^{tot}}{pib_t^{anual}}$$

79
$$\Theta_{b_t} = \frac{b_t}{pib_t^{anual}}$$

4.2 Calibration and Estimation

The model calibration was done using historical information from the period 2000-2014, adjusting the parameters associated with the fiscal rule in order to adjust the government expenditure and investment. Also the local goods proportion in consumption and investment were used to adjust the total imports. The capital depreciation and the capital participation in the production function were needed to adjust total consumption and private investment. The amount of exports is an equilibrium outcome coherent with the amount of imports and foreign debt.

In the case of the government income and debt, the values are adjusted using the historical effective tax rates. In order to adjust the credit level and the bank spread, the firms, leverage and spread elasticity are used. The long-term value for the interest rate, inflation and unemployment are adjusted using the Central Bank inflation target, the discount factor and the elasticity of substitution of labor.

A preliminary estimation of the model is performed in order to find the parameters that affect the model dynamics. Among the estimated values are the wage and price rigidities, the persistence and variances to the shocks as well as the adjustment costs. In order to find these parameters the models uses the cyclical component of the logarithm of the quarterly series of output, private, government and total consumption, capital formation, exports, imports, local and foreign inflation, nominal interest rate and finally the world total output from 2000Q1 until 2014Q3. These are affected by a series of possible shocks that include shocks to government consumption, investment, government transfers, government consumption taxes, government capital taxes, government labor taxes, monetary policy, foreign inflation, foreign prices, international interest rate, foreign demand shock, productivity shock. Following we present the priors and posteriors obtained from the estimation process as well as the calibration results.

Table 4

ESTIMATION RESULTS

Parameters

	Prior mean		*Pstdev*	*Post. mean*	*90% HPD interval*		*Mode*	*S.D.*
ε_w	0.50	β	0.15	0.9127	0.8650	0.9580	0.9368	0.0234
ε_w	0.50	β	0.15	0.3451	0.2196	0.4519	0.3581	0.0690
ρ_s	0.50	β	0.15	0.4952	0.3787	0.6148	0.5005	0.0676
ρ_z	0.50	β	0.15	0.5531	0.4512	0.6812	0.5880	0.0597
ρ^{c^G}	0.50	β	0.15	0.9273	0.8808	0.9728	0.7566	0.0795
ρ^{c^*}	0.50	β	0.15	0.8290	0.7580	0.9061	0.8358	0.0466
$\rho^{z^{i^*}}$	0.50	β	0.15	0.7486	0.6799	0.8143	0.6771	0.0815
ρ^{π^*}	0.50	β	0.15	0.2821	0.1954	0.3989	0.0266	0.0144
$\rho^{p^{f^*}}$	0.50	β	0.15	0.9467	0.9206	0.9725	0.8833	0.0303
a	1.00	Γ	0.50	0.3311	0.2152	0.4370	0.3258	0.0748

Standard Deviation of the Shocks

Prior mean		*Pstdev*	*Post.mean*	*90% HPD interval*		*Mode*	*S.D.*
0.013	Γ^{-1}	Inf	0.0264	0.0207	0.0325	0.0217	0.0058
0.013	Γ^{-1}	Inf	0.0098	0.0066	0.0125	0.0094	0.0017
0.013	Γ^{-1}	Inf	0.0110	0.0080	0.0140	0.0106	0.0017
0.013	Γ^{-1}	Inf	0.0053	0.0045	0.0060	0.0051	0.0005
0.013	Γ^{-1}	Inf	0.0042	0.0031	0.0054	0.0048	0.0011
0.013	ε^{i^*}	Inf	0.0063	0.0029	0.0094	0.0535	0.0084
0.013	Γ^{-1}	Inf	0.0218	0.0166	0.0267	0.0217	0.0036

Table 5

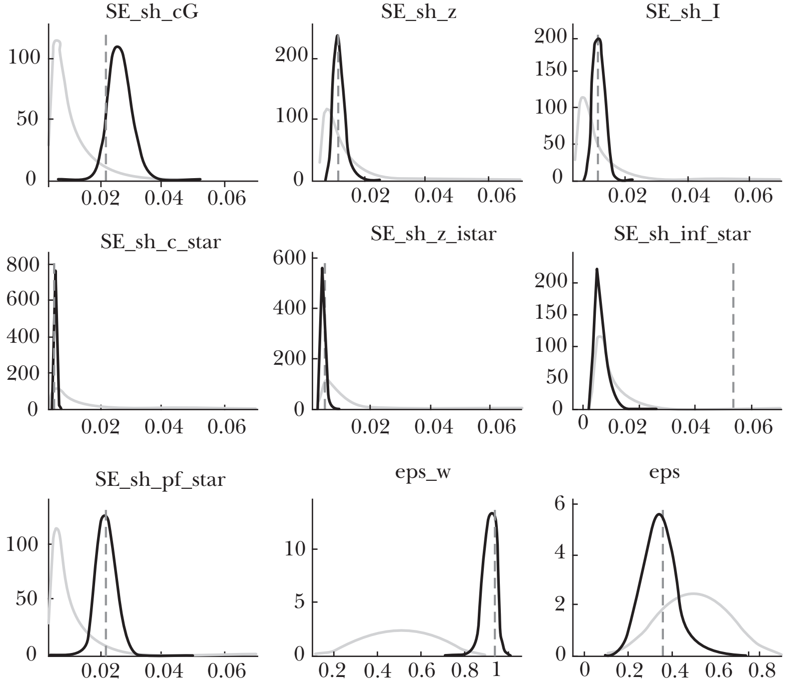
CALIBRATION RESULTS

Percentages

Aggregate demand	*Model*	*Data 2000-2014*
Household Consumption/GDP	58.34	
Entrepreneurs Consumption/GDP	6.52	
Total Consumption/GDP	64.86	66.16
Private Investment/GDP	12.78	15.59
Public Investment/GDP	4.48	4.48
Capital/GDP	7.10	
Ord. Govt. Expenditure/GDP	15.40	15.40
Total Govt. Expenditure/GDP	19.88	19.88
Imports Consumption/GDP	12.57	12.00
Imports Capital Goods/GDP	6.65	7.00
Total Imports	19.22	19.00
Total Exports	19.53	43.06
Trade Balance/GDP	0.31	
Foreign Debt/GDP	16.20	33.60
Government		
Consumption Taxes/GDP	6.46	6.38
Labor Taxes/GDP	3.95	3.95
Capital Taxes/GDP	1.58	1.58
Transfers/GDP	8.58	
Goverment Income/GDP	20.56	14.53
Government Primary Result/GDP	0.68	
Govt. Debt Service/GDP	0.68	
Central Govt. Debt/GDP	35.48	35.48
Financial sector		
Total Credit/GDP	1.80	41.80
Local Currency Credit/GDP	20.16	21.90
Foreign Currency Credit/GDP	21.64	19.90
Local Currency Deposits/GDP	0.16	20.15
Foreign Currency Deposits/GDP	5.44	5.44
Total Deposits/GDP	5.60	25.59
Leverage	1.60	2.11
Loan to Value	7.61	
Spread Loan Interest Rates	10.00	10.04

Figure 2

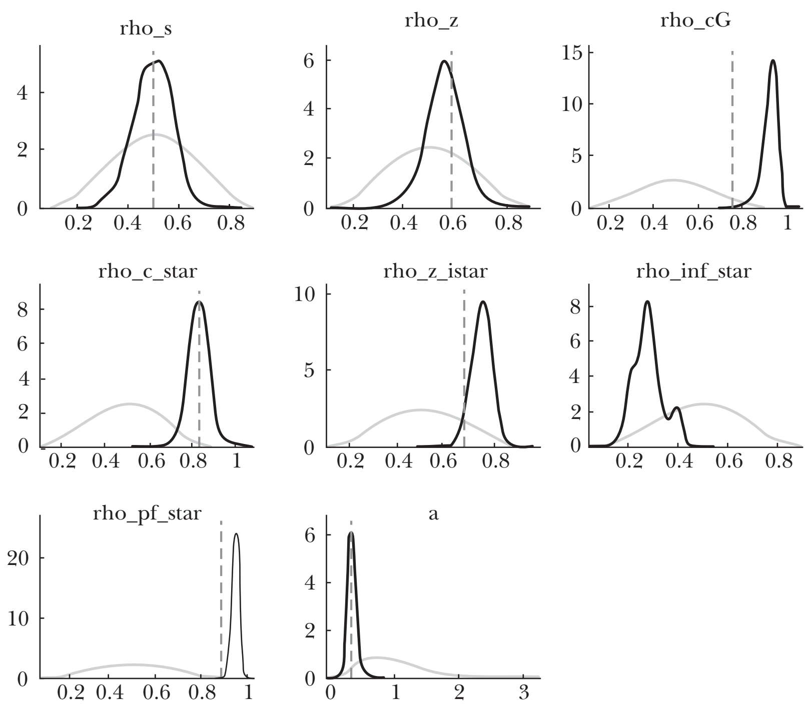
PRIORS AND POSTERIORS GRAPHS[1]



[1] Labels: sh_cG stands for government consumption shock; sh_z for productivity shock; sh_i for monetary policy shock; sh_c_star for foreign demand shock; sh_z_istar for sovereign risk shock; sh_inf_star for foreign inflation shock; sh_pf_star for foreign prices shock; eps_w for concentration coefficient for labor market; and eps for concentration coefficient for goods market.

Figure 2 (cont.)

PRIORS AND POSTERIORS GRAPHS[1]



[1] Labels: sh_cG stands for government consumption shock; sh_z for productivity shock; sh_i for monetary policy shock; sh_c_star for foreign demand shock; sh_z_istar for sovereign risk shock; sh_inf_star for foreign inflation shock; sh_pf_star for foreign prices shock; eps_w for concentration coefficient for labor market; and eps for concentration coefficient for goods market.

4.3 Impulse-response Analysis

This model allows evaluating the impact of unexpected shocks affecting the Costa Rican economy through the use of impulse response analysis. In this case the model shows the reaction over nine selected macroeconomic variables (consumption, GDP, unemployment, wages, investment, real exchange rate, monetary policy rate and inflation) from four different unexpected shocks to local and international interest rate, international inflation and finally international demand. This will allow us to evaluate the relative importance of the local monetary policy over the economy compared to the effect of the international monetary policy.

4.3.1 International Monetary Policy Shock

Figure 3 shows the responses of the variables to an unexpected increase in the international interest rate that a country faces either because of the external interest or the risk premium increase. First, consumption decreases and investment in the local economy too since it is more advantageous to just save in foreign currency. Second, and in contrast, GDP drops and employment grows since the shock leads a capital outflow that produces a depreciation in the real exchange rate (through the uncovered interest rate parity) that pushes exports. In addition, the rise in the depreciation of the currency is balanced with an increase in the domestic interest rate and the foreign debt.

The rise in income derived from the production of more exports does not overtake the reduction derived from consumption and domestic assets. Then, with lower levels of domestic savings and external funds, financing supply contracts while entrepreneurial fundamentals weaken increasing firms financing costs.

4.3.2 Local Monetary Policy Shock

Figure 4 shows the responses of the variables to an unexpected increase in the domestic interest rate, which has a contractive effect. Therefore it reduces consumption and investment. The reduction in consumption can be explained by the substitution effect between current and future consumption. The decrease in investment is due to the fact that now the price of capital is lower and therefore also discourages investing.

The total amount of savings of the economy rises even though there is a net contraction of the domestic assets because this reduction is less than the drop in the GDP.

Figure 3

IMPULSE RESPONSE SHOCK TO THE INTERNATIONAL MONETARY POLICY

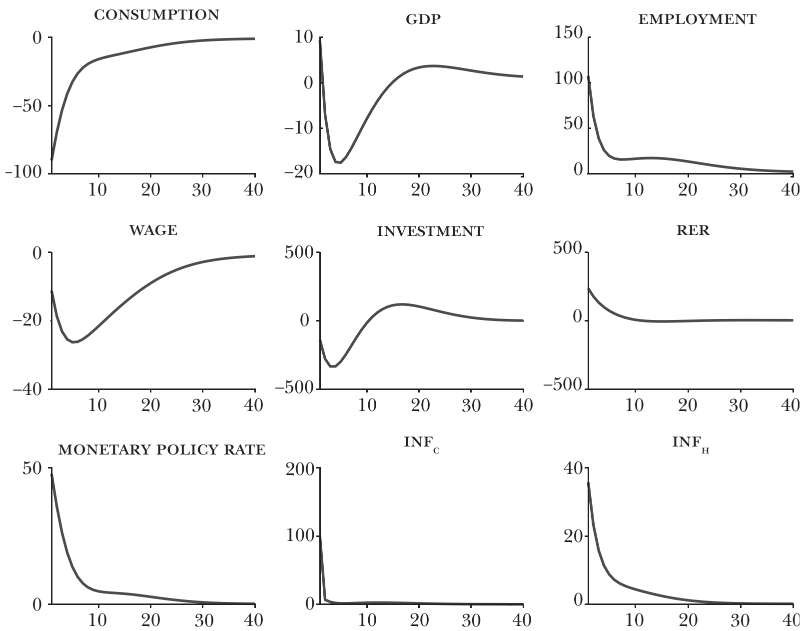
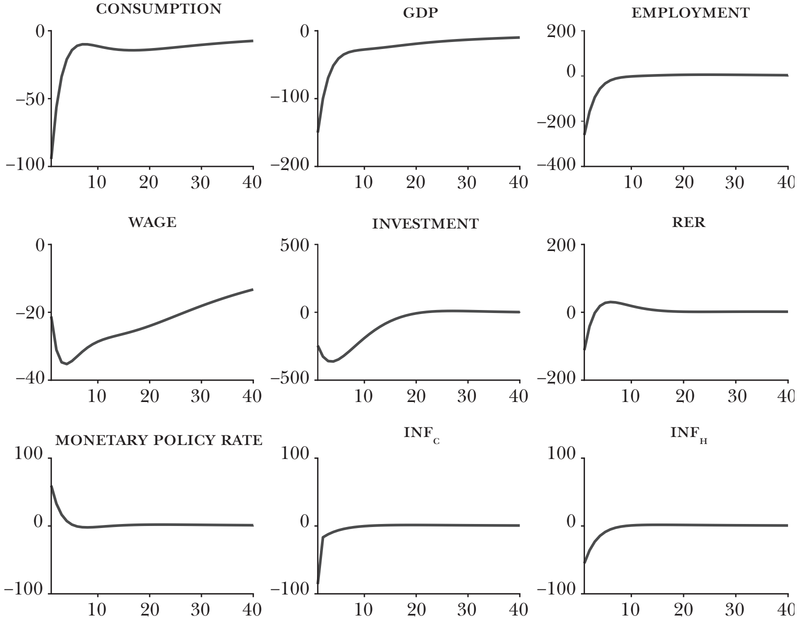


Figure 4

IMPULSE RESPONSE SHOCK TO LOCAL MONETARY POLICY



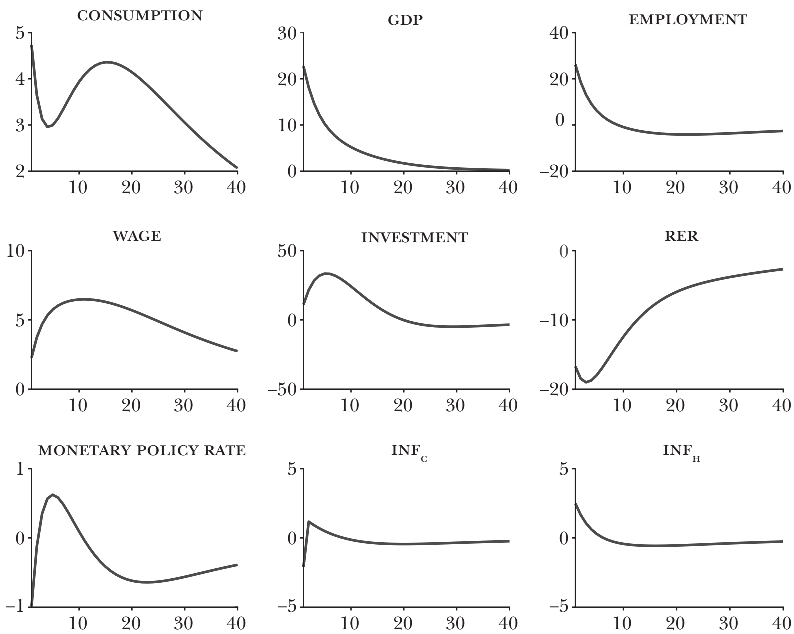
Net exports also suffer a reduction as a result of the real appreciation due to the interest rate differential. Consequently, with all these effects inflation is also lower.

4.3.3 International Demand Shock

Figure 5 shows the responses of the variables to an unexpected increase in the international demand. In this case, first, GDP grows and employment increases since foreign demand is stronger. Second, since the international interest rate has not increased yet, consumption and investment increase in the local economy at the time since it is more advantageous to save in local currency. Additionally, the real exchange rate decrease through the uncovered interest rate parity.

Figure 5

IMPULSE RESPONSE SHOCK TO INTERNATIONAL DEMAND

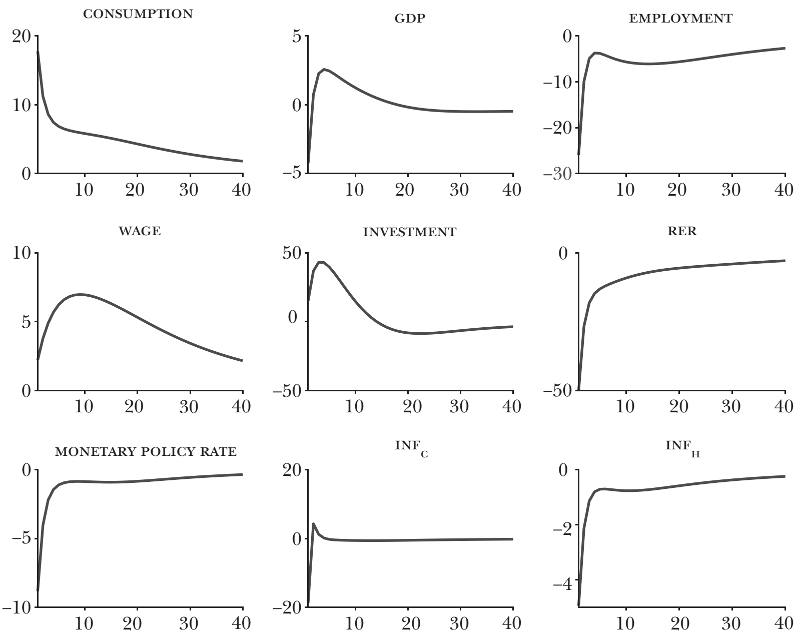


4.3.4 International Inflation Shock

Figure 6 shows the responses of the variables to an unexpected increase in the international inflation. In this case, the rise in the international inflation means that the international monetary policy rate increases and therefore the external demand will decrease so two seemingly contrary effects are observed. First, consumption increases and investment in the local economy too because of advantages to save in local currency. Second, and in contrast, GDP drops and unemployment grows since foreign demand is weaker.

Figure 6

IMPULSE RESPONSE SHOCK TO INTERNATIONAL INFLATION



Finally, it is important to mention that since this is a model that depicts a small open economy it needs to have the best possible integration of the financial system if not the effects from the international policy are just a consequence of the model selected and not of the characteristics of the economy, just like mentioned by Justiniano and Preston (2010). In this regard the model uses the international interest rate as the channel to link the international financial system to the local economy, where the financial system is allowed to take deposits and give loans in foreign currency as well as the households and entrepreneurs are able to take advantage of both choices, and therefore try to reduce the small open economy effect. Given the results from both models are consistent we can assert the actual importance of the international monetary policy over the Costa Rican economy.

5. CONCLUSION

This paper finds that the international monetary policy has a major effect on the Costa Rican economy which is consistent with Costa Rica being is a small open economy. Therefore external shocks play an important part in determining the dynamic of the economy. Given this result, the inflation target regime, as well as the flexible exchange rate provide important flexibility to absorb external shocks. All these was done using first a SBVAR model and then a DSGE formal approach where both allow learning which policies are actually the most important determinants of fluctuations in the Costa Rican economy.

Finally, the authors recognize that the model needs to be improved to integrate more sectors and characteristics of the Costa Rican economy in order to depict a better picture of the reality; however, we believe that the model is complete enough to show a good picture of the effects of the local and international monetary policies which is the objective of this paper.

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Cross-countries Studies of International Spillovers of Monetary Policy

The Effects of US Unconventional Monetary Policies in Latin America

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Abstract

This paper offers an empirical analysis of the way in which US unconventional monetary policy has affected Latin American countries. First, we estimate the effects of US monetary policy announcements on sovereign bond interest rates, exchange rates, and stock market indices for a set of emerging countries, including five Latin American economies. We found that QE announcements in 2008 and 2009, and the tapering talk in 2013 generated sizable sovereign yield and exchange rate fluctuations. We further find some excess response of Latin American asset prices that disappear once we take into account their country characteristics. In the second part of the paper we estimate a simple model that measures the influence of country-specific macroeconomic fundamentals on the transmission of US financial disturbances. An estimated model including the inflation rate, the CDS spread, the ratio of official reserves, and market capitalization explains some of the observed cross-country heterogeneity of spillovers from US monetary policy announcements. Under this model, a greater impact from the normalization of US monetary policy can be expected in Latin American relative to other emerging economies.

Keywords: unconventional monetary policy, spillovers, emerging economies, event study.

JEL classification: E52, F32, G11.

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1. INTRODUCTION

After the 2007-2008 global financial crisis, once central banks in the major advanced economies had used up conventional instruments, these central banks resorted to new, unconventional monetary policy tools to help improve the weak economy. This unprecedented monetary policy reaction–and, perhaps more importantly, the perception that major central banks were firmly committed to adopting any measure needed to preserve an orderly financial intermediation–was instrumental in calming financial markets. Against this background, from late 2009 until the beginning of the tapering tantrum in the spring of 2013, emerging market economies (EME) received a high volume of capital flows that ran in parallel with asset appreciation and the reduction of interest rates.

The opposite movement occurred after the Federal Reserve's announcement in May 2013 that anticipated the end of expansionary monetary policy in the United States. There were sudden reversals of capital inflows in several episodes between May 2013 and early 2014, as market perceptions of the Federal Reserve's intention to gradually withdraw its asset purchase program solidified. Capital outflows from emerging markets during these episodes led to exchange rate depreciations of emerging market currencies, increases in the risk premia on their financial assets, and falls in their equity markets.

In this paper, we analyze the effects of US unconventional monetary policy announcements on sovereign bond yields, exchange rates and stock market indices for 20 EMEs, including five from Latin America, and we also explore how the transmission of such monetary impulses is influenced by country-specific variables, such as macroeconomic variables, market conditions, and the external position, reflecting the countries' fundamentals. Thus, we analyze spillover effects by focusing on the reaction of the prices of financial assets. But, admittedly, we disregard other dimensions of the international transmission of monetary policy, namely changes in quantities (gross capital flows) and policy reactions.

This paper contributes to an already extensive literature which has explored the effects of the new unconventional instruments, mainly asset purchase programs in the United States. A number of papers have focused on the impact of these programs on the US economy. Although results differ across studies depending on their methodology, sample periods, and variables analyzed, a number of general conclusions can be drawn. First, quantitative easing programs have been successful in improving financial conditions, sustaining activity and mitigating deflation risks (IMF, 2013). There is an ample literature that quantifies the effects of balance sheet policies on asset pricing (Gagnon et al., 2011, Meaning and Zhu, 2011, Neely, 2010, Krishnamurthy and Vissing-Jorgenson, 2011, among many others) and there is also some evidence, although admittedly scarcer, documenting the fact that asset purchases provided significant stimulus to activity and counteracted disinflationary pressures (Chen et al., 2012, for the US LSAP; and Kapetanios et al., 2012, or Joyce et al., 2011, for the UK APF programs).Second, the effects of the subsequent programs have been documented as being progressively smaller (Krishnamurthy and Vissing-Jorgensen, 2011; and Bauer, 2012). Third, three main transmission channels of unconventional monetary policy (UMP) measures are identified: the *portfolio-balance channel* (increase in the demand for other riskier assets, reducing financing costs), the *signaling channel* (reinforcement of the perception that the monetary policy stance will remain loose for a prolonged period), and the *confidence channel* (increasing investors' risk appetite) (Woodford, 2012; IMF, 2013).

With regards to the analysis of cross-border spillovers (especially to EMEs) of unconventional monetary policy measures, the recent literature also offers some robust results. The overall picture provided by this literature is that asset purchase programs (especially those of the Federal Reserve) encouraged capital flows to EMEs, leading to appreciations of their exchange rates, increases in their stock market indices and contractions in their credit spreads. A number of papers have focused on more specific features. Fratzscher et al. (2013) document that LSAP1 policies induced a portfolio rebalancing from the rest of the world into the US, in particular into US bonds lowering their yields. In contrast, LSAP2 policies triggered a rebalancing from US funds into foreign funds, in particular EME equities. Bowman et al. (2015) found that the effects of US unconventional monetary policy on EMEs' financial assets prices depend on country-specific time-varying characteristics. Comparing the impact of conventional and unconventional measures, Chen et al. (2014) found that unconventional monetary policies had larger spillovers than conventional policies and they argue that this result is explained by structural issues–related to the instruments used during the UMP period–and, to a lesser extent, to weaker EME growth prospects. Gilchrist et al.

(2014) also found a substantial pass-through of unconventional US monetary policy to EME bond yields but with larger heterogeneity than that observed in the transmission to advanced economies.

Finally, more recent papers have focused specifically on the cross-border impact of the *tapering talk*. Market reaction to talk of tapering was initially indiscriminate during the bout of volatility in May-June 2013, although later some differential effects relating to fundamentals were observed (Sahay et al. 2014). In particular, Eichengreen and Gupta (2013), and Aizenman et al. (2014) found that the impact was greater in countries that had accumulated external vulnerabilities in terms of currency appreciation and a deteriorating current account during the previous expansionary period, although liquidity, market depth, and the size of investors' holdings also influenced the magnitude of the spillover effects. Mishra et al. (2014), in keeping with Bowman et al. (2015), showed that countries with stronger fundamentals, deeper financial markets, and a tighter macroprudential policy stance in the run-up to the tapering announcements experienced smaller currency depreciations and smaller increases in government bond yields. Sahay et al. (2014), reviewing the evidence of the cross-border impact of the tapering period, conclude that those countries that responded earlier and decisively to the initial tapering announcements fared better in later episodes of volatility in international financial markets.

This paper adds to this literature in two respects. Its first contribution is to analyze whether the impact of the US nonstandard monetary policies on Latin American economies differs from the impact on other EMEs. In this connection, there are reasons to expect that Latin American economies might be more vulnerable to increases in US interest rates. First, although many Latin American economies have reduced their reliance on dollar-denominated debt, this is still higher than in other EME economies. Second, financial interdependencies with the United States are particularly high within this region. Third, the main export products for most of these economies are commodities whose prices on international markets are set in US dollars. All these factors support the large and significant responses of Latin American macroeconomic variables to US monetary disturbances found in the literature in *normal times* (Canova, 2005) and the higher estimated sensitivity of sovereign bond yields in Latin America to US yields during the taper tantrum episode (IMF, 2014). Nevertheless, if the normalization of US monetary policy mirrors a better US growth performance, for those economies that are close trading partners (for example, Mexico) the positive impulse from stronger US growth is likely to counteract the impact of the rise in US interest rates.

The second contribution of this paper is to explore whether the role of fundamentals in conditioning the responses in emerging market economies to US unconventional monetary policy shocks differs across different episodes. More precisely, country characteristics were more decisive in explaining differences in the reaction to QE announcements than they were in response to news on the tapering process.

Taking together these two contributions, we want to test whether the impact of US nonstandard monetary policies on Latin American economies differs from the impact on other EMEs and, secondly, whether or not these differences remain once we control for fundamentals.

The remainder of the paper is organized as follows. In Section 2, using a daily panel data sample for the period from October 2008 to April 2015, we first analyze the effects of US monetary policy announcements on sovereign bond yields, exchange rates, and stock market indices for 20 countries, including five from Latin America. In Section 3, we explore whether the reaction of EME asset prices to US monetary policy differs depending on country-specific characteristics and whether the impact on Latin American asset prices differs from that found for other EMEs. Section 4 summarizes the main results of the paper and identifies some remaining issues.

2. EVENT STUDIES

This section presents an event study to show the effect of US policy changes on emerging markets. We report the results for two-day changes (from the day before to the day after) in foreign markets after monetary policy announcements, assuming that economic news does not affect the policy choice in that short period of time. The daily data run from October 1, 2008 to April 24, 2015. This is a simple alternative to VAR analysis that considers the asset price changes in volatility (Wright, 2012) or in future interest rates (Gertler and Karadi, 2015) to identify the monetary shocks within the period of unconventional monetary policy. Thus, we refrain from differentiating in the announcements between the impact effect and the signal about future policy intentions (Chen et al., 2014), and we simply consider them as unanticipated events.

Our analysis covers three types of financial assets: 10-year sovereign bonds in local currency, bilateral exchange rates relative to the US dollar, and headline stock market indices. Annex I describes the data sources and defines the variables, and Annex II presents a summary of statistics. The sample includes the following 20 emerging economies: Brazil, Chile, China, Colombia, Czech Republic, Hong Kong, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, Philippines, Poland, Singapore, South Africa, Taiwan, Thailand, and Turkey. This country sample is similar to others considered recently in the literature but we will also present some robustness analysis.

Table 1 describes the selected set of official announcements and speeches by the Federal Reserve considered since the establishment of unconventional policies in November 2008. The set of events includes announcements relating to the first two large-scale asset purchases (LSAP-1 and LSAP-2) in 2008-2009 and in 2010, the maturity extension program in 2011 (MEP), the third LSAP (LSAP-3) in 2012, the so-called *tapering tantrum* in May-October 2013 and the official tapering period of asset purchases from December 2013 to October 2014. Besides these QE events we also consider statements on forward guidance policy and some speeches by chairman Bernanke that could prompt potential market reactions.

Figure 1 shows the time series for the aggregate index for EMEs, Latin American and US sovereign yields (panel A) and stock market prices (panel B), along with the aggregate index for EMEs and Latin American exchange rates with respect to the US dollar (panel C). This figure provides some insight into the relationship between US unconventional monetary policy phases and EME financial asset prices. First, a co-movement between US sovereign yields and EME (and Latin American) yields is observed, and it is clearer in the case of the LSAP-1 and tapering periods. Second, the relationship between US unconventional monetary policy measures and EME stock market prices and exchange rates is less clear. Third, the series of Latin American financial asset prices display wider fluctuations than the corresponding aggregate EME series.

Figure 2 shows the time series for the aggregate capital inflows for different regions. In the aftermath of the global financial crisis, capital flows displayed a steep upward trend in most emerging market regions and particularly in Latin America, while the increase in advanced economies was less marked.

Table 1

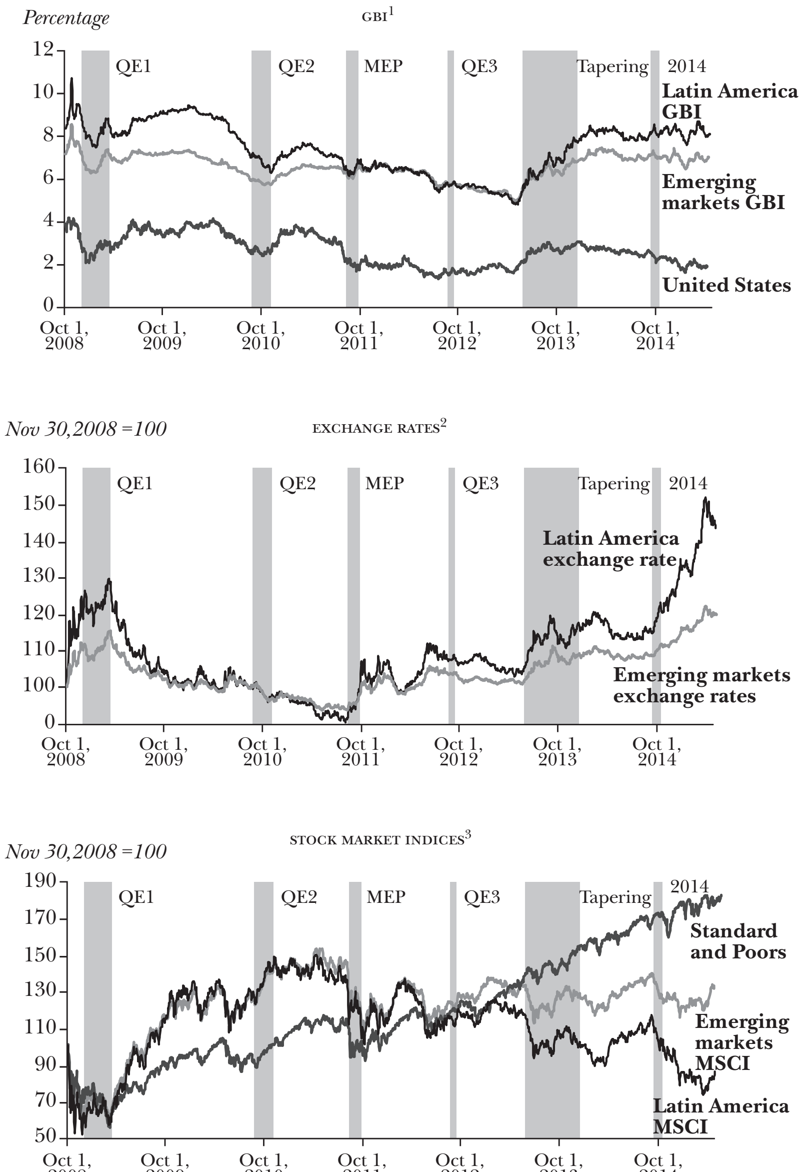
LIST OF RELEVANT FOMC MEETINGS AND EVENTS: NOVEMBER, 2008 TO OCTOBER, 2014

First Large Scale Asset Purchase (LSAP)		
Nov 25, 2008	Announcement	The Federal Reserve announces the purchases of MBS backed by government agencies, and the creation of TALF
Dec 1, 2008	Speech (Austin)	Bernanke hints future Treasury purchases
Dec 16, 2008	FOMC statement	The Federal Reserve cuts the target federal funds rate to zero
Jan 28, 2009	FOMC statement	The Federal Reserve announces the PDCF, the TLSF and the AMFL
March 18, 2009	FOMC statement	The Federal Reserve extends its purchases of MBS and announces that it will start to purchase Treasury securities
Second LSAP		
Aug 10, 2010	FOMC statement	The Federal Reserve announces it is willing to buy long-term Treasury securities through reinvestment of payments of its MBS
Aug 27, 2010	Speech (Jackson Hole)	Bernanke's speech at Jackson Hole
Sep 21, 2010	FOMC statement	According to the FOMC, the short term interest rate will stay at low levels for a long period of time
Oct 15, 2010	Speech (Indiana)	According to chairman Bernanke, new measures might be necessary
Nov 2, 2010	FOMC statement	The Federal Reserve decides to purchase additional 600 billions of dollars of long-term Treasury securities
Maturity Extension Program (MEP)		
Aug 09, 2011	FOMC statement	According to the FOMC, the short term interest rate will stay at low levels for a long period of time and will take new measures if necessary
Aug 26, 2011	Speech	Bernanke' s speech at Jackson Hole

Sep 21, 2011	FOMC statement	The Federal Reserve announces its Maturity Expansion Program
	Third LSAP	
Aug 22, 2012	FOMC minutes	The Federal Reserve will take new measures if necessary
Aug 31, 2012	Speech (Jackson Hole)	Chairman Bernanke suggests new QE
Sep 13, 2012	FOMC statement	The Federal Reserve announces new quantitative easing
	Events in 2013	
March 20, 2013	FOMC statement	The Federal Reserve will continue its accommodative monetary policy until certain goals of unemployment and inflation are reached
May 01, 2013	FOMC statement	FOMC: accommodative monetary policy will be held for a long period of time
	Taper Talk Period	
May 22, 2013	FOMC minutes and testimony	Bernanke suggests the end of expansive monetary policy
Jun 19, 2013	FOMC statement	The Federal Reserve suggests that *tapering* could begin next year
Jul 11, 2013	FOMC minutes and speech (NBER)	Bernanke says that the central bank's easing of monetary policy would continue for the foreseeable future
Oct 30, 2013	FOMC statement	The Federal Reserve decides to continue its accommodative monetary policy
Dec 18, 2013	FOMC statement	*Tapering* is officially announced
	Events in 2014	
Sep 17, 2014	FOMC statement	Announcement of policy normalization principles and plans
Oct 29, 2014	FOMC statement	Concluded tapering period. Starts *indefinite* forward guidance

Figure 1

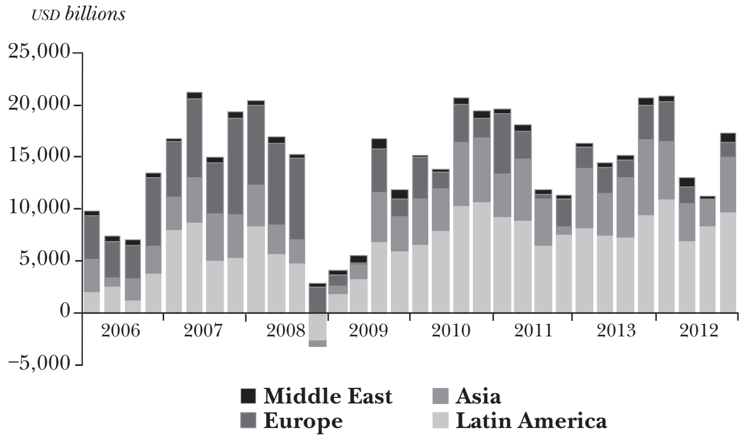
EMERGING MARKET ASSET PRICES AND US FINANCIAL VARIABLES



Sources: [1] JPMorgan and Federal Reserve Board. [2] National sources and own calculations. [3] Standard and Poors, and Morgan Stanley.

Figure 2

EMERGING ECONOMIES: CAPITAL INFLOWS
CHANGING DISTRIBUTION (2004-2013)



Source: IFS, International Monetary Fund.

2.1 Emerging (and Latin American) Market Reactions

The standard event-study specification to test the impact of unconventional monetary measures would be:

$$\Delta y_{it} = E_{it-1}\left[\Delta y_{it-1}\right] + \sum_{j=1}^{25} \beta_j * D_j + \varepsilon_{it}, \quad (1)$$

where Δy_{it-1} is the change in the financial variable of interest, $E_{it-1}\left[\Delta y_{it-1}\right]$ denotes the expected change in this variable in absence of shocks, and β_j is the coefficient associated with the dummy of each unconventional policy announcement (D_j).However, in our analysis we focus on the impact of these announcements at high frequency (daily data), which limits the possibility to control for real variables that are not available at that frequency. Moreover, in practice, the inclusion of different sets of controls influence very modestly the magnitude of the β_j coefficient (see Fratzscher et al., 2013). For these reasons, we estimate a simplified version of Equation 1, removing the expected change.

Table 2

EVENT STUDY FOR CHANGES IN SOVEREIGN YIELDS: DAILY DATA

(November 30, 2008 to April 24, 2015)

Dates	*US yields*	*EME GBI index*	*LATAM GBI index*	$\Delta y_{it} = \alpha_i + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$	
				Event effect (β)	*LATAM effect* (γ)
First LSAP					
Nov 25, 2008	−33.84[c]	21.46[c]	−22.24[b]	−15.56[c]	2.26
Dec 1, 2008	−26.46[c]	−2.86	−25.04[b]	−2.25	−50.51[c]
Dec 16, 2008	−33.23[c]	−16.86[b]	12.74	−29.36[c]	1.95
Jan 28, 2009	29.88[c]	9.24	10.46	4.11	−6.94
Mar 18, 2009	−40.31[c]	−5.86	9.84	−7.63[b]	−10.34
Second LSAP					
Aug 10, 2010	−14.59[a]	−2.96	−6.84	−2.64	−4.16
Aug 27, 2010	5.28	4.14	7.36	2.44	4.62
Sep 21, 2010	−14.25[a]	−3.26	−2.84	−1.09	−3.42
Oct 15, 2010	0.64	1.34	3.66	4.36	−6.61
Nov 3, 2010	−12.58	−2.06	0.00	0.93	0.12
MEP					
Aug 9, 2011	−19.87[b]	−8.06	−13.14	−6.74[a]	3.33
Aug 26, 2011	5.33	−5.56	−10.44	1.48	−11.45[a]
Sep 21, 2011	−22.57[c]	17.24[b]	21.36[b]	4.65	20.57[c]

Dates	*US yields*	*EME GBI index*	*LATAM GBI index*	$\Delta y_{it} = \alpha_i + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$	
				Event effect (β)	*LATAM effect* (γ)
Third LSAP					
Aug 22, 2012	−13.87[a]	−7.36	−11.94	−2.94	−1.00
Aug 31, 2012	−6.47	−3.87	−1.94	−3.09	2.87
Sep 13, 2012	10.63	4.04	4.36	2.15	6.14
Events in 2013					
Mar 20, 2013	2.19	2.01	3.06	0.94	3.19
May 1, 2013	−4.49	−3.89	−1.84	−4.02	1.41
May 22, 2013	8.03	9.84	12.86	6.27[a]	11.12
Jun 19, 2013	23.84[c]	36.64[c]	46.76[c]	23.80[c]	14.35[b]
Jul 11, 2013	−7.56	−5.26	−9.54	−2.56	−3.83
Oct 30, 2013	3.76	18.04[b]	35.06[c]	5.34	3.79
Dec 18, 2013	8.37	1.84	−0.24	3.58	2.91
Events in 2014					
Sep 17, 2014	4.15	1.54	0.02	0.11	1.56
Oct 29, 2014	2.44	5.24	0.12	0.84	−1.18

Note: Column 2 reports the changes in US 10-year sovereign yields. Columns 3 and 4 report the changes in two aggregate indexes. Columns 5 and 6 report the average country changes and their significance level. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence level.

Table 3

EVENT STUDY FOR CHANGES IN EXCHANGE RATES[1]: DAILY DATA

September 30, 2008 to April 24, 2015

Dates	*EME index*	*LATAM index*	$\Delta y_{it} = \alpha_i + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$	
			Event effect (β)	*LATAM effect* (γ)
First LSAP				
Nov 25, 2008	−0.76[a]	−1.46	−1.22[c]	0.11
Dec 1, 2008	0.89[b]	0.81	1.07[c]	−0.31
Dec 16, 2008	−0.96[b]	−1.11	−1.68[c]	0.03
Jan 28, 2009	0.05	−0.69	0.38	−0.27
Mar 18, 2009	−0.74[a]	−0.39	−1.48[c]	1.69[c]
Second LSAP				
Aug 10, 2010	0.55	0.56	0.94[c]	−0.75
Aug 27, 2010	0.01	0.07	−0.06	−0.18
Sep 21, 2010	−0.36	−0.44	−0.78[c]	0.66
Oct 15, 2010	0.19	0.07	0.64[b]	−0.38
Nov 3, 2010	−0.62	−0.99	−0.91[c]	0.41
MEP				
Aug 9, 2011	0.19	0.42	0.22	0.53
Aug 26, 2011	−0.35	−0.55	−0.44	0.17
Sep 21, 2011	1.67[c]	5.12[c]	1.74[c]	1.80[c]

Dates	*EME index*	*LATAM index*	$\Delta y_{it} = \alpha_i + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$	
			Event effect (β)	*LATAM effect* (γ)
Third LSAP				
Aug 22, 2012	−0.19	0.17	−0.32	0.19
Aug 31, 2012	−0.33	−0.95	−0.29	−0.28
Sep 13, 2012	−0.62	−1.00	−0.79[c]	0.16
Events in 2013				
Mar 20, 2013	0.08	0.11	0.14	−0.13
May 1, 2013	−0.21	0.27	−0.18	0.28
May 22, 2013	0.51	0.66	0.36	0.31
Jun 19, 2013	1.46[c]	3.43[c]	1.44[c]	1.01[a]
Jul 11, 2013	−0.34	−0.42	−0.69[b]	0.27
Oct 30, 2013	0.32	0.83	0.41	0.15
Dec 18, 2013	0.51	0.82	0.57[b]	−0.05
Events in 2014				
Sep 17, 2014	0.27	0.65	0.35	−0.25
Oct 29, 2014	−0.02	−1.80[a]	0.23	−1.37[b]

Note: Columns 2 and 3 report the changes in two aggregate indices. Columns 3 and 4 report the average country changes and their significance level. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels.
[1] A positive (negative) value in the Table indicates depreciation (appreciation) of the domestic currency against the US dollar.

Table 4

EVENT STUDY FOR CHANGES IN STOCK MARKET INDEX: DAILY DATA

November 30, 2008 to April 24, 2015

Dates	*US S&P 500*	*MSCI EME index*	*MSCI LATAM index*	$\Delta y_{it} = \alpha_i + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$	
				Event effect (β)	*LATAM effect* (γ)
First LSAP					
Nov 25, 2008	4.12[b]	5.66[c]	6.23[b]	3.33[c]	−0.87
Dec 1, 2008	−5.38[c]	−4.94[b]	−7.99[c]	−3.48[c]	0.32
Dec 16, 2008	4.04[b]	4.12[a]	6.25[b]	1.36[b]	1.32
Jan 28, 2009	0.15	2.50	2.49	1.28[b]	−0.41
Mar 18, 2009	0.67	2.81	3.10	2.10[c]	0.27
Second LSAP					
Aug 10, 2010	−3.49[a]	−3.38	−3.80	−2.00[c]	−0.10
Aug 27, 2010	0.08	0.59	0.66	0.59	0.24
Sep 21, 2010	−0.82	0.31	−0.22	0.14	0.14
Oct 15, 2010	0.84	−1.37	−0.18	−0.58	−0.27
Nov 3, 2010	2.22	2.34	3.07	1.49[c]	−0.04
MEP					
Aug 9, 2011	0.03	−1.01	3.79	−2.45[c]	6.09[c]
Aug 26, 2011	4.30[b]	3.19	4.12	1.26[b]	1.44
Sep 21, 2011	−6.12[c]	−7.47[c]	−9.57[c]	−4.12[c]	−1.38

Dates	*US S&P 500*	*MSCI EME index*	*MSCI LATAM index*	$\Delta y_{it} = \alpha_i + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it}$	
				Event effect (β)	*LATAM effect* (γ)
Third LSAP					
Aug 22, 2012	−0.87	−0.20	−0.80	−0.17	−0.36
Aug 31, 2012	0.42	0.84	0.92	0.87[a]	−0.88
Sep 13, 2012	1.95	3.58[a]	3.58	1.76[c]	0.55
Events in 2013					
Mar 20, 2013	−0.25	−0.30	−0.22	−0.09	0.20
May 1, 2013	−0.09	−0.26	−1.07	0.14	−0.27
May 22, 2013	−1.20	−2.17	−1.43	−1.18[b]	1.08
Jun 19, 2013	−3.94[b]	−4.78[b]	−6.57[b]	−3.34[c]	−0.43
Jul 11, 2013	1.58	3.19	1.84	2.57[c]	−1.29
Oct 30, 2013	−0.96	−0.28	−1.05	−0.28	−0.13
Dec 18, 2013	1.52	−0.04	0.72	−0.08	0.49
Events in 2014					
Sep 17, 2014	0.53	0.16	−1.16	0.70	−0.70
Oct 29, 2014	0.40	1.46	2.27	0.88[a]	−0.47

Note: Column 2 reports the changes in the S&P 500 returns. Columns 2 and 3 report the changes in two aggregate return indexes. Columns 4 and 5 report the average country change and their significance level. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels.

Tables 2, 3 and 4 report the two-day changes in sovereign yields, exchange rates and stock prices, respectively, around the 25 selected dates of the announcements.[1] As a reference, in each Table we include a first column that reports the estimated changes in the US variable, a second column with the changes in the corresponding aggregate EME index, and a third column with the responses in a similar aggregate LATAM index. The fourth and fifth columns report the coefficients for a regression that considers as dependent variables each of the assets not only with time variation but also with country variation:

2 $$\Delta y_{it} = \alpha_i + \sum_{j=1}^{25} \beta_j * D_j + \sum_{j=1}^{25} \gamma_j * Lat * D_j + \varepsilon_{it},$$

where α_i is a country fixed effect, β_j is the coefficient associated with the dummy of each event (D_j) and γ_j refers to the interaction coefficient of the event dummy with a LATAM dummy (Lat). Thus, the coefficients reported in column 4 (β_j) represent the average change of the dependent variable at date *j* for a non-Latin American country, while the sum of the coefficients reported in columns 4 and 5 $(\beta_j + \gamma_j)$ represent the average change of the dependent variable at date *j* for a Latin American country.[2]

United States yields (first column in Table 2) dropped significantly around the first LSAP announcements, except for the January 28, 2009 event, at which time yields rose. Fluctuations in US yields are smaller and less significant around the second and third LSAP, and they are again significant around two of the MEP announcements. Finally, the only significant reversal event with respect to yields is on June 19, 2013, when the FOMC suggested that tapering could begin in 2014. Other US assets such as the stock market index (reported in Table 4) show more mixed results. The number of significant events is lower and in some cases a fall is observed after the expansionary QE announcements.

Looking now at foreign assets, the changes in the EME aggregate yield index (GBI-EME in column 2, Table 2) are less uniform and of

[1] The results for one-day and seven-day windows around events do not differ much from those reported in the tables, and similarly when we consider for Asian asset prices opening times in *t+1*.

[2] It is worth mentioning that the sample includes only five Latin American countries (the five largest inflation targeters in the region). For this reason, the results should not be extrapolated to other economies of the region, that in many cases have very different characteristics.

a lower magnitude. As in the case of the United States, the most significant events are those around the LSAP-1 and the tapering. The changes in EME exchange rates and the stock market indices are relevant around the same dates, although in general with a lower significance. The results for the LATAM aggregate yield index (column 3 in Table 2) are similar and, in general, of a larger size. The different response of assets has already been reported by, among others, Bowman et al. (2015).More generally, the decreasing effect of the different QE programs has been documented in the US economy (e. g., Krishnamurthy and Vissing-Jorgensen, 2011) and internationally (e. g., Fratzscher et al., 2013).

The last two columns in Table 2 allow us to see the significance of country variability and to test whether the movements in sovereign yields around the relevant events differ in the Latin American countries with respect to other emerging market economies. EME yields decreased on average 20 basis points within the LSAP-1 period. We also find that after the first LSAP announcements the yields of the Latin American countries fell more than did the whole sample of emerging economies, and that these differences were highly significant for the December 2008 announcements.[3]

The decreasing effect of subsequent QE programs in EME economies is clear since the movements in yields are not significant between 2010 and 2012. The only exception is the August 2011 FOMC meeting, prior to the launching of the maturity extension program (MEP) with a higher LATAM effect after Bernanke's 2011 Jackson Hole speech. By contrast, when Operation Twist was launched in September 2011, the effect was the opposite, with a significant differential effect for Latin America. Finally, during the tapering period, yield increases were found around the relevant dates of May and June 2013. The size of the yield change was similar to the one during the LSAP-1 period and the reaction for Latin American countries was significantly higher in June.[4]

A monetary shock that lowers US yields also generates an appreciation of the EME currencies (Table 3) and an increase in the stock market indices of the EME economies (Table 4). Contrary to Fratzscher et al. (2013) results, we do not find evidence of a significant US dollar

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3 The *p*-value for the coefficient capturing the differential effect for Latin American economies to the FOMC statement in March 2009 extending the first LSAP was 0.14.

4 The *p*-value for the coefficient capturing the differential effect for Latin American economies to Bernanke's testimony in May 2013 was 0.11.

appreciation during the LSAP1 period and that would support a portfolio rebalancing out of EME assets into US assets.

Interestingly, the EME movements in exchange rates and stock markets are more significant when the cross-country dimension of the data is taken into account than when looking to aggregate indices, and we found more significant events for the EME coefficient with these two assets than with the yields. But again the LSAP-1 and the Tapering periods are the most significant. For example, the LSAP-1 caused, on average, a dollar depreciation of 1%-2% and a stock market increase of 2%.[5] Nevertheless, other events did not have the expected sign coefficient. In the case of exchange rate fluctuations, the depreciation after the June 2013 FOMC announcement of tapering was significantly greater in Latin America. This same pattern was also observed around the March 2009 LSAP-1 announcement, but in this case LATAM and aggregate EME moved in opposite directions. The MEP announcement in September 2011 had a significant negative impact on equity markets internationally and induced a cross-country rebalancing on bonds, especially out of LATAM yields and into US bonds that appreciated the dollar significantly, particularly against LATAM currencies. After the October 2014 FOMC meeting, when the tapering process concluded and an indefinite forward guidance policy was announced, the aggregate LATAM exchange rate against the US dollar appreciated. Thus, it seems that LATAM exchange rates were more sensitive to some of the US monetary shocks. On the contrary, there is no evidence of a significant higher stock market response for the Latin American countries, with the exception of the announcement on August 9, 2011, when the FOMC assured that interest rates would remain exceptionally low over the period to mid-2013.

In sum, a simple time series analysis of US unconventional monetary policies shows that they have had a more significant effect across EME asset prices after the LSAP1 (2008-2009) and the tapering (2013) periods with some excess response by LATAM assets. Comparing the three asset prices, the exchange rate is the variable which has more significant events, consistently with the relevance of the exchange rate channel in the transmission of monetary shocks to EME economies (Taylor, 2013).

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5 When the regression analysis was repeated, eliminating the five countries with higher per capita income, the significant events and their coefficients remain very much the same.

3. TRANSMISSION OF US MONETARY POLICY

This section examines the role played by country characteristics in financial market reactions to the Federal Reserve's policy actions. We first make use of the previous event study framework and analyze differences in transmission between the previously identified positive and negative events. In the second part, we study country heterogeneity in a monthly panel data set-up modeling a specific transmission channel. In both cases, we test whether or not Latin American countries follow different patterns in response to the exogenous policy announcements relative to the sample of emerging market economies (EMEs).

The country characteristics are detailed in Annex I. They can be classified in four categories:

1) macro fundamentals: GDP growth, inflation, and public debt/GDP;

2) financial market conditions: CDS spread and the policy interest rate;

3) external conditions: reserves/GDP, current account/GDP, external debt/GDP, short-term external debt/GDP, net banking position/GDP, portfolio flows/GDP, nominal exchange rate deviation, and the accumulated change in the real exchange rate; and

4) structural characteristics: an index of financial openness; exports to the United States/GDP and stock market capitalization (relative to GDP).

Note that among the external conditions we have included two exchange rate indicators that measure the competitiveness gains in the most recent period, while among the structural variables we have included stock market capitalization as a proxy of financial market size.

Some of these characteristics may represent country vulnerabilities in the sense that the market reaction of those country assets could be stronger in response to an exogenous shock. Others represent country strengths and the market reaction to the US monetary policy announcement might be negatively correlated with them. However, for variables that measure the level of financial and real integration as well as the change in competitiveness, the effect may be more uncertain.

3.1 Market Reaction and Country Characteristics: Sample of UMP Events

We initially estimate a set of regressions by pooling the previously identified 25 policy events across the 20 EMEs. The dependent variable Δy_{ij} is the two-day change for one of three financial asset prices considered in country *i* and event date *j*. The explanatory variables, besides the country fixed effect, include each of the country characteristics $\left(CC_{it-1}\right)$, a dummy variable $\left(D_j^s\right)$ for the selected events that were significant (positively or negatively) in the previous time-series regression, and the interaction between the significant event dummies and the country characteristics. The specification is as follows:

3 $$\Delta y_{ij} = \alpha_i + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \varepsilon_{it}.$$

The regression with positive events includes three LSAP-1 dates that became significant across EME or LATAM economies in regression 2: November 25, 2008; December 16, 2008; and March 18, 2009. And the regression with the negative events considers the two significant events during the tapering talk by the Federal Reserve: May 22, 2013; and June 19, 2013. All the characteristics are lagged one month to avoid correlation with the error term.

Table 5 presents the regression results for changes in sovereign yields. For each of the country characteristics, the left-hand side of the Table reports the estimated coefficients for the regression with the dummy variable under the significant LSAP-1 events and the interaction of the dummy with the characteristics. The right-hand side of the Table reports the regression results under the significant tapering events.[6]

First, the dummy variable for most of the country characteristics is significant and has a negative effect for the LSAP-1 events (reducing yields) and a positive effect for the tapering events (increasing yields). The exceptions are the dummy coefficients when including the inflation rate, the policy rate, and the CDS, since those characteristics are very much correlated with the countries' bond yields. In general, the significance around these events, their sign, and magnitude is consistent with the average event estimates in Table 2.

[6] We do not report the general vulnerability coefficients since we are only interested in the effects around the significant policy events.

Table 5

EFFECT OF THE LSAP-1 AND THE TAPERING TALK PERIODS ON EMERGING MARKET YIELDS AND THEIR RELATION TO COUNTRY CHARACTERISTICS

$$\Delta y_{ij} = \alpha_i + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \varepsilon_{it}$$

	LSAP-1 Period		*Tapering Talk Period*	
	Dummy (β)	*Dummy*CC* (δ)	*Dummy* (β)	*Dummy*CC* (δ)
Macroeconomic variables				
GDP	−0.181[c]	−0.006	0.234[c]	−0.007
Inflation	0.063	−0.042[c]	0.120[b]	0.019
Debt	−0.236[c]	0.001	0.262[c]	−0.001
Market conditions				
Policy rate	−0.030	−0.018[b]	0.199[c]	−0.001
CDS	0.112	−0.001[c]	0.104	0.000
External variables				
Current account to GDP	−0.209[c]	0.012[c]	0.203[c]	−0.012[b]
Reserves to GDP	−0.314[c]	0.004[c]	0.266[c]	−0.002
External debt to GDP	−0.303[c]	0.003[a]	0.234[c]	−0.000
Portfolio flows to GDP	−0.217[c]	−0.001	0.222[c]	0.004
Net banking position to GDP	−0.208[c]	0.002	0.210[c]	−0.005[b]
Exchange rate deviation	−0.196[c]	0.000	0.202[c]	0.001
Real exchange rate	−0.188[c]	−0.001	0.196[c]	0.003
Structural variables				
Market size (capitalization to GDP)	−0.215[c]	0.032	0.220[c]	0.000
Real integration (exports to US to GDP)	−0.223[c]	0.004	0.189[c]	0.003
Financial integration (Chinn Ito index)	−0.187[c]	0.025		

Notes: This Table reports the set of regressions, pooling the 25 policy events across the 20 EMEs. Each line contains the regression results for one of the country characteristics (CC) and the corresponding event period. In the LSAP1 period the dates considered are November 25, 2008; December 16, 2008; and March 18, 2009. In the tapering talk period the dates are May 22, 2013; and June19, 2013. The general country characteristics coefficients are not reported. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels.

A second result is that a number of the interaction coefficients are significant under the LSAP-1, whereas they are not so under the tapering events. Thus, we can say that on impact, the tapering had a more indiscriminate effect across EMEs whereas the LSAP-1 had a differential effect across countries depending on the country characteristics. During the LSAP-1 period, countries with a higher inflation rate, higher CDS spread, and higher policy rate yields responded more to the US monetary shock, whereas countries with higher current account surpluses or higher reserves yields responded less. The size of these effects is non-negligible: A one standard deviation increase in CDS (92.4 bp), the inflation rate (2.9%) and the policy rate (2.8%) implies an additional reduction in sovereign yields after LSAP-1 announcements of 12 bp, 9 bp and 5 bp, respectively, while a one standard deviation increase in the reserves to GDP ratio (28%) and the current account to GDP ratio (6.28) implies an increase in sovereign yields after LSAP-1 announcements of 11 bp, and 8 bp, respectively. There is also a significant variable, the external debt that does not affect yields with the expected sign when interacting with the LSAP-1 events. Stock market capitalization has a positive sign, indicating, in this case, that large markets reacted less to the external shock, but it is not significant.

The results are even stronger when the dependent variable is the change in exchange rates (see Table 6).In all the cases the dummy for the LSAP-1 event is significant, indicating the relevance of this variable in the transmission of monetary policy shocks. There are three country characteristics that interact significantly with the first set of unconventional Fed policies, which were also significant in the yields regression: the domestic policy rate, the current account, and the reserves. Now the interaction with the public debt instead of the inflation rate becomes significant and the external debt has the expected sign. Moreover, two of the structural variables are significant: the market capitalization and the share of exports. Again, most of the country characteristics are not significant when interacting with the tapering period.

Therefore, we have found significant coefficients for some country characteristics that are consistent with differential effects of the LSAP-1 measures depending on variables proxying vulnerabilities and strengths of these economies. However, the asset price responses around the first two months of the tapering process are consistent with the indiscriminate impact of the earlier events in this process,

Table 6

EFFECT OF THE LSAP-1 AND THE TAPERING TALK PERIODS ON EMERGING MARKET EXCHANGE RATES AND THEIR RELATION TO COUNTRY CHARACTERISTICS

$$\Delta y_{ij} = \alpha_i + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \varepsilon_{it}$$

	LASP-1 period		*Tapering talk period*	
	Dummy (β)	*Dummy*CC* (δ)	*Dummy* (β)	*Dummy*CC* (δ)
Macroeconomic variables				
GDP	−1.686[c]	0.043	1.716[c]	−1.172[b]
Inflation	−1.366[c]	−0.032	0.854[b]	0.064
Debt	−0.851[b]	−0.0153[a]	0.557	0.011
Market conditions				
Policy rate	−0.920[b]	−0.121[b]	0.814	0.092
CDS	−1.481[c]	−0.001[c]	0.358	0.005
External variables				
Current account to GDP	−1.633[c]	0.076[c]	1.158[c]	−0.043
Reserves to GDP	−2.042[c]	0.017[b]	1.575[c]	−0.013[a]
External debt to GDP	−0.705[b]	−0.036[c]	0.745	0.013
Portfolio flows to GDP	−1.849[c]	0.038	1.179[c]	0.055
Net banking position to GDP	−1.704[c]	−0.014	1.284[c]	−0.003
Exchange rate deviation	−1.433[c]	0.015	1.042[c]	0.025
Real exchange rate	−1.871[c]	0.007	1.326[c]	0.006
Structural variables				
Market size (capitalization to GDP)	−1.723[c]	0.243[a]	1.305[c]	−0.136[a]
Real integration (exports to US to GDP)	−2.058[c]	0.076[b]	0.992[c]	0.024
Financial integration (Chinn-Ito index)	−1.426[c]	−0.154		

Notes: This Table reports the set of regressions pooling the 25 policy events across the 20 EMEs. Each line contains the regression results for one of the country characteristics (CC) and the corresponding event period. In the LSAP1 period the dates considered are November 25, 2008; December 16, 2008; and March 18, 2009. In the tapering talk period the dates are May 22, 2013; and June 19, 2013. The general country characteristics coefficients are not reported. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels.

although market differentiation was gradually becoming more relevant later on (Sahay et al., 2014).Nevertheless, these results differ from Mishra et al. (2014) since they find that the impact of the taper talk was significantly related to macroeconomic fundamentals.[7]

Next, we examine whether there are additional specific Latin American effects besides those captured by the country characteristics. To that end, we repeat the estimation of Equation 3, adding an interaction effect with a Latin American dummy (*Lat*) for each of the previous variables considered. The specification is as follows:

4

$$\Delta y_{ij} = \alpha_i + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \eta Lat D_j^s + \\ + \lambda Lat\, CC_{it-1} + \rho Lat D_j^s CC_{it-1} + \varepsilon_{it}.$$

The estimation results for Equation 4 with sovereign yields as the dependent variable and under the relevant LSAP-1 events are presented in Table 7.[8] As in the previous regression, we find a negative and significant dummy effect around those policy events, and their interactions with the country characteristics remain significant and with the expected sign for the same variables: inflation, CDS spreads, policy rates, reserves, the current account and the market capitalization. But the interaction of the LSAP-1 event and the *Lat* dummy is not significant in most cases, and a similar result holds for the regression with the dummy for the tapering talk events and the interaction with the *Lat* dummy.

We consider the above regression results as evidence of the rejection of an independent effect coming out of the Latin American economies, once the country characteristics are taken into account to explain the EME country heterogeneity when facing US monetary policy shocks. That spillover result qualifies the excess response on LATAM asset prices found in the event study section.

7 This difference with the results in Mishra et al. (2015) might be explained by the higher number of significant events identified in their case over the tapering process.

8 The magnitude of the effects is similar to that of the results reported in Table 5.

Table 7

EFFECT OF THE LSAP-1 ON EMERGING AND LATIN AMERICAN ECONOMIES YIELDS DEPENDING ON THEIR COUNTRY CHARACTERISTICS

$$\Delta y_{ij} = \alpha_i + \beta D_j^s + \gamma CC_{it-1} + \delta D_j^s CC_{it-1} + \eta LatD_j^s + \lambda LatCC_{it-1} + \rho LatD_j^s CC_{it-1} + \varepsilon_{it}$$

	Dummy (β)	*Dummy*CC* (δ)	*Dummy*Lat* (η)	*Dummy*Lat*CC* (ρ)
Macroeconomic variables				
GDP	−0.167[c]	−0.010	−0.079	0.024
Inflation	0.076	−0.048[c]	−0.329	0.067[b]
Debt	−0.300[c]	0.001	0.246[b]	−0.005[a]
Market conditions				
Policy rate	−0.016	−0.029[c]	−0.027	0.025
CDS	0.139	−0.001[c]	−0.313	0.002[b]
External variables				
Current account to GDP	−0.230[c]	0.013[c]	0.029	−0.011
Reserves to GDP	−0.360[c]	0.004[c]	0.026	0.005
External debt to GDP	−0.338[c]	0.002	0.041	0.003
Portfolio flows to GDP	−0.233[c]	−0.003	0.017	0.021
Net banking position to GDP	−0.235[c]	0.002	−0.001	−0.009
Exchange rate deviation	−0.249[c]	0.001	0.184[c]	−0.002
Real exchange rate	−0.190[c]	0.001	0.010	−0.003
Structural variables				
Market size (capitalization to GDP)	−0.222[c]	0.026	−0.114	0.518[a]
Real integration (exports to US to GDP)	−0.281[c]	0.021[b]	0.109	−0.024[b]
Financial integration (Chinn-Ito index)	−0.201[c]	0.0186	−0.002	0.05

Notes: this Table reports the set of regressions pooling the 25 policy events across the 20 EMEs. Each line contains the regression results for one of the country characteristics (CC) and the corresponding event period. In the LSAP1 period the dates considered are November 25, 2008; December 16, 2008; and March 18, 2009. The general country characteristics coefficients are not reported. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels.

3.2 Channels of Transmission

This section estimates a simple model for the transmission of unconventional US monetary policy. The objective is to analyze whether the observed asset price responses for EME economies found in the event study (Section 2) correspond to the implied model response.

We adopt the specification of Bowman et al. (2015) , which distinguishes the monetary policy effect through US ten-year sovereign yields $\left(\Delta Y_{sovt}^{US}\right)$ and high-yield corporate bond $\left(\Delta Y_{hyt}^{US}\right)$ spreads:

$$\Delta y_{it} = \alpha_i + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y_{sovt}^{US} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y_{hyt}^{US} + \delta Z_t + \varepsilon_{it}. \quad (5)$$

Thus we characterize for the transmission of US monetary shocks through the interest rate channel $\left(\Delta Y_{sovt}^{US}\right)$ and the risk channel $\left(\Delta Y_{hyt}^{US}\right)$ that has been found for the US economy at the zero lower bound (e. g., Rogers et al., 2013). The specification considers how international spillover differences may depend on the country characteristics $\left(CC_{it-1}\right)$, consistent with the evidence presented in the previous section around policy events. The specification 5 also includes a set of control variables (Z_t) to explain the changes in EME asset prices: the VIX index, the change in commodity price index, and the change in the return on the S&P500 index. The model is estimated with monthly data for the period from October 2008 to December 2014.

The estimation results, including one country characteristic at a time, for yields, exchange rates, and the stock market index are reported in Tables 8, 9 and 10, respectively. We report the coefficients of the interactions of the country characteristics with the changes in both US sovereign yields and high-yield corporate bonds (β_2 and γ_2), and their significant value. Later on (Table 11) we report the joint estimation results for the sovereign yields including a set of country characteristics with the highest explanatory power.

In the panel regression of EME sovereign yields (Table 8), inflation is the only macroeconomic variable with significant interactions. Countries with higher inflation are experiencing a higher response to fluctuations in US sovereign yields and in high-yield bond spreads. But we do not find a similar result for the public debt ratio or GDP growth. Agents seem to be more concerned with the real return of their investments, which may explain the significance of inflation. The market conditions measured by a high CDS

Table 8

REACTION OF EMERGING MARKET YIELDS TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y_{sovt}^{US} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y_{hyt}^{US} + Z_t + \varepsilon_{it}$$

	US sovereign yield (β_2)	*US high yield spread* (γ_2)	R^2 *gains*
Macroeconomic variables			
GDP	0.000	−0.010	0.01
Inflation	0.137[c]	−0.048[c]	6.16
Debt	0.002	0.001	0.26
Market conditions			
Policy rate	−0.176[c]	−0.029[c]	10.96
CDS	0.005[c]	−0.001[c]	10.40
External variables			
Current account to GDP	−0.043[c]	−0.014[c]	3.63
Reserves to GDP	−0.011[c]	−0.004[c]	4.42
External debt to GDP	−0.001	0.001	0.39
Portfolio flows to GDP	−0.057[b]	−0.016[c]	1.56
Net banking position to GDP	−0.010[b]	−0.004[c]	2.33
Exchange rate deviation	0.010	0.003	0.99
Real exchange rate	−0.000	0.004	0.49
Outstanding international debt	−0.029	−0.017[c]	
Structural variables			
Market size (capitalization to GDP)	−0.222[c]	−0.031[c]	1.59
Real integration (exports to US to GDP)	−0.281[c]	−0.009	0.88
Financial integration (Chinn Ito index)	−0.201[c]	0.001	0.00

Note: Δy_{it} is the one-month change in each EME sovereign bond yield. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations were corrected by panel data Newey West.

spread or a high policy rate also positively affect the response to US fluctuations since they may be proxies for financial risk. Four out of the seven external variables considered are significant: the current account, reserves, portfolio flows, and the net lending banking position all measure the strengthening of the external position of the country and consequently reduce the variability of yields to US shocks. The external debt to GDP does not prove to be significant.[9] Similarly, a positive nominal exchange rate deviation from its long-run baseline or the last year's cumulative real appreciation reflect vulnerability and cause larger changes in yields, but they are not significant.

We also obtained that out of the three structural variables only market size is relevant. As in the previous event regression, a bigger market size, and thus a more liquid financial system, reduces the response of yields to a financial shock.

Table 9 presents the estimation results for the panel data model with the EME exchange rates. An increase in the bilateral rate against the dollar represents a depreciation of the EME currency. Interestingly, a similar group of country characteristics to the yields equation affect the exchange rate fluctuations in a significant way. Higher inflation, higher policy rates, lower reserves, a lower current account, and a lower market capitalization depreciate the exchange rate more after an increase in US sovereign yields or in high-yield spreads, and Table 10 shows the estimation results for the EME stock market returns. The number of significant country characteristics is smaller and the risk channel plays a more important role in this case.

9 Non-financial corporations' external debt has risen after the global financial crisis in many EMEs. The interaction of that variable in regression 4 was significant, but with the sign opposed to the expected one.

Table 9

REACTION OF EMERGING MARKET EXCHANGE RATES TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y^{US}_{sovt} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y^{US}_{hyt} + Z_t + \varepsilon_{it}$$

	US sovereign yield (β_2)	*US high yield spread* (γ_2)	R^2 *gains*
Macroeconomic variables			
GDP	−0.058	−0.028	0.09
Inflation	0.314[c]	0.130[c]	1.67
Debt	−0.008	0.008	0.39
Market conditions			
Policy rate	0.260	0.127[c]	1.51
CDS	0.008[b]	0.004[c]	2.00
External variables			
Current account to GDP	−0.154[c]	−0.096[c]	3.25
Reserves to GDP	−0.044[c]	−0.029[c]	4.06
External debt to GDP	0.027	0.016[b]	1.36
Portfolio flows to GDP	−0.200[b]	−0.047	0.33
Net banking position to GDP	−0.025	−0.0125[c]	0.30
Exchange rate deviation	−0.010	0.002	0.03
Real exchange rate	−0.037	−0.021	0.25
Outstanding international debt	−0.185[c]	−0.106[c]	
Structural variables			
Market size (capitalization to GDP)	−0.333[c]	−0.240[c]	1.39
Real integration (exports to US to GDP)	−0.123	−0.052	0.50
Financial integration (Chinn Ito index)	−0.244	−0.035	0.13

Note: Δy_{it} is the one-month depreciation rate of each EME currency with respect to the US dollar. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations were corrected by panel data Newey West.

Table 10

REACTION OF EMERGING MARKET STOCK INDICES TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y^{US}_{sovt} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y^{US}_{hyt} + Z_t + \varepsilon_{it}$$

	US sovereign yield (β_2)	*US high yield spread* (γ_2)	*R^2 gains*
Macroeconomic variables			
GDP	−0.311[b]	0.036	0.49
Inflation	−0.304[b]	−0.049	0.16
Debt	0.005	−0.017[b]	0.44
Market conditions			
Policy rate	−0.098	−0.021	0.02
CDS	−0.006	−0.001	0.07
External variables			
Current account to GDP	0.092	0.013	0.05
Reserves to GDP	0.025	−0.003	0.14
External debt to GDP	−0.005	−0.022[b]	2.51
Portfolio flows to GDP	0.193	−0.007	1.9
Net banking position to GDP	0.003	−0.005	0.14
Exchange rate deviation	−0.013	−0.002	0.89
Real exchange rate	−0.055	−0.005	0.03
Outstanding international debt	0.047	−0.002	
Structural variables			
Market size (capitalization to GDP)	0.000	−0.000	0.02
Real integration (exports to US to GDP)	0.079	0.0960[c]	0.54
Financial integration (Chinn Ito index)	−0.412	−0.319[b]	0.01

Note: Δy_{it} is the one-month return of each EME country stock market index. [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations were corrected by panel data Newey West.

We conducted some robustness exercises controlling for domestic variables besides global ones in regression 5. For example, when the Z_{it} vector includes the countries' policy rate, inflation rate, and output growth, the same country characteristics became significant with the exception of the market size.

Moreover, once each of these characteristics is introduced into the panel regression, there is not a significant common LATAM dummy to explain any of the three asset price movements.[10] That reinforces the previous specific event analysis (QE1 and tapering) where there was no evidence of excess sensitivity for Latin American economies to US monetary disturbances once country-specific fundamentals are taken into account.

Table 11 presents a joint estimation of the specific country variables for the EME sovereign yields. Based on the R^2 gains of the variable by variable estimation in Table 8, the multivariate specification considers the following characteristics: CDS spread for market conditions, inflation for macroeconomic conditions, the official reserves ratio for external conditions, and market capitalization for structural conditions. The three first estimates are consistent with previous univariate estimations: An increase in CDS spread and inflation or a decrease in reserves is related to a country's higher vulnerability. By contrast, the coefficient of the stock market capitalization is estimated with a positive sign, implying that relatively large markets display larger responses to US monetary policy announcements.[11] This result is consistent with the more specific evidence around the tapering period where investors found it easier to rebalance their portfolios in larger EME and therefore experienced higher asset price responses (Eichengreen and Gupta, 2013).When experimenting with an alternative set of relevant country characteristics such as the current account or the policy rate, the results did not change much, but the explanatory power decreased.

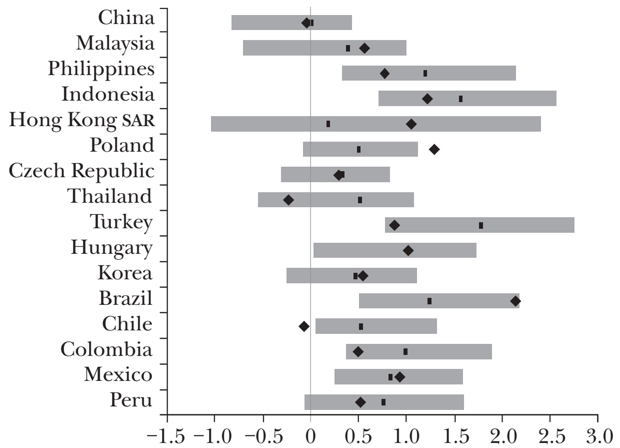
This multivariate estimation is similar to one by Bowman et al. (2015), although they consider a vulnerability index estimating a principal component of a set of macro variables and control for the currency regime. Nevertheless, our estimates present two important differences: First, both channels of transmission, sovereign yields

10 These results are not reported to save space.

11 The estimates of the joint specification for the two other asset prices (not reported) go in the same direction, although the coefficients present a lower significance level.

Figure 3

AVERAGE RESPONSE OF THE EME YIELDS IN US SOVEREING YIELDS



Note: The squares indicate the average observed response (two-day change). The gray area represents the average and the one-standard deviation of each country's model response for the multivariate panel-data model (Table 11, specification 3).

and high-yield bond spreads, are relevant for explaining the heterogeneity of EME yields; and second, the explanatory power of the country characteristics considered in our multivariate estimation is much higher than their vulnerability index.

From the estimation results in Table 11 we can now compare the observed country response to US monetary policy announcements with the implied response by the estimated model. Figure 3 shows the average and one standard deviation of the model's response to a change in US Treasury yields.[12] Thus, taking the multivariate version of Equation 5, we calculate the average response $\left(\beta_1 + \beta_2 ECC_{it-1}\right)$ of the three country characteristics for each of the countries for which we have data and their standard deviation from the parameters' uncertainty. Similarly, Figure 3 draws the average country response (also relative to the US) using the two-day changes in the event study (Table 2).

[12] An event study around the effect of US monetary policy announcements on the high-yield bond spread gave few significant events. That is the reason to focus on the response through the Treasury yields.

Table 11

MULTIVARIATE ANALYSIS OF THE REACTION OF EMERGING MARKET YIELDS TO US FINANCIAL VARIABLES

$$\Delta y_{it} = \alpha_i + \left(\beta_1 + \beta_2 CC_{it-1}\right) * \Delta Y^{US}_{sovt} + \left(\gamma_1 + \gamma_2 CC_{it-1}\right) * \Delta Y^{US}_{hyt} + Z_t + \varepsilon_{it}$$

	Specifications			
	1	*2*	*3*	*4*
Inflation				
US sovereign yield	0.201[c]	0.151[c]	0.144[c]	0.115[b]
High yield spread	0.039[c]	0.019[b]	0.014	0.009
R^2 gains	10.38			
CDS				
US sovereign yield		0.003[c]	0.003[c]	0.003[c]
High yield spread		0.001[c]	0.001[c]	0.001[c]
R^2 gains		13.55		
Reserves				
US sovereign yield			−0.003	−0.017[b]
High yield spread			−0.003[b]	−0.005[b]
R^2 gains			14.30	
Capitalization to GDP				
US sovereign yield				0.134[c]
High yield spread				0.026
R^2 gains				15.04

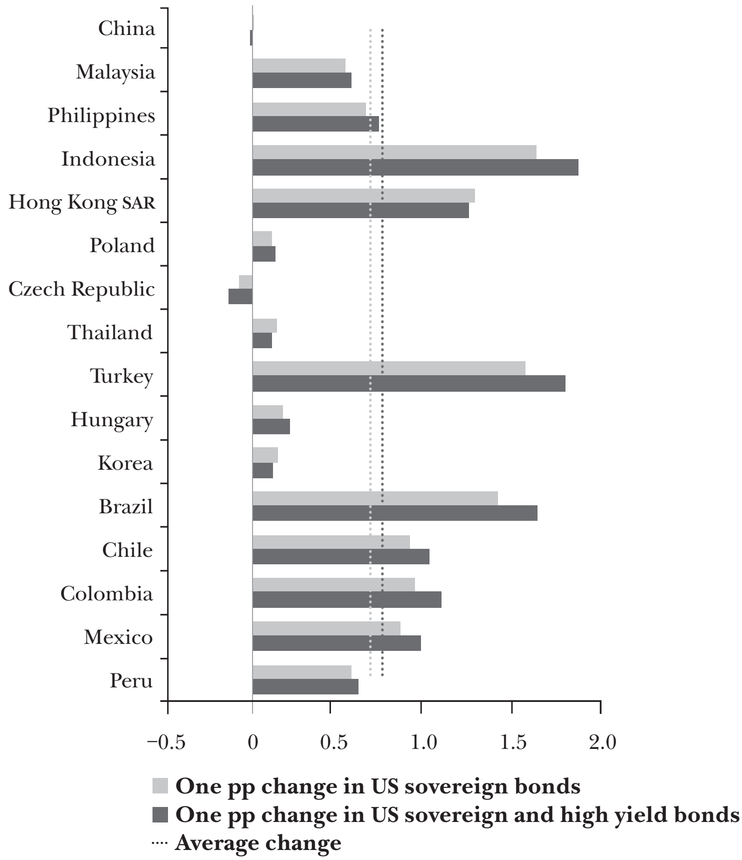
Note: Δy_{it} is the one-month change in each EME sovereign bond yield [a], [b] and [c] represent significance at the standard 10, 5 and 1 percent confidence levels, where standard deviations were corrected by panel data Newey West.

We find a large variability across countries. Nevertheless, for most of the countries in the sample the responses to the US policy have not outsized the expected price response of the model once the parameter uncertainty has been considered. The only country with an observed response above the upper limit of the confidence band is Poland. Interestingly, the model for Brazil is within the limit. Brazil is an example of a large EME with a relatively open capital account and a flexible exchange rate regime where carry trade operations, and thus capital flows, have responded very significantly to external QE policies. Other Latin American countries' responses are within the model bands or have had a nil response, as seen in the case of Chile. Thus, the observed EME heterogeneity of sovereign yields spillovers of unconventional US monetary policy, including that of the LATAM economies, can be explained to a large extent by the model setup above.

Finally, we used the estimated Model 5 to obtain some inference relative to the future normalization of US monetary policy. Figure 4 simulates a monetary shock that increases US sovereign bonds by 100 bp versus a shock that simultaneously increases sovereign bonds and high-yield spreads by 100 bp. We take the estimated model as the true one and fix the parameter values abstracting any model uncertainty. The simulation exercise considers the observed country characteristics in December 2014. There are two significant results. First, the interest rate channel, represented by changes in the Treasury bond, is more relevant than the risk channel represented by the high-yield spreads. The average EME yield response is 62 bp through the interest rate channel and 68 bp when adding the risk channel. The size of the impact of the country characteristics on these responses is non-negligible: A one standard deviation increase in CDS (92.4 bp), the inflation rate (2.9%) and the stock capitalization (258%) implies an increase in the average EME yield response of 39 bp, 45 bp and 41 bp, respectively, while a one standard deviation increase in the reserves to GDP ratio (28%) implies a 61 bp reduction in the average EME yield response. Second, the countries with weaker economic fundamentals (Indonesia, Brazil or Turkey) respond more than the average country, and thus experience a higher vulnerability to changes in US monetary conditions. Other group of countries combines better fundamentals with lower sensitivity to US shocks like the Eastern European economies that are more linked to the euro area (Poland, Hungary or Czech Republic).Moreover, the remaining Latin American countries are above the EMEs average showing also a higher vulnerability. That is a consequence of the relative deterioration of their financial and macroeconomic fundamentals at the end of the sample period as a result of a number of shocks (slowdown of the Chinese economy, reduction of commodities' prices, and tightening of global financial conditions) that affected Latin American economies more severely.

Figure 4

MODEL RESPONSE TO AN INCREASE IN THE US SOVEREIGN YIELD AND THE US HIGH YIELD SPREAD, DECEMBER 2014



Note: Average response of countries to 100 basis points in US sovereign yields (light gray bar) and 100 basis points increase in US sovereign yields and high-yield spread (dark gray bar). It uses the multivariate panel-data model (Table 11, specification 3).

4. CONCLUSIONS

The empirical literature has shown that Latin American economies are very sensitive to US monetary policy shocks. Higher dollarization of assets and liabilities, closer financial and commercial links with the United States, and dependency on the commodities cycle could account for this historically. Moreover, after the financial crisis and the launching of unconventional monetary policies in advanced economies, Latin America was one of the regions that received massive capital flows. Now that the US monetary cycle is starting to turn, it is important to anticipate the asset price response considering country specificities, as this may be relevant for designing the proper policy response.

First, we analyzed whether there was a significant impact of US nonstandard monetary policies on financial asset prices for a set of emerging economies, including five Latin American countries. The analysis of policy events showed a more significant effect across EME asset prices after the first set of quantitative easing announcements in 2008-2009 and the tapering talk in 2013, consistent with previous results in the literature. We also found an excess response by Latin American yields and exchange rates.

Second, we explored whether the role of fundamentals in conditioning the responses in EME economies to US unconventional monetary policy shocks differed across different episodes. We found that a set of country characteristics were relevant in explaining the first set of unconventional measures in 2008-2009, but that the tapering talk in 2013 initially had a more indiscriminate effect across EMEs, and in either case there is no evidence of an independent effect coming out of the Latin American economies.

Finally, we estimated a simple model of the international transmission of US financial conditions that incorporated the domestic country characteristics to explain the observed cross country differences. The inflation rate, the CDS spread, the official reserves ratio, and the market capitalization are the most significant variables for measuring the vulnerability of the EME economies, and Treasury yield changes are a relevant channel to measure the spillover effects of US financial shocks. On average, the observed event responses to US unconventional monetary policies were within the estimated model bands, including those of the five Latin American countries in our sample.

Overall, we showed that the intensity of the reaction of a number of financial asset prices in emerging economies to US monetary policy announcements depends on macroeconomic fundamentals. In particular, we found that a parsimonious model including CDS spreads, the ratio of official reserves to GDP, the inflation rate, and the market capitalization explains, to a large extent, the cross-country heterogeneity in the spillovers of US monetary policy. In addition, although we found some excess response of Latin American asset prices to recent US monetary policy announcements, this differential response disappears once we take into account country-specific characteristics. In light of our results, the current deterioration of macroeconomic fundamentals in the Latin American region suggests that they are particularly vulnerable to the foreseeable normalization of US monetary policy.

The evidence provided by the effect of US monetary policies on EME asset prices did not consider the policy responses and the exchange rate framework of the domestic economies. These are relevant aspects to be considered in future work. Moreover, this future work should also consider the response of other financial market variables (dollar-denominated sovereign bonds, corporate bonds, capital flows, to name a few) to US monetary policy measures, in order to assess the robustness of our spillover results.

ANNEXES

Annex 1: Definitions of the Variables

Dependent variables	*Description*	*Source*	*Unavailability*
Sovereign yields	In local currency	Bloomberg[1]	
Exchange rates	Bilateral exchange rate with US dollar	Datastream	
Stock market prices	Aggregate index	Reuters	

Country characteristics	*Description*	*Source*	*Unavailability*
GDP	Year to year GDP growth	National statistics, IFS, OECD	
Inflation	Year to year consumer price index growth	National statistics, IFS	
Debt to GDP	Public debt to GDP (%)	Oxford Economics	Chile
Policy rate	Official interest rate, set by the central bank	National central banks, IFS	China, Singapore, Taiwan
CDS	Credit default spread	Datastream	South Africa, Singapore, Taiwan, India
Current account	Current account balance respect to GDP (%) (+): surplus, (−): deficit	National statistics, IFS, OECD, Oxford Economics	
Reserves	Reserves assets to GDP (%)	National statistics, Datastream, IFS	
External debt	External debt to GDP (%)	National statistics, Oxford Economics	Singapore, Malaysia, Philippines, Hong Kong, Taiwan, Korea

Country characteristics	*Description*	*Source*	*Unavailability*
Portfolio flow	Net inflows of capital to GDP (%)	National statistics, IFS, OECD, Datastream	Singapore, Malaysia, Philippines, Hong Kong, Taiwan
Net banking position	Foreign assets minus foreign liabilities to GDP (%)	National statistics, IFS	Singapore, Malaysia, Philippines, Hong Kong, Taiwan, Poland, Korea
Exchange rate deviation	Deviation from equilibrium exchange rate (proxied as a deviation from the historical average). A positive value indicates that the national currency is overpriced	JP Morgan	Singapore, Malaysia, Philippines, Hong Kong, Taiwan
Real exchange rate growth	Last year real exchange rate growth. An increase is an appreciation of the national currency	JP Morgan	-
Capitalization	Stock market capitalization to GDP	Bloomberg	-
Chinn-Ito index	Chinn and Ito index. An increase in the value implies a greater degree of openness of the financial account	Chinn and Ito web	Taiwan
Exports	US exports to GDP (%)	National statistics, FRED	

[1] For Chile, the source is the Central Bank of Chile; and for Brazil, the source is De Pooter et al. (2013).

Annex 2: Summary of Statistics

Variable	*Obs.*	*Mean*	*Standard deviation*	*Min*	*Max*
Yields (one month change)	1,500	−0.04	0.50	−4.39	4.30
Exchange rates (one month change)	1,500	0.12	4.42	−14.02	26.69
Stock indices (one month change)	1,500	0.77	6.39	−37.28	38.46
GDP growth	1,500	3.61	3.86	−14.74	18.86
Inflation	1,500	3.67	2.94	−9.48	16.22
Current account to GDP	1,500	1.36	6.28	−9.55	24.18
Chinn Ito index	969	0.53	1.39	−1.18	2.42
Exports to GDP	1500	4.73	4.69	0.42	25.67
CDS	1,200	178.97	92.36	51.00	725.00
Policy rate	1,275	4.41	2.76	0.05	16.75
Capitalization	1,500	1.35	2.58	0.99	14.94
Debt to GDP	1,500	44.11	22.00	3.79	106.65
Net banking position	1,022	−0.33	21.25	−27.66	90.39
External debt	1,035	37.12	30.20	3.31	148.15
Portfolio flow	1,023	2.19	3.27	−6.46	16.85
Exchange rate deviation	1,080	7.78	18.86	−35.70	72.74
Reserves	1,500	33.32	27.70	8.78	122.13
Real exchange rate growth	1,500	−0.39	7.14	−30.00	30.90

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Have QE Programs Affected Capital Flows to Emerging Markets?: A Regional Analysis

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Miriam González

Abstract

In the aftermath of the 2008-2009 financial crisis, international capital flows to emerging markets increased substantially and have remained close to all-time highs, although with volatility. The most recent episode of capital inflows has taken place in the context of extremely accommodative monetary policies in advanced economies, characterized by exceptionally low interest rates and the implementation of unconventional monetary policies, which have generated additional reductions in long-term interest rates. This paper presents an empirical analysis of the drivers of international capital flows to emerging economies in the postcrisis period. Using the pull versus push framework, we estimate a panel for 15 emerging economies, and we find that external factors remain the main determinants of capital flows. Within external factors, QE programs implemented in the United States, measured both directly through treasuries purchases and indirectly through the long-term interest rate, had an impact on capital flows. However, the effect was different across regions, playing an important role in Asia and Latin America. Finally, we found that risk aversion seems to be an important driver of these flows for all regions.

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JEL classification: F32, G11.

1. INTRODUCTION

Capital flows to emerging economies (EME) have increased sharply during the last decade, reaching all-time highs and this trend seems to have strengthened after the financial crisis of 2008. This recent episode of capital inflows was different compared to previous episodes, not only in magnitude but also in the composition of such flows. This situation has been a major challenge for policymakers in emerging economies due to the trade-off between the potential benefits and the risks associated with these episodes of massive capital inflows. On the one hand, the increase in capital flows to emerging economies should be a positive factor for such countries, to the extent that an increase in capital availability can contribute to higher economic growth through *1)* increased investment in those economies, *2)* reducing the cost of capital through a more efficient allocation of resources, *3)* further development of the financial system and, *4)* in the case of foreign direct investment (FDI), contributing to the adoption of more advanced technologies (Prasad et al., 2003). On the other hand, the size and volatility of capital flows can pose risks to financial stability in these countries given: *1)* the possibility of a sudden stop of capital flows, and *2)* the emergence of bubbles in asset prices. Given this trade-off, it is important to understand the factors behind the most recent episode of capital inflows.

The most recent episode of capital inflows has taken place in a context of extremely accommodative monetary policy in advanced economies, characterized by exceptionally low interest rates and the implementation of unconventional monetary policies, which have generated additional reductions in long-term interest rates. In this context, it is worth reviewing the analytical framework of pull versus push factors that has been widely used in the literature on the determinants of capital flows, and thus analyze the causes behind the resurgence of capital flows to emerging economies in the last decade. This paper aims to contribute to this analysis by identifying the factors that have led to the increase of capital inflows observed since 2005 in the major emerging economies. As Fernández-Arias (1993) noted, to the extent that the increase in capital flows is motivated by internal factors, the risk of a sudden reversal of these capitals is lower.

Our contribution with respect to previous studies on this subject is twofold. First we focus on gross capital inflows to specifically describe the behavior of capital inflows by non-residents, contrasted with net capital flows, which refer to the change in balances of residents and foreign investors. Secondly, we conduct a regional analysis to measure how the drivers of capital flows differ across regions of emerging countries. Additionally, we aim to measure the impact of the USA quantitative easing using two variables, one associated with the USA long-term interest rate, and the second one through treasuries purchased as part of QE programs.

Our analysis suggests that external factors have been among the main drivers of capital flows to EME, and within these factors, QE programs implemented in the United States have been particularly important in the current episode, both through the asset purchases programs and through the impact of the USA long-term interest rate, particularly to Asian and Latin American economies. Finally, we found that risk aversion seems to be an important driver of these flows for all regions. These results are very relevant in view of the current macroeconomic environment, in which the Federal Reserve concluded its last QE program in October 2014. Looking forward, these results are even more pertinent since, after seven years of extraordinarily low interest rates, the United States started the normalization of its monetary policy towards higher interest rates in December 2015.

This paper is organized as follows. In the second section we present a brief review of related literature. In the third section we describe the evolution of capital flows to EME in the recent episode of capital inflows. In the fourth section we summarize the unconventional monetary policies that have been implemented in the USA after the financial crisis of 2008. In the fifth and sixth sections we describe our empirical strategy and summarize our main findings. Lastly, in section 7 we present our conclusions.

2. LITERATURE REVIEW

During the nineties, several studies were published attempting to explain the factors that had triggered the growth of capital flows to emerging economies at the beginning of that decade. One of the most important papers in this field is the one of Calvo, Leiderman, and Reinhart (1993), where the authors analyzed the importance of external factors in the growth of capital flows to Latin America. They noted that while the economic and political reforms implemented in some Latin American countries in the late eighties contributed to the resurgence of capital flows, this reason was not enough to explain why the region in general benefited from greater flows, including countries that had not undergone economic transformations. Therefore, they argued that because there were different macroeconomic policies and important differences in economic performance among countries in the region, external factors must have played a major role in the decisions of investors to bring their resources to Latin America; in particular, the role of low interest rates in the United States is crucial, as well as the economic recession in the USA and the evolution of its balance of payments. With this analysis, the authors developed the analytical framework that divides the determinants of capital flows into domestic factors, also known in the literature as *pull* factors, and external or *push* factors, which has been widely used in subsequent studies on this subject.

Chuhan, Claessens, and Mamingi (1993) also used this approach of pull versus push factors to explain the surge in capital flows to emerging economies. These authors analyzed the flows of debt and equity to Latin American and Asian economies using a panel that included both pull and push factors. This analysis found that debt flows respond strongly to the country's credit rating, which is a variable that reflects the domestic conditions of each economy. However, they also found a high sensitivity of debt and equity flows to USA interest rates. To analyze the relative importance of pull and push factors, the authors calculated the sum of the standardized coefficients for each category, finding that, in Latin America, pull and push factors were equally important in explaining the rise in equity flows, while in Asian economies pull factors were four times more important than external ones.

Another important document that emerged during the nineties, and to some extent contributed to reconciling the results of the two documents mentioned above, was that of Fernández-Arias (1993). This author used a structural model to explain the dynamics of capital flows to emerging economies. As with Calvo et al. (1993) he found that the surge of private capital flows in that period was mainly due to the fall in interest rates in advanced economies, noting that the behavior capital flows had previously registered would not be sustainable when interest rates in developed countries started to rise. He also analyzed the improvement in credit conditions in emerging economies during that period, and found that this apparent improvement was due to the reduction in funding costs resulting from lower interest rates globally and not, as Chuhan et al. (1993) argued, due to the improvement in macroeconomic conditions in emerging economies.

More recently, the literature on the determinants of capital flows has focused on analyzing the new resurgence of capital flows in the postcrisis period, and has tried to analyze whether the increment of capital flows has been associated with the unconventional monetary policies that have been implemented by advanced economies in recent years. Since the transmission channels of those types of measures differ from the traditional channels, an intense debate has arisen concerning the spillover effects they may have on other economies, particularly on emerging countries. Due to the relevance of this debate for policymakers, many authors have analyzed this topic.

Fratzscher (2011) analyzed the role of different drivers of global capital flows during the crisis and in the subsequent period. Using a factor model coupled with micro level data from EPFR of portfolio capital flows to 50 economies, he found that common factors (*push* factors) were overall the main drivers of capital flows during the crisis, while country-specific determinants (*pull* factors) were dominant in accounting for the dynamics of global capital flows throughout 2009 and 2010, in particular for emerging markets.

Another important document in this regard is Fratzscher et al. (2013) that analyzed the global spillovers of USA QE1 and QE2 programs on 65 foreign financial markets. Specifically, they investigated the impact on capital flows, asset prices and exchange rates. Using EPFR's daily data on portfolio equity and bonds flows from January 2007 to December 2010, they analyzed the response of portfolio decisions to unconventional policy actions, both operations and announcements. They found that the Federal Reserve's QE programs functioned in a procyclical manner for capital flows to EME, with portfolio rebalancing out of EME under QE1 and in the opposite direction under QE2.

Ahmed and Zlate (2013) analyzed the determinants of net private capital flows to 12 emerging economies from Asia and Latin America over the period 2002 to 2012. The main explanatory variables included in the model were the growth and interest rate differentials between advanced and emerging economies, risk aversion, and accumulation of reserves. To capture the effect of unconventional monetary policy in the United States they used two dichotomous variables: The first one takes the value of one in the quarters in which the Federal Reserve announced or extended QE programs, and the second takes the value of one during the period when these programs were in place. Their results suggest that interest rate differentials and growth are important determinants of capital flows. Regarding the effect of non-conventional monetary policy, they do not find a statistically significant relation in total flows; however, they do find an effect on portfolio flows.

3. EVOLUTION OF CAPITAL FLOWS TO EMERGING ECONOMIES

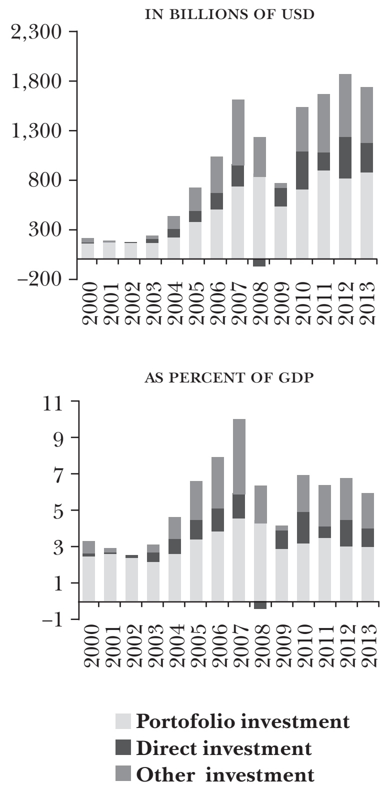
Capital flows to EME remained stable at the beginning of the last decade, but since 2004 they have increased substantially, reaching all-time highs (Figure 1). Even after the retrenchment that was observed in the onset of the financial crisis, capital flows recovered very quickly, rebounding to the levels seen prior to the crisis by 2012. Although capital flows as a percentage of GDP have not returned to their precrisis peak, it is worth noting that in recent years they have remained on average around 6%, which represents an increase of 100% from the levels that were seen in 2000.

The recent episode of capital inflows has been characterized by an increase in all types of investment: Direct investment (FDI), portfolio flows, and other investments. Nevertheless, after the financial crisis there was a shift in the composition of capital flows towards greater portfolio investment, which includes debt and equity securities that are more liquid.[1] On the one hand, portfolio flows –and in particular debt securities– have allowed EME to take advantage of the global

[1] *Balance of Payments and International Investment Position Manual,* sixth edition.

low interest rates by issuing debt at lower costs. On the other, the increased share of this kind of investment has been a source of concern among policymakers in EME given the volatility of such capital flows, and the fact that their negotiability allows investors to withdraw their investment readily, raising the risks of abrupt capital outflows. This represents a major challenge for policymakers in all EME, but especially in Latin America, which has been the largest recipient of this kind of investment (Figure 2).

Figure 1
GROSS CAPITAL FLOWS
TO EMERGING ECONOMIES



Source: *Balance of Payments Statistics* and WEO, IMF, and authors' calculations.

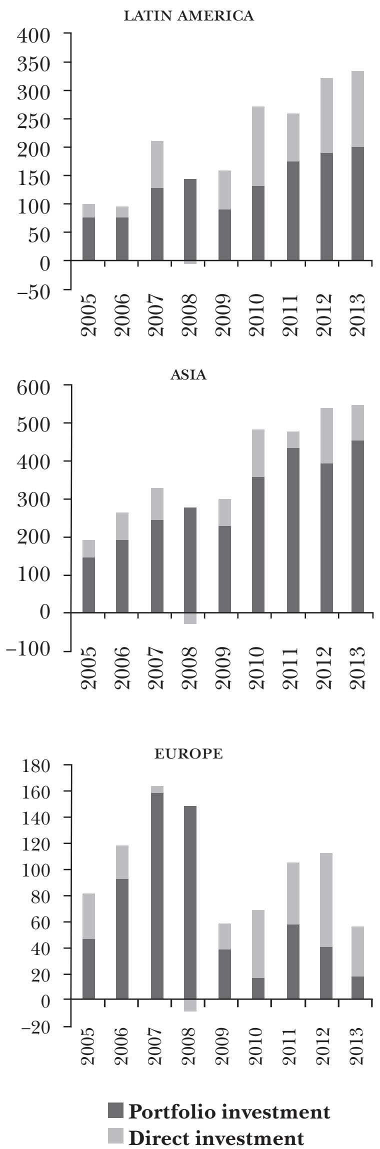
Looking at the composition of portfolio flows in our sample of EMEs, we noted that in the post-crisis period, equity and debt securities increased sharply, albeit with some volatility, but in general debt flows have represented a larger share of portfolio investment. This trend started even before the financial crisis, and has been associated with the expansion and deepening of local currency bond markets in EME, particularly in government bonds. Compared to previous episodes of capital inflows in EME, in the recent episode most of the debt investment has been denominated in domestic currency, eliminating the *original sin syndrome* which refers to the propensity of EME to borrow in hard currency, mainly in USA dollars.[2] Although this has been a general trend in EME (probably reflecting the structural changes in financial markets), some countries stand out for the magnitude of debt flows that

[2] This term was coined by Eichengreen and Hausmann (1999).

Figure 2

COMPOSITION OF CAPITAL FLOWS PER REGION

USD billions



Source: *Balance of Payments Statistics* and IMF.

they have received from non-residents, mainly through government securities. As we show in Figure 3, this is the case for many of the countries in our analysis such as Indonesia, Poland and Mexico, where non-residents' holdings in local currency government debt represent more than 30% of total outstanding debt. We can also observe that the holdings of foreign investors increased more sharply in the post crisis period, which could suggest that this trend is associated with some of the monetary developments that have taken place in the last few years.

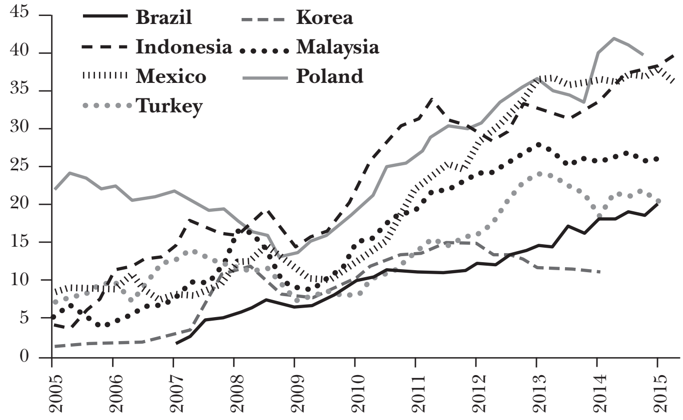
Although there must be common factors that have pushed capital flows to EME in the last decade, such as low interest rates in advanced economies or the excess of liquidity generated by QE programs in advanced economies, there must also exist domestic, or pull, factors that explain why some countries have received larger flows than others, and that also account for the difference in the composition of such capital flows among regions. This also suggests that some drivers of capital flows may be more important for certain kinds of investment than for others, or maybe there are different drivers for every type of investment.

Since FDI is associated with a

Figure 3

GOVERNMENT SECURITIES HOLDINGS BY FOREIGN INVESTORS

Percentage of total outstanding amount



Note: Data up to the 2015Q1 except for Mexico and Indonesia (2015Q2).

Source: Haver Analytics and Banco de México.

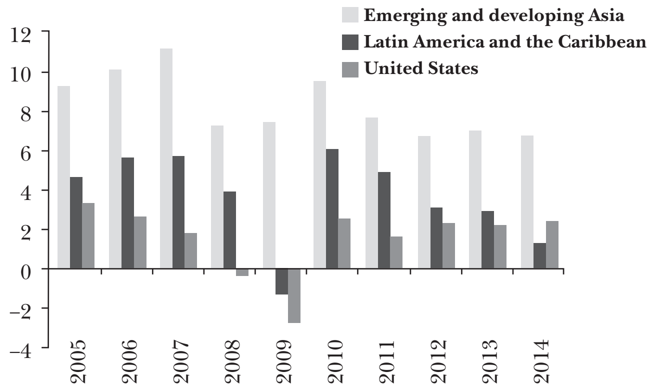
long-term horizon, we could think that domestic variables are more important for this type of investment. We showed in Figure 2 that in the most recent episode of capital inflows, Asian economies received a larger share of FDI compared to other emerging regions. Following the previous pull factors that have been cited in the literature, one of the possible explanations for the predominance of FDI in Asia is its economic performance. In Figure 4, we show that the economic growth in Asia has outperformed the one in Latin America, and even in 2009, when most countries registered a contraction in economic activity as a result of the financial crisis, the Asian economies maintained positive growth.

In sum, even though we could attribute the increase of capital flows to external factors –that are common to all EME– it is not straightforward to understand why the composition of portfolio flows has differed among regions, which suggests that we must also take into account domestic variables to try to explain the increase that capital flows have registered in the last decade.

Figure 4

ECONOMIC GROWTH

Percent change



Source: World Economic Outlook, IMF.

4. US UNCONVENTIONAL MONETARY POLICES

Due to the severity of the 2008-2009 financial crisis, the Federal Reserve implemented a set of unorthodox policies. At the beginning of the crisis such policies were aimed at restoring the correct functioning of financial markets and some specific sectors in the economy, but as time passed more policies were implemented in order to boost economic activity and employment. The most important of those policies have been forward guidance and quantitative easing (QE). In our analysis we will focus on the impact of the latter.

Two months after the bankruptcy of Lehman Brothers, and with the federal funds rate close to zero, the Federal Reserve announced on November 25, 2008, that it would buy up to 500 billion dollar in mortgage-backed securities (MBS) and 100 billion dollar in direct obligations of housing-related government-sponsored enterprises (GSEs). This program of asset purchases was denominated QE1. Unlike the subsequent programs, QE1 was implemented at a time when demand for liquidity was particularly high, so the program helped to ease conditions in credit markets; in particular, the objective of this first program was to reduce the cost and increase the availability of credit for the housing sector.

Because conditions in the credit market remained tight, employment continued deteriorating and household wealth declined further, and the Federal Reserve decided at its meeting in March 2009 to increase the amount of assets that it would buy to 750 billion dollar, making total purchases amounting to 1.25 trillion dollar. In addition, the Federal Reserve announced that it would buy up to 300 billion dollars in long-term Treasury bonds in order to help ease conditions in private credit markets. Purchases of treasuries were completed towards the end of that year, while purchases of MBS and agency debt continued until March 2010. The total amount of QE1 was 1,725 billion dollar.

Months after the conclusion of the first purchase program, following weeks of speculation among market participants, the Federal Reserve announced at its November 3, 2010, meeting that it would start a second round of asset purchases (QE2), which would consist of monthly purchases of 75 billion dollar in long term Treasury bonds, for a total of 600 billion dollar. Unlike QE1, this program was implemented when conditions in financial markets had normalized, so its goal was aimed at stimulating economic activity in a context in which inflation was below the Federal Reserve inflation target of 2% and unemployment well above long-term rates. This program ended in June 2011.

After QE2 ended, the Federal Reserve announced the implementation of a program called Operation Twist. This program unlike QE did not imply an increase in the central bank balance sheet, as the Federal Reserve bought long-term assets and sold the same amount of short-term assets, but this program contributed to a further reduction in long-term interest rates. This program was in effect until December 2012.

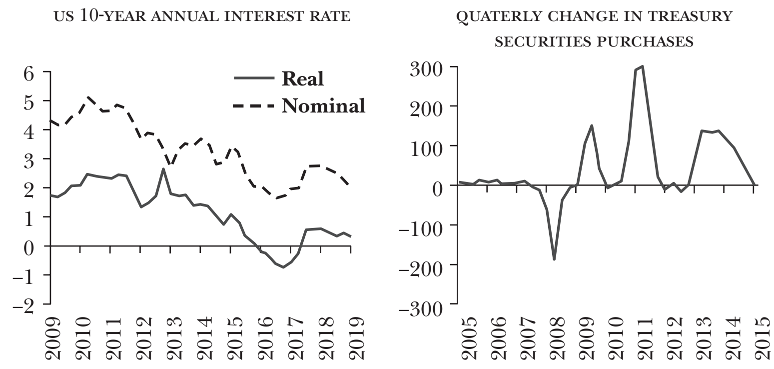
The third round of asset purchases (QE3) was announced in September 2012. Unlike the first two programs, the Federal Reserve did not determine the total amount of the program; instead, it announced that it would purchase MBS at a pace of 40 billion dollar per month. The implementation of this program was aimed at further reducing interest rates, thus contributing to strengthening the economic recovery.

In December 2012, the Federal Reserve announced that it would also purchase longer-term Treasury securities at a pace of 45 billion dollar per month, making total monthly purchases of 85 billion dollar. It is noteworthy that in the same statement, the Committee added that the exceptionally low interest rates would continue until the unemployment rate was located at 6.5% and inflation expectations for the next two years were no more than 0.5 percentage points above the

Figure 5

10-YEAR INTEREST RATE AND TREASURIES PURCHASES

USD billions



Source: Federal Reserve.

target of 2%. With this change of language, the continuity of asset purchases was linked to economic conditions, particularly labor market conditions, which meant a major shift from previous programs. Given this change in the communication of the Federal Reserve, financial markets became more sensitive to changing economic conditions in the United States, particularly to the evolution of labor conditions.

The third program ended in October 2014; however, the Federal Reserve has maintained its policy of reinvesting principal payments from its holdings of agency debt and agency mortgage-backed securities in agency mortgage-backed securities and of rolling over maturing Treasury securities at auction, so the balance sheet of the central bank is still at historically high levels. Furthermore, there is no clear position on what actions the Federal Reserve will take regarding the size of its balance sheet once it starts the cycle of monetary policy tightening.

As described before, the asset purchase programs differed in terms of quantity and type of assets purchased; in this sense the level of treasuries purchased in each phase captures the intensity of each program. Additionally, the long term USA interest rate decreased as a result of these purchases, as has been widely analyzed.[3] For this reason we will

[3] See Gagnon et al. (2010); Krishnamurthy and Vissing-Jorgensen (2011);

use these purchases and the 10-year USA interest rate (Figure 5) as variables that capture the effect of unconventional monetary policy on capital flows to emerging economies.

5. EMPIRICAL ANALYSIS

We estimate a panel of 15 emerging economies to analyze the drivers of gross capital inflows using pull and push factors as explanatory variables. Regarding pull factors we include real monetary policy rate and economic growth differentials with respect to the USA. The push factors that are included in this model are: The USA 10-year interest rate, treasuries purchases, and the VIX index, which is used as a proxy for risk aversion in international markets. It is important to highlight that the policy rate differential is used following Ahmed and Zlate's (2013) argument, which assumed that it affects return differentials and this could change investors' decisions. For the USA policy rate we use the shadow interest rate calculated by Wu and Xia (2016) and updated by the Federal Reserve Bank of Atlanta. Moreover, including it balances the model specification, given that we use the long-run USA rate. Importantly, we use real interest rates in order to control for domestic monetary developments.

To measure the impact of USA QE programs on capital flows, we conduct two exercises. In the first exercise, we aim to measure how capital flows were affected in the postcrisis period and the indirect effect of USA monetary policy through the long-term interest rate channel. In the second one, we measure directly the effect of treasuries purchases on capital inflows to EME. Since the first QE program was implemented in the USA, there have been several studies published that try to analyze the impact of those programs on USA interest rates. Although the magnitude of the effect varies among different studies, in general all have found that, in the context of the zero lower bound, QE programs have generated additional reductions in the USA 10-year interest rate.[4] Having this in mind, we also want to analyze whether the effect of the USA interest rate on capital flows has changed with the implementation of QE programs in

Hamilton and Wu (2011); and Glick and Leduc (2011).

4 See Gagnon et al. (2010); Krishnamurthy and Vissing-Jorgensen (2011); Hamilton and Wu (2011); and Glick and Leduc (2011).

the postcrisis period. For this purpose we include a dummy variable equal to one from the fourth quarter of 2008 –when the first QE program began– to the last observation. Even though the last QE program ended on October 2014, the Federal Reserve has continued reinvesting principal payments from its holdings of agency debt and agency mortgage-backed securities in agency mortgage-backed securities, therefore we set the dummy variable equal to 1 up to the first quarter of 2015.[5] In addition to the dummy variable that helps us to see how capital flows were affected in the postcrisis period, we include in our model the interaction of the USA 10-year interest rate with the dummy variable. This coefficient helps us capture the indirect effect of long-term interest rates in the postcrisis period.

According to the specification that we mentioned above, we set our regression equation as follows:

$$
\begin{aligned}
f_{i,t} = {} & \beta_1 f_{i,t-1} + \beta_2 r_t^{US} + \beta_3 s_t + \beta_4 \left(i_{i,t} - i_{i,t}^{US} \right) + \\
& + \beta_5 \left(g_{i,t} \quad g_{i,t}^{US} \right) + \beta_6 D_t + \beta_7 \left(r_t^{US} * D_t \right) + \varepsilon_t .
\end{aligned}
\tag{1}
$$

Where:

$f_{i,t}$ Capital flow to country *i*.
r_t^{US} US 10-year real interest rate.
s_t VIX index.
$i_{i,t}$ Real monetary policy rate in country *i*.
$i_{i,t}^{US}$ Real monetary policy rate in the USA (shadow interest rate).
$g_{i,t}$ Economic growth rate in country *i*.
$g_{i,t}^{US}$ USA economic growth rate.
D_t Dummy for postcrisis period.

The expected signs of coefficients are positive for β_1, β_4, β_5 and β_6, and negative for β_2, β_3 and β_7. We expect β_1 to be positive reflecting the persistence of capital flows which could indicate that investors are more likely to invest new resources in countries where they already have capital invested. β_4 should be positive to reflect the search for yield phenomenon. We expect β_5 to be positive, reflecting that low growth in advanced economies, USA in this case, tends to support capital flows to EME with higher economic growth. Looking at the behavior of capital flows in the postcrisis period, we expect β_6 to be positive, reflecting that the increase in global liquidity had a positive

[5] See Federal Reserve's July 2015 monetary policy press release.

impact on capital flows to EME. In accordance to previous literature,[6] we expect β_2 to be negative, indicating that reductions in the USA interest rates tend to favor capital flows to EMEs and vice versa. For the same reason we expect β_7 to be also negative. β_3 should be negative, reflecting that an increase in risk aversion in financial markets leads to a reduction of capital flows to EME, which is also consistent with what previous studies had found.[7]

In the second exercise, we use the natural logarithm of treasuries purchases in order to see whether the effect of the postcrisis period found before was specifically affected by the treasuries purchases that the Federal Reserve implemented.

$$f_{i,t} = \beta_1 f_{i,t-1} + \beta_2 r_t^{US} + \beta_3 s_t + \beta_4 \left(i_{i,t} \quad i_{i,t}^{US} \right) + \beta_5 \left(g_{i,t} - g_{i,t}^{US} \right) + \beta_7 Tre_t + \varepsilon_t . \tag{2}$$

Where:

Tre_t Treasury securities purchased in time *t*.

We estimate our regressions using the panel general method of moments (GMM), which allows us to control for endogeneity since we are using a number of variables as instruments. In particular, we use current values for exogenous variables, which in the model are the variables common for all EME, and lagged values for domestic variables.[8]

Our sample covers 15 EME: Brazil, Chile, Colombia, Czech Republic, India, Indonesia, Korea, Malaysia, Mexico, Peru, Poland, Philippines, South Africa, Thailand and Turkey.[9] For the dependent variables, we use quarterly gross capital inflows from balance of payments statistics (BOP) over the period 2005Q1 to 2015Q1. Specifically we use FDI, portfolio and other investment liabilities, and we estimate total flows as the sum of those three components. The data is in USA current dollars and we normalized it by the GDP of each country. We use GDP in current dollars from Haver Analytics. Although the data

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6 Calvo et al. (1993), Fernández-Arias (1993), IMF (2011) and IMF (2013).

7 IMF (2011), Marcel Fratzscher (2011), M. Fratzscher et al. (2013), IMF (2013) and S. Ahmed and A. Zlate (2013).

8 We assumed that the USA 10-year interest rate, QE programs and the VIX index are exogenous variables. Presumed endogenous variables are lagged capital flows, EME's monetary policy rates, inflation, economic growth and real exchange rate depreciation.

9 We use this group of emerging countries since we think they are the most representative countries for each region with data availability.

from BOP is not as timely as the one of EPFR, using it allows us to analyze the behavior of all types of capital flows, including FDI.[10] It is also important to highlight that in our analysis we are trying to explain the drivers of foreign capital, and therefore we are using gross capital flows instead of net flows.

The USA 10-year real interest rate is obtained from the Federal Reserve website. We use the quarterly change of the VIX index from Bloomberg. The monetary policy differential is estimated as the difference between the real monetary policy rate and the USA real effective rate from 2005:1Q to 2008:4Q. From 2009:1Q to 2015:1Q, we use the real shadow rate proposed by Wu and Xia (2016), the real monetary policy rate is obtained from Haver Analytics and both of the last two variables are obtained from the Federal Reserve of Atlanta. The growth differential is estimated as the difference between the growth rate of each emerging country and the USA growth rate with information from Haver Analytics. We use quarterly data.

The information regarding the implementation of QE programs in the USA is obtained from FOMC press releases that are available on the Federal Reserve website.

As we saw in the previous section in Figure 2, the behavior of capital flows has been different across regions of EME. Within our sample of 15 EME, there exists a lot of heterogeneity that might affect the average result we obtained in the previous section. Therefore, in this section we analyze whether the impact of QE programs has been differentiated across regions. For this purpose, we conduct the same exercises as before but we divide our sample into three groups: Latin America, Asia and in the third group we include European countries and South Africa, as shown in Table 1.

Table 1

COUNTRY GROUPS

Latin America	*Asia*	*Europe & Africa*
Brazil	India	Czech Republic
Chile	Indonesia	Poland
Colombia	Korea	South Africa
Mexico	Malaysia	Turkey
Peru	Philippines	
	Thailand	

[10] EPFR data captures only about 5-20% of the market capitalization in equity and in bonds for most countries.

6. RESULTS

6.1 General Results

In this section, we present the results that we obtained from our sample.

In the first exercise, we find that USA monetary policy has a significant impact on capital flows to EME. This effect is captured with the postcrisis dummy and the USA 10-year interest rate. In the first case, we find that for the postcrisis period, portfolio investment and total flows have increased, and it is a significant change, but not for FDI (see Table 2). The effect, as expected, is positive, which means that during the postcrisis period, particularly starting with the implementation of QE programs, capital inflows in EME have increased with respect to the previous episode. According to our analysis, capital flows as a percentage of GDP have increased around 19 percentage points since the first QE program was implemented, and 11 percentage points in terms of portfolio investment.

To measure the impact of the USA interest rate when unconventional monetary policies were in place, we should take into account the effect of this variable plus the interaction term with the postcrisis period. It is worth noting that the coefficient of the USA interest rate – without the interaction term- has a positive sign, contrary to what we might have expected; nevertheless, this is consistent with some literature that has found that in the period prior to the crisis the relation between USA interest rates and capital flows was positive.[11] When we add the interaction term, we find a negative relation between the USA interest rate and capital flows in EME, which means that the decline that the USA 10-year interest rate has registered since the financial crisis has pushed capital flows into EME. Specifically, we find that a 1 percentage point decrease in the USA 10-year interest rate leads, on average, to a 2.16 percentage point increase in total capital flows as a percentage of GDP, and a 0.65 increase in the case of portfolio flows.[12] For FDI, the relation is positive but not statistically significant.

[11] See Marcel Fratzscher (2011).

[12] With regards to the real policy rate differential, we do not find it statistically significant for either of the two exercises conducted. It is worth noting that the policy rate for the Czech Republic reached the zero lower bound (ZLB). Nevertheless, there are few observations where the ZLB is registered in this country, thus the results obtained did not change when not considering this episode.

We also find that increases in risk aversion in financial markets are associated with capital outflows from EME. These outflows take place on portfolio and other investments.

Our results suggest that for the pull factors, we only find growth differential to be statistically significant; for every percentage point that growth in EME surpass the USA growth rate, capital flows as a percentage of GDP increase on average 0.65percentage points. The external or push factors have been important drivers of capital flows in the last decade.

In order to test for other pull factors that might have helped attracting capital flows to emerging economies, in the Annex we include the run of the same regression presented in Table 2 including trade openness, measured as the sum of exports and imports as percentage of GDP. The results do not change in terms of significance and direction, and trade openness is not significant. This is consistent with the fact that the biggest changes in these indicators happened before our sample period started.

In the second exercise, we find that when the natural logarithm of treasuries purchases is the main variable capturing USA unconventional monetary policy, these also have an important and significant effect on capital flows to EME.[13] Our results –reported in Table 3– suggest that a 1% increase in treasuries purchases increases capital flows by 8.84%, whereas the effect for portfolio investment is an increase of around 2.65 percent.

It is also worth noting that for the FDI, the coefficients of treasuries are positive but not significant, whereas the uncertainty in financial markets continues to be an important determinant of capital flows to emerging market economies.

Note that the variation that allows this model to measure the effect of unconventional monetary policy in the USA is captured in the treasuries purchases and not in the long-term interest rate, as in the previous exercise, since the latter is neither statistically significant for portfolio investment nor FDI.

We do not find the policy rate differentials statistically significant, similar to the results found by Ahmed and Zlate (2013), although it has a positive sign for total inflows in both exercises. The lack of significance of policy rate differentials when fixed effects are included

[13] This exercise also includes a dummy for the taper talk period as control, which was not statistically significant.

is consistent with the idea that these fixed effects may be partly capturing the long-run interest rate differentials between EME and AE, as Ahmed and Zlate (2013) argue.

Table 2

DETERMINANTS OF CAPITAL FLOWS TO EME:
PANEL REGRESSION RESULTS

	Total	*Portfolio Investment*	*FDI*
	(1)	*(2)*	*(3)*
L(−1)	0.103[b]	0.147[c]	0.118[c]
	(0.048)	(0.047)	(0.042)
USA 10-year real interest rate	8.967[c]	5.041[c]	0.406
	(3.324)	(1.957)	(1.036)
VIX	−0.059[c]	−0.042[c]	−0.002
	(0.009)	(0.005)	(0.004)
Policy rate differential	0.014	−0.011	0.053
	(0.170)	(0.106)	(0.067)
Growth differential	0.656[c]	0.214[b]	0.023
	(0.162)	(0.099)	(0.060)
Postcrisis period	19.459[c]	11.792[c]	0.426
	(7.086)	(4.246)	(2.259)
Postcrisis period* USA 10-year real interest rate	−11.122[c]	−5.693[c]	−0.565
	(3.761)	(2.200)	(1.149)
Country fixed effects	Yes	Yes	Yes
J-statistic	1.71	3.58	4.60
P(J-statistic)	0.43	0.31	0.47

Coefficients estimated with GMM. Standard errors are reported in parentheses.
[a], [b], [c] indicates significance at the 90%, 95%, and 99% level, respectively.

Table 3

DETERMINANTS OF CAPITAL FLOWS TO EME:
PANEL REGRESSION RESULTS

	Total	*Portfolio investment*	*FDI*
	(1)	*(2)*	*(3)*
L(−1)	0.133[b]	0.153[a]	0.120[c]
	(0.059)	(0.062)	(0.045)
USA 10-year real interest rate	4.417[c]	1.008	0.210
	(1.532)	(0.609)	(0.185)
VIX	−0.086[c]	−0.044[c]	−0.003
	(0.016)	(0.007)	(0.004)
Policy rate differential	0.149	−0.357	−0.013
	(0.251)	(0.314)	(0.069)
Growth differential	0.661[c]	0.095	0.024
	(0.225)	(0.179)	(0.064)
Treasuries	8.839[c]	2.653[a]	0.223
	(2.344)	(1.067)	(0.343)
Country fixed effects	Yes	Yes	Yes
J-statistic	3.39	1.13	10.23
P (J-statistic)	0.34	0.57	0.18

Coefficients estimated with GMM. Standard errors are reported in parentheses.
[a], [b], [c] indicates significance at the 90%, 95%, and 99% level, respectively.

6.2 Regional Analysis

In this section, we run the same regressions as before but divide our sample into three regions.[14] For the first exercise, where we include the interaction term of the dummy for the postcrisis period and the USA interest rate, we find that during the postcrisis period, capital

[14] Even though South Africa is not related to Europe, we decided to include it in this group of countries because some of the developments observed in that country are similar to Turkey and other EME in the region. Nevertheless, we run the same regressions dropping South Africa and the results presented below did not change.

inflows in Latin America and Asia increased, while we do not find evidence of any effect on Europe and South Africa. As we can see in Table 3, during the postcrisis period flows increased more in Asia and the difference is significant for all types of investment, including FDI. Meanwhile, in Latin America, the evidence suggests that the main effect during the postcrisis period is on portfolio investment.

Regarding the effect of the USA 10-year interest rate, our evidence suggests that it is much stronger for capital flows to Latin America; in particular, we find that a one percentage drop in the USA interest rate leads to an increase of 2.42 percentage points in total flows as a percentage of GDP, whereas in Asia the increase is around 1.42percentage points.[15] Similarly, a reduction of 100 basis points in the USA interest rate generates an increase of 1.35 percentage points in portfolio inflows in Latin American economies, and of 0.49percentage points in Asia. These results are consistent with the behavior that we have observed of capital flows in those regions.

The VIX index is statistically significant for the three regions, and in all cases has a negative sign, suggesting that in periods of increased risk aversion, capital moves out of EME. We find that this effect is greater for total flows in Asia, although the effect is very similar for portfolio investment in Asia, Europe, and South Africa. In Latin America the total effect of VIX index is smaller.

In the analysis by region, we find that in the last decade, economic growth has been a driver of total capital flows to emerging Asia. For this region, we find that for every 1 percentage point that the domestic economy outgrows the USA, total flows as a percentage of GDP increase by 0.63 percentage points.

In the second exercise, we measure the impact of Treasury securities purchases directly, and we find that these indeed are associated with more capital flows in both Asia and Latin America. Our evidence suggests that the effect is greater in Asia, although the effect was statistically significant for the total and portfolio flows in Latin America. We find that these programs are associated with an increase of total capital flows in Asia and Latin America. Additionally, our results suggest that economic growth has an impact on total capital flows in EME, in all three regions. These results are summarized in Table 5.

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[15] The total effect from the USA 10-year interest rate is obtained from the sum of β_2 and β_7.

In this regression, we find that a 1% increase in treasuries purchases is associated with a 7.6% and 12.0% increase of total capital flows in Latin America and Asia, respectively, but with no effect in Europe and Africa. In terms of portfolio investment, the effect of treasuries purchases is higher in Latin America than in Asia, but in the former, FDI is not affected by these programs.

Consistent with our previous results, higher growth differential with respect to the USA is associated with higher capital flows. In the case of Latin America, this is statistically significant for total and portfolio investment, and in the case of Asia, we find evidence for total capital flows. It is also worth noting that uncertainty in financial markets measured by the VIX is an important factor behind capital flows in all regions and for all types of investment.

6.3 Robustness Checks

In order to check the robustness of our results, we test an additional hypothesis.

Since our model is better at explaining total and portfolio flows, we want to rule out other possible explanations of the increase in this kind of investment. In particular, we test whether the inclusion of a country in the Citigroup World Government Bond Index (WGBI) is associated with the observed increase in portfolio investment. In order to measure the impact of the inclusion in the WGBI we decide to use a dummy variable equal to 1 for the countries which bonds are included in this index since the quarter that they were included. To have a better specification of our model, we decide to measure the impact of QE programs by the total purchases of MBS and treasuries. We run this regression for total portfolio investment and for debt flows. The results are reported in Table 6.

Our analysis suggests that the inclusion in the WGBI is not associated with the increase of capital flows that is observed in the last decade, which supports our previous results that QE programs were among the main drivers of portfolio investment in the last years.

Table 4

DETERMINANTS OF CAPITAL FLOWS TO EME: PANEL REGRESSION RESULTS

	Latin America			*Asia*			*Europe and Africa*		
	Total	*Portfolio Investment*	*FDI*	*Total*	*Portfolio Investment*	*FDI*	*Total*	*Portfolio Investment*	*FDI*
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
L(−1)	−0.015	0.118	0.026[b]	0.154	0.110[b]	0.164[b]	0.061	0.222[c]	0.141[a]
	(0.092)	(0.083)	(0.080)	(0.079)	(0.082)	(0.070)	(0.085)	(0.086)	(0.076)
US 10-year real interest rate	9.275[a]	3.671[a]	−2.332	10.411[b]	9.297[c]	1.622	5.418	−0.462	0.476
	(5.481)	(2.059)	(1.972)	(4.328)	(3.395)	(1.055)	(4.914)	(2.827)	(1.654)
VIX	−0.029[b]	−0.021[c]	0.009	−0.085[c]	−0.055[c]	−0.005	−0.052[c]	−0.050[c]	−0.010
	(0.015)	(0.007)	(0.007)	(0.014)	(0.010)	(0.004)	(0.015)	(0.009)	(0.007)
Policy rate differential	−0.692[a]	−0.085	0.098	0.293	0.084	−0.027	−0.076	−0.037	0.035
	(0.379)	(0.165)	(0.192)	(0.322)	(0.235)	(0.085)	(0.307)	(0.186)	(0.133)
Growth differential	0.490	0.250	−0.173	0.625[a]	0.280	0.092	0.467	0.175	0.003
	(0.305)	(0.139)	(0.145)	(0.342)	(0.243)	(0.084)	(0.296)	(0.179)	(0.123)
Post-crisis period	21.88[a]	9.901[b]	−4.798	21.272[b]	19.976[c]	3.215	9.509	−0.090	−0.446
	(11.544)	(4.489)	(4.33)	(9.467)	(7.476)	(2.351)	(10.041)	(5.838)	(3.52)
Post-crisis period *USA 10-year real interest rate	−11.69[b]	−5.024[b]	2.151	−11.832[b]	−9.784[c]	−1.959[a]	−7.237	0.519	−0.324
	(5.813)	(2.320)	(2.210)	(5.080)	(3.900)	(1.200)	(5.341)	(3.073)	(1.783)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
J-statistic	0.02	1.95	7.19	3.33	1.17	8.16	1.87	4.04	2.00
P(J-statistic)	0.99	0.58	0.21	0.19	0.76	0.15	0.39	0.26	0.85

Coefficients estimated with GMM. Standard errors are reported in parentheses. [a], [b], [c] indicates significance at the 90%, 95%, and 99% level, respectively.

Table 5

DETERMINANTS OF CAPITAL FLOWS TO EME: PANEL REGRESSION RESULTS

	Latin America			*Asia*			*Europe and Africa*		
	Total	*Portfolio Investment*	*FDI*	*Total*	*Portfolio Investment*	*FDI*	*Total*	*Portfolio Investment*	*FDI*
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
L(−1)	0.019	0.127	0.022	0.166[b]	0.163[b]	0.175[c]	0.162	0.253[c]	0.175[b]
	(0.1)	(0.106)	(0.078)	(0.088)	(0.074)	(0.068)	(0.104)	(0.088)	(0.083)
US 10-year real interest rate	3.171[a]	0.976	−0.453	7.098[b]	3.287[b]	0.406[a]	7.153[a]	2.575	0.518
	(1.697)	(0.968)	(0.380)	(2.892)	(1.580)	(0.214)	(3.845)	(1.918)	(0.413)
VIX	−0.058[b]	−0.029[c]	0.010	−0.113[c]	−0.067[c]	−0.007*	−0.021	−0.50[c]	−0.011
	(0.023)	(0.009)	(0.007)	(0.029)	(0.013)	(0.004)	(0.031)	(0.011)	(0.006)
Policy rate differential	−0.133	−0.142	−0.060	0.435	0.077	−0.019	−0.739	−0.449	−0.031
	(0.425)	(0.207)	(0.190)	(0.431)	(0.298)	(0.298)	(0.468)	(0.236)	(0.114)
Growth differential	0.528[a]	0.157	−0.121	0.853[b]	0.322	0.063	−0.241	−0.320	0.029
	(0.305)	(0.178)	(0.142)	(0.404)	(0.245)	(0.076)	(0.596)	(0.305)	(0.113)

Treasuries	7.587[c]	3.034[b]	−0.550	12.033[b]	5.561[c]	0.859[b]	10.273[b]	2.651	0.108
	(2.798)	(1.576)	(0.748)	(4.445)	(2.149)	(0.432)	(4.983)	(2.147)	(0.622)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
J-statistic	1.03	1.59	11.07	0.99	1.27	11.63	5.92	5.09	5.83
P(J-statistic)	0.80	0.66	0.14	0.91	0.74	0.11	0.12	0.28	0.67

Coefficients estimated with GMM. Standard errors are reported in parentheses. [a], [b], [c] indicates significance at the 90%, 95%, and 99% level, respectively.

Table 6

DETERMINANTS OF CAPITAL FLOWS TO EME: PANEL REGRESSION RESULTS

	Total		*Latin America*		*Asia*		*Europe and Africa*	
	Portfolio Investment	*Debt*	*Portfolio Investment*	*Debt*	*Portfolio Investment*	*Debt*	*Portfolio Investment*	*Debt*
	(2)	*(3)*	*(2)*	*(3)*	*(2)*	*(3)*	*(2)*	*(3)*
L(−1)	0.186[c]	0.150[c]	0.123	0.079	0.171[c]	0.182[b]	0.212[c]	0.039
	(0.041)	(0.050)	(0.088)	(0.090)	(0.068)	(0.073)	(0.075)	(0.110)
USA 10-year real interest rate	0.329	0.073	−0.385	−0.194	1.341[b]	0.915[a]	−0.035	−0.152
	(0.285)	(0.324)	(0.331)	(0.346)	(0.608)	(0.51)	(0.464)	(0.591)
VIX	−0.043[c]	−0.126[c]	−0.022[c]	−0.021[a]	−0.057[c]	−0.026[c]	−0.048[c]	−0.026[c]
	(0.005)	(0.104)	(0.007)	(0.012)	(0.010)	(0.008)	(0.008)	(0.010)
Policy rate differential	−0.047	−0.024	−0.081	−0.112	0.028	0.115	−0.207	−0.370[a]
	(0.097)	(0.005)	(0.161)	(0.152)	(0.231)	(0.164)	(0.171)	(0.22)

Growth differential	0.174[a] (0.096)	0.116 (0.078)	0.360[b] (0.168)	0.269[a] (0.141)	0.224 (0.225)	0.086 (0.168)	0.032 (0.149)	−0.105 (0.204)
WGBI	0.588 (0.790)	−1.540 (5.072)	−2.845 (3.55)	−1.080 (2.604)	2.281 (1.992)	−0.172 (1.564)	−1.312 (1.149)	−10.746 (7.100)
Treasuries purchases	1.397[c] (0.538)	1.289[c] (0.518)	2.202[b] (0.912)	1.879[b] (0.753)	2.568[b] (1.259)	1.529 (1.029)	0.186 (0.767)	1.686[c] (1.506)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
J-Statistic	4.40	3.74	2.94	1.76	2.19	0.60	8.15	1.55
P (J-statistic)	0.36	0.29	0.57	0.62	0.70	0.74	0.15	0.91

Coefficients estimated with GMM. Standard errors are reported in parentheses. [a], [b], [c] indicates significance at the 90%, 95%, and 99% level, respectively.

7. CONCLUSIONS

With the increase in capital inflows that was observed in EME since 2005 and the deepening of this trend in the years following the 2008 financial crisis, the debate about the potential benefits and risks associated with massive capital inflows has regained importance. On the one hand, capital flows can contribute to further growth in the region –through more investment and lower capital costs–. However, the magnitude and composition of capital flows can pose risks to financial stability in these countries. In this context, it is relevant to understand the factors behind the increase that has been observed in capital flows in recent years.

The empirical evidence suggests that during the postcrisis period there was an increase in capital inflows to EME and that the effect of USA quantitative easing programs, measured both through the long-term USA interest rate and through the treasuries purchases, had an impact on capital flows. However, the effect was different depending on the region and type of investment. In particular, our results suggest that during the postcrisis period, massive capital inflows into Asian and Latin American economies were observed, but there is not a statistically significant effect for emerging Europe and South Africa. We also find that this increase in capital inflows to EME in the postcrisis period is associated with a reallocation of resources across types of investment. In the case of Latin America, a lower USA interest rate generates an increase in portfolio investment, while Asian economies registered an increase in both portfolio and total investment, though FDI is not statistically significant. The results obtained for FDI confirm that this is a long-term process and the analysis of this type of capital flow should be examined more carefully using other methodologies. When we measure the impact of QE through treasuries purchases directly we find that the effect is bigger in Asia for the three types of investment and is significant for Latin America as well.

As previous studies have found, risk aversion seems to have a significant impact on capital flows to EME, particularly on portfolio investment. Our evidence suggests that episodes of increased risk aversion are associated with capital outflows from all EME, although the impact seems to be higher in Asia.

Regarding pull factors, we find that economic growth has played an important role in the increase of capital flows in EME during the last decade, with respect to the full sample. On the contrary, we do not find evidence to suggest that in our period of analysis the policy rate differential is an important driver of capital flows nor trade openness nor the WGBI.

These results are particularly relevant in the current economic environment, in which the last QE program in the USA has ended and where the Federal Reserve started the normalization of its monetary policy by raising federal funds in December 2015. It is anticipated that the increase of interest rates in the United States will generate a reallocation of resources, encouraging capital flows to the United States. If this process also comes amid greater market volatility, capital outflows from EMs could be exacerbated due to the sensitivity of capital flows to the implied volatility in financial markets. It is also worth noting that the normalization of USA monetary policy will take place in an environment where USA growth is gaining strength, while growth perspectives for EME are less optimistic.

ANNEX

Table 7

DETERMINANTS OF CAPITAL FLOWS TO EME: PANEL REGRESSION RESULTS

	Total	*Portfolio investment*	*FDI*
	(1)	*(2)*	*(3)*
L(−1)	0.092[b]	0.144[c]	0.134[c]
	(0.058)	(0.047)	(0.047)
USA 10-year real interest rate	8.853[b]	5.374[b]	0.461
	(3.359)	(2.319)	(0.32)
VIX	−0.060[c]	−0.041[c]	−0.007
	(0.009)	(0.006)	(0.005)
Policy rate differential	0.123	0.022	0.026
	(0.194)	(0.121)	(0.077)
Growth differential	0.640[c]	0.125[b]	0.053
	(0.206)	(0.159)	(0.085)
Post-crisis period	20.194[c]	13.248[b]	0.771
	(8.322)	(5.553)	(1.053)
Post-crisis period*USA 10-year real interest rate	−10.834[c]	−6.057[b]	−0.576[a]
	(3.754)	(2.578)	(0.299)
Trade openness	0.021	0.023	−0.014
	(0.052)	(0.039)	(0.021)
Country fixed effects	Yes	Yes	Yes
J-Statistic	6.25	2.59	2.66
P(J-statistic)	0.10	0.28	0.62

Coefficients estimated with GMM. Standard errors are reported in parentheses.
[a], [b], [c] indicates significance at the 90%,95%, and 99% level, respectively.

Table 8

VARIABLES USED

Variable	*Description*	*Source*
Capital flows	FDI, portfolio investment, debt and other investment liabilities	Balance of Payments, IMF
GDP	Nominal, in current USAD, quarterly	Haver Analytics
USA 10-year interest rate	Real interest rate, monthly	Federal Reserve
VIX index	The CBOE volatility index, daily	Bloomberg
Monetary policy rate	Percent, monthly	Haver Analytics and Banco de México
Inflation rate	Annual percent change of CPI, monthly	Haver Analytics
Growth rate	Annual percentage change, quarterly	Haver Analytics

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The Effects of USA Monetary Policy on Central America and the Dominican Republic

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Abstract

This paper estimates the impact of US monetary policy shocks on Central America and the Dominican Republic economies, using a factor augmented VAR model. A sign restriction approach is implemented for the identification of such shocks. Our results indicate that US monetary policy shocks affect these economies mostly through its effects on the real side of the economy due to its impact on external demand and the reduced role of the exchange rate as a shock absorber, where countries with less flexible exchange rate regimes are more affected. Likewise, the flow of remittances is also negatively influenced, revealing another channel through which foreign monetary shocks impact the Central American and the Dominican Republic economies. On the financial side, domestic interest rates will rise and net international reserves will fall as central banks limit volatility in exchange rates.

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1. INTRODUCTION

A year after the end of its unconventional monetary policy strategy, the Federal Reserve decided to increase the federal funds rate (FFR), event that puts an end to seven years of policy interest rates at the zero lower bound. This phenomenon, known as monetary policy normalization, has been a source of concern for policymakers of both advanced and emerging economies, given that a steep path in interest rates could increase financial market volatility. This decision reopens the question of how USA monetary policy shocks spillover to the rest of the world, in particular in the context of historically low interest rate levels. Of particular interest is the question of how this type of shocks affects economies with a low degree of financial linkages with international capital market flows, such as Central American and Caribbean economies.

The main objective of this paper is to quantify the effects of foreign interest rate shocks, measured through the USA FFR (a conventional monetary policy instrument), on the economies of Central America and the Dominican Republic (hereafter CADR). This is a relevant subject for policy makers in these economies because of the important commercial linkage of CADR countries with the USA economy, despite the low degree of financial development and linkages with international capital market flows relative to other Emerging Market Economies in Latin America.

The empirical strategy employed to study this phenomenon intends to measure the country-specific effects of USA monetary policy shocks. We estimate a factor-augmented vector autoregressive model (FAVAR) with a foreign variables block, where the USA is the relevant foreign country for these economies. Common factors are extracted from a country data set of nearly 80 macroeconomic variables of CADR countries[1] for the period 2003-2014.

[1] Countries include: Costa Rica, El Salvador, Guatemala, Honduras, and the Dominican Republic. Nicaragua is excluded from the sample due to lack of data prior to 2007.

Two empirical issues arise in the quantification of the effect of USA monetary policy shocks. One issue is the identification of this type of shock. The proper identification is critical to understanding the transmission mechanism of this type of shock to these economies (see Canova and De Nicoló, 2003; Kim, 2001; Canova, 2005). We address this problem using sign restrictions to identify the effects of a USA MP on the economies under study.

Another issue is the decreasing variability after 2008 of the FFR as it adjusts to the zero lower bound. While the FFR has remained unchanged for the last seven years, the Federal Reserve has employed nonconventional instruments, known as quantitative easing (QE) programs, which have led to a more expansive monetary policy than what can be accounted for by the effective FFR. Therefore, in order to address this issue, we use the shadow federal funds rate (Wu and Xia, 2016) as our measure of the monetary policy instrument.

To date, this is one of the first works that addresses the effects of USA monetary policy shocks for Central America and the Dominican Republic. Other papers have used the FAVAR methodology to study the international transmission of monetary policy shocks. Mumtaz and Surico (2008) extend the model of Bernanke et al.(2004) to the open economy case, analyzing the transmission to seventeen industrial countries. Meanwhile, Cruz-Zuniga (2011) studies the effects of a change in the USA monetary policy for the Mexican and Brazilian case.

Summarizing the main findings, USA monetary shocks have contractive effects on these economies. The evidence suggests an unambiguous fall in real output for each of the considered economies, revealing that foreign interest shocks work as an important driver of the common business cycle in CADR countries. The relative importance of exchange rate stability for monetary authorities in these countries minimizes the response of this variable, hence rising interest rates and falling net international reserves do most of the adjustment. On the real side, exports fall due to the dominance of the income absorption effect over the expenditure switching effect, backed by the limited fluctuation in real exchange rates. However, a recovery in trade balance is observed, as imports decrease more than exports, product of a fall in domestic demand due to the contractionary effects of monetary tightening. Finally, remittances, which are an important source of non-labor income in these economies, respond negatively since the contractionary monetary shock is a signal of a future fall in USA aggregate demand.

The paper is organized as follows: Section 2 presents the literature review; Section 3 describes the exchange rate arrangements in these economies. This is important because it is a characteristic feature of CADR economies that could influence the empirical responses to foreign monetary shocks. Section 4 describes the empirical methodology; Section 5 compares the results for a positive interest rate shock to main Central American and Dominican indicators; Section 6 concludes.

2. LITERATURE REVIEW

Literature related to conventional monetary shocks, measured through interest rate changes, although extensive, focuses on *normal times*, i.e., periods that do not include hyperinflation episodes, currency crises, or massive recessions (Canova, 2005). When studying monetary shocks and their international transmission, two empirical strategies can be distinguished: Those based on the estimation of structural (DSGE) models, which by construction suggests expected paths for variables under this type of shocks, and those which are data oriented, based on empirical relations.

In theoretical models, inspired by the Mundell-Fleming-Dornbusch (MFD) model and the Obstfeld-Rogoff extension (1996), the transmission of monetary shocks to other economies occurs through two main channels: Current account and exchange rate.

A tightening shock in the country of origin is associated with a fall in output and an appreciation of the currency of that country. However, the impact of that shock on other countries is ambiguous, since two offsetting mechanisms work simultaneously, with no clear evidence of which one would dominate: on one side, the exchange rate in the foreign country depreciates, having a positive effect on economic activity (expenditure-switching effect); meanwhile, the interest rate hike shrinks domestic output in the country of origin, leading to a fall in the demand for exports of foreign countries (income-absorption effect; Kawai, 2015). Likewise, intertemporal models also show ambiguous results, even after including future expectations from economic agents as an additional mechanism (Kim, 2001).

Empirical models (see Lastrapes,1992; Eichenbaum and Evans, 1995; Grilli and Roubini, 1995; Kim and Roubini, 2000; Clarida and Galí, 1994) employ strategies that minimize restrictions, using data to identify transmission mechanisms for the exchange rate case. Kim (2001) compares the empirical results with different theoretical models, finding that an expansive monetary shock in the USA, measured by a drop in the world interest rate, has a positive effect on growth for G6 economies, which matches the results suggested by intertemporal models (see Svensson and van Wijnbergen, 1989; Obstfeld and Rogoff, 1995). Also, the trade link is not significant, which is not consistent with the *beggar-thy-neighbor* theory of the MFD basic model. The paper concludes that the exchange rate response does not depend on whether the identifying strategies are recursive or not, as prompted by Kim and Roubini (2000) and Cushman and Zha (1997). Other findings of Kim (2001) include the exogeneity of USA to non-USA monetary policy.

The international transmission of monetary shocks to industrial countries has been recently addressed by Vespignani (2015). Mumtaz and Surico (2008) explore the effects of a decrease in the international short term interest rates on the United Kingdom, finding a positive impact on GDP, investment and consumption after a year. On the other hand, the study of Jannsen and Klein (1991) finds that an increase in a foreign interest rate (Eurozone, in this case) has a positive impact on domestic interest rates for a set of countries that have not adopted the euro.[2] The increase in the interest rates translates into a contraction in GDP through a reduction in domestic demand. Meanwhile, exports decline, exposing the importance of the income-absorption effect in these economies. Since both exports and imports decline, no significant changes are observed in the trade balance. The response of these variables, as well as the negligible role observed in the exchange rate, is similar to the reaction of countries with a fixed exchange rate regime, revealing the importance of exchange rate stabilization for these small open economies.

For developing economies, the degree of transmission of international monetary shocks varies according to the currency regime, macroeconomic fundamentals and country-specific structural characteristics (see Borda et al., 2000; Arora and Cerisola, 2001; Mackowiak, 2007; Canova, 2005; Cruz-Zuniga, 2011). These authors identify, through different VAR specifications, two key transmission channels: Trade balance and interest rates.

[2] The set of countries include the United Kingdom, Denmark, Sweden, Norway, and Switzerland.

The research of Borda et al. (2000), related to the contribution of USA monetary policy to Caribbean business cycles, concludes that for countries with a flexible exchange rate regime, a world interest rate shock has a negative effect on output due to an increase in the real exchange rate that augments the cost of inputs. However, it indicates that GDP for Caribbean countries is not mainly driven by the world interest rate, but rather by the exchange rate, highlighted as an important transmission mechanism. This result is consistent with the conclusions of Mackowiak (2007), where the typical response of an emerging market economy to a tightening of the USA monetary policy is exchange rate depreciation, inflation and a fall in economic activity.[3] Meanwhile, the results provided by Canova (2005) suggest that the interest rate channel serves as an amplifier of USA monetary changes, conferring the trade channel an insignificant role in the transmission of monetary shocks from the United States to Latin America.

Since interest rates remained at the ZLB up to December 2015, the study of the international transmission of monetary policy focused on the impact of unconventional instruments adopted by industrial countries after the 2007 international crisis. This approach has been used by different authors, who analyze its spillover effects to emerging economies. Overall, their results confer a more important role to financial linkages and trade channels.

Hausman and Wongswan (2006) explore the channels of USA monetary policy transmission through the Federal Open Market Committee announcements, noting that a country with a higher degree of real and financial integration with the USA has a greater interest rate response, as well as those with less flexible exchange rates. In summary, unlike Ehrmann and Fratzscher (2006), they suggest that real and financial linkages with the USA are more important than those with the rest of the world.

Likewise, Bauer and Neely (2013) distinguishes the relative importance of the signaling and portfolio balance channels to explain the contribution of unconventional policy to the reduction of bond yields in most countries after the international crisis of 2007.[4] Through a dynamic term structure model, they conclude that both channels are

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3 Countries under analysis are Korea, Thailand, Malaysia, Philippines, Singapore, Hong Kong, Mexico, and Chile.

4 Australia, USA, Germany, Canada, and Japan

important.[5] Nonetheless, Chen et al. (2014) indicate that the spillovers to asset prices and capital markets are larger if they come from signal surprises. They highlight that even if unconventional monetary policies have a greater impact than conventional ones, characteristics such as better fundamentals and a more liquid market structure help to mitigate the effects. Bowman et al. (2014) also demonstrates that although fluctuations of asset prices in emerging markets after a USA monetary shock are bigger than fluctuations in the country of origin (USA), weaker fundamentals explain, in part, this overreaction. For the effects of unconventional monetary policy to other countries, see also Craine and Martin (2008).

More recently, the expectations of an interest rate hike in the USA prompted the study of the international impact of such an event. In this context, research analyzing the spillover effects on foreign countries of this conventional monetary policy instrument has resurged. For the Central American region, Valle and Morales (2016) employ a recursive identification strategy (Cholesky) for a foreign interest rate shock (USA, in this scenario). A VAR is constructed for each economy, where the USA block of variables is exogenous. Their main results include a multiple shock approach (including as well separate growth and remittances shocks), summing an overall positive effect for the normalization of USA monetary policy. Nonetheless, as Fornero et al. (2016) indicate, the identification of foreign monetary shocks is not straightforward in recursive VAR models. For this reason, those authors compare the results from a SVAR model with sign and zero restrictions (SZR) and a DSGE model for the Chilean economy to study the effects of foreign monetary policy on Chilean output and the overall economy. For the SZR model, a one percent positive shock of the foreign interest provokes a statistically significant decrease in local activity and exchange rate depreciation, while inflation (although with no significant change) first increases by the depreciation and later on decreases by the weak demand. The impulse responses derived from this scheme provide results in line with macroeconomic theory. The main differences with the DSGE model come from the length of the propagation of the shock and the impact on inflation, where in this scheme the impact on inflation is statistically significant.

5 The signal channel is more important for countries with a strong response to conventional monetary policy surprises in the USA; and the portfolio balance is consistent with the degree of substitution of international bonds between countries.

3. EXCHANGE RATE ARRANGEMENTS IN CADR ECONOMIES

One of the peculiarities of these economies is the importance of exchange rate stability as a policy objective. For the region, de facto exchange regimes for most countries are classified between different degrees of managed floating to dollarization. According to the *Annual Report on Exchange Rate Arrangements and Exchange Restrictions 2014* by the International Monetary Fund, Guatemala has shown greater flexibility, being classified as floating for different years in the period under consideration, even though it shares the volatility of its international reserves with the other exchange rate targeters (Jácome and Parrado, 2007).[6] Honduras and the Dominican Republic follow a crawl-like arrangement, while Costa Rica has the least flexible regime after El Salvador, which is a dollarized economy.

Table 1

CLASSIFICATION OF EXCHANGE RATE ARRANGEMENT FOR CADR COUNTRIES

Country	*Exchange rate arrangement*[1]
Costa Rica	Other managed arrangement[2]
El Salvador	No separate legal tender
Honduras	Crawl-like arrangement
Guatemala	Crawl-like arrangement
Dominican Republic	Crawl-like arrangement

[1] Classification according to the *Annual Report on Exchange Rate Arrangements and Exchange Restrictions 2014* by the IMF.
[2] As the report states, "this exchange rate arrangement is characteristic of periods when volatile foreign exchange market conditions hinder the use of more clearly defined exchange rate arrangements". It was previously classified as *stabilized arrangement* in 2013.

[6] The *Annual Report on Exchange Rate Arrangements and Exchange Restrictions 2014* reclassified Guatemala as crawl-like arrangement, previously considered a floating regime.

The exchange rate regime of a country determines the conduct of its monetary policy. Even though price stability is the aim of all regimes, their primary shock absorber is not the same; therefore, it shapes the degree of transmission mechanisms of foreign monetary policy shocks. Likewise, many countries claim to be floaters, while actually adhering to an exchange rate regime. As Canova (2005) explains, the lack of a differentiated transmission mechanism of USA monetary shocks between groups of floaters and non-floaters, for a set of Latin America countries,[7] may arise because floaters may suffer from *fear of floating*, see Calvo and Reinhart (2000), thus using international reserves to offset exchange rate volatility.

4. EMPIRICAL METHODOLOGY

In this section we describe the empirical strategy used to characterize the transmission mechanism of USA monetary policy shocks to CADR economies. [8] The approach consists of two steps. In the first step, we use a multicountry dataset comprising 76 macroeconomic variables for all CADR countries to estimate common factors through Principal Components. These factors sum up the macroeconomic information for the whole sample of abovementioned countries and are used as indicators of the state of the economy (business cycle) for the CADR region. In the second step, we specify a dynamic model between the estimated common factors and a block of foreign variables, where the latter includes the FFR. Once the model is estimated, we address the issue of proper identification of the impact of USA monetary policy shocks on foreign economies and estimate the effects on CADR macroeconomic variables.

4.1 First Step: Data Description and Common Factors Estimation

This section explains how we collect and treat data of the economies under analysis. First we describe the dataset used and its characteristics. Then we discuss the procedure for data reduction through factor estimation.

7 Countries under analysis include Argentina, Brazil, Chile, Ecuador, Mexico, Panama, Peru, and Uruguay.

8 Countries include: Costa Rica, El Salvador, Guatemala, Honduras, and the Dominican Republic. Nicaragua is excluded from the sample due to lack of data prior to 2007.

4.1.1 Data Description

We take a broad sample of data, consisting of the main macroeconomic indicators for a set of small open economies on a monthly basis: Costa Rica (CR), El Salvador (ES), Honduras (HN), Guatemala (GT), and the Dominican Republic (DR), for the 2003-2014 period. The complete set of variables and the transformations performed are shown in Annex A. All variables are expressed in twelve-month variation, and standardized by subtracting the sample mean and dividing by the sample standard deviation.

The dataset comprises three main groups:

a) Real Indicators

This group contains variables from the real sector of the economy, i.e. real activity indicators,[9] exports, imports, trade balance and remittances, all in real terms. From the fiscal sector, we incorporate total fiscal revenue and expenditure, both in real terms. By including this group, we aim to capture the varying responses across sectors and periods to business cycles, and how they might respond differently to a foreign interest shock.

b) Prices and Relative Prices

This group consists of real exchange rates and consumer price indexes (CPI). Finally, nominal and real exchange rates (local currency price of USA dollar) are included.

c) Financial and Monetary Sector Indicators

This set is composed of several measures of interest rates, including lending and deposit rates (in nominal terms). We also include credit growth to the private sector in real terms as an indicator of the business cycle. Finally, to capture the overall evolution of money supply, we include M1.

4.1.2 *Common Factor Estimation*

Instead of estimating a structural VAR model for each country, we address the research question using a data reduction approach to deal with the dimension of the by-country dataset described in the last section.

[9] We utilize a monthly indicator of economic activity called Indicador Mensual de Actividad Económica (IMAE, for its acronym in Spanish).

Our methodology employs the estimation of common factors through principal components analysis summarizing the set of variables described above. This methodology –introduced to forecasters by Stock and Watson (2002) and to macroeconomics by Bernanke et al. (2004)– extracts from a large set of data a smaller group of factors that drive the dynamics of the whole sample. This mechanism allows the researcher to summarize *big data* neatly, avoiding the *curse of dimensionality*, while at the same time accounting for the crucial information.

We use the principal components analysis to estimate these common factors. This analysis extracts a series of factors from N number of variables, which are linear combinations of this data set, and attempts to: *a)* minimize noise, since the extracted factors contain the most important information, leaving aside noisy deviations and *b)* minimize redundancy, since two factors should not contain the same *information* from the dataset, but should express different dimensions along which the data varies.

Suppose we have M series spanning T periods, collected in $M \times 1$ vectors X_t, from which we extract N factors spanning the same T periods in a $N \times 1$ vector F_t, where $N < M$. These factors resume the information shared by the variables in X_t. X_t and F_t are related by the measurement equation:

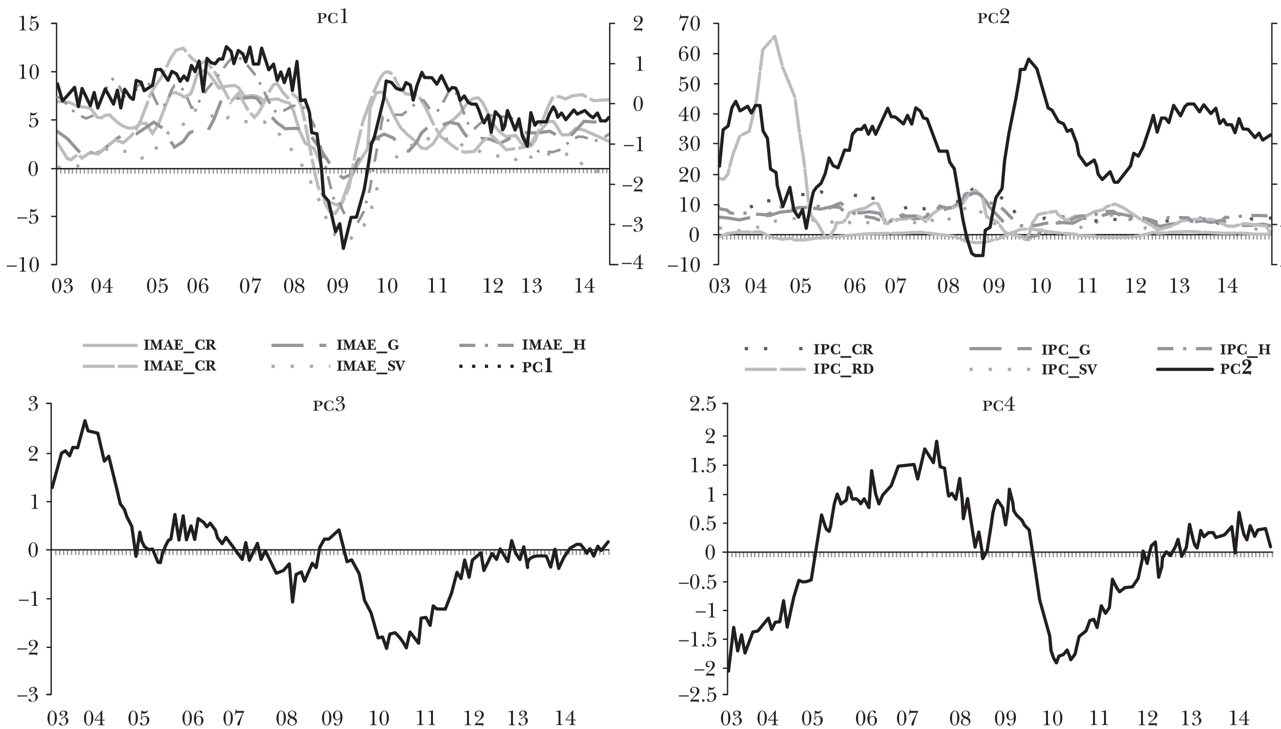
$$X_t = \Lambda F_t, \quad (1)$$

where the matrix Λ is $M \times N$. Its elements are called factor loadings; these associate the value of the factors to the measured variables of the model.

For the empirical exercise, we choose the first four estimated factors, which account for 53% of the common variance of the whole set (76 series). Since the complete dataset is used, we interpret these factors as the *state of the economy* or common cycles between CADR economies. After a visual inspection (Figure 1) we observe a strong correlation between the first factor and GDP growth rates in these economies. Likewise, the second factor could be related to the common behavior of CPI inflation in the countries under study.

Figure 1

ESTIMATED PRINCIPAL COMPONENTS FACTORS



4.2 Second Step: FAVAR Specification and Estimation

In this step we specify a FAVAR model between the set of estimated factors, F_t, as discussed in Section 4.1.2, and a block of foreign variables. The block of foreign variables includes the USA CPI, USA Industrial Production Index (IPI), and Real Balances (M1), which are the typical set of variables used to analyze the impact of MP shocks in the USA (Sims, 1992). As for the measure of the USA monetary policy instrument, the effective FFR remained unchanged for the last seven years. Nonetheless, the Federal Reserve has employed nonconventional instruments, known as quantitative easing (QE) programs, which have led to a more expansive monetary policy than what can be accounted for by the effective FFR. Therefore, in order to address this issue, we consider the Wu-Xia Shadow Federal Funds Rate as our measure of the monetary policy instrument (Wu and Xia, 2016). We also consider the Volatility Index (VIX) as a measure of the international risk premium.

Following Canova (2005), we assume that domestic variables (summarized in the common factors from the first step) do not have an impact on foreign variable dynamics (the small open economy assumption). In addition, we assume that VIX has no impact on USA macroeconomic variables, but the latter have influence on the level of risk perception. This assumption is justified under the argument that the macroeconomic impact of financial risk shocks is difficult to trace, because *1)* it is difficult to rule out the contemporaneous response of uncertainty shocks from financial shocks, and *2)* that the effects of uncertainty shocks seem significant only in cases of tightening financial conditions (Caldara et al., 2016). Expression 2 summarizes the specification of the FAVAR model:

2 $$W_t = C + \sum_{i=1}^{p} A(i) W_{t-1} + V_t,$$

where $W_t = \begin{bmatrix} Y_t \\ VIX_t \\ F_t \end{bmatrix}$, $C = \begin{bmatrix} C^Y \\ c^{VIX} \\ C^F \end{bmatrix}$, $A(i) = \begin{bmatrix} A_{10} & 0 & \tilde{O} \\ a_{20} & a_{21} & \tilde{O} \\ A_{30} & A_{31} & A_{32} \end{bmatrix}$, $V_t = \begin{bmatrix} V_t^Y \\ v_t^{VIX} \\ V_t^F \end{bmatrix}$.

Here, Y_t includes USA macroeconomic variables mentioned above. Exogeneity restrictions are represented by the matrix $\tilde{O}$. V_t is the reduced form error term with mean zero and covariance matrix Σ_V. This error is a linear combination of structural shocks.

To assess the dynamic responses of the measurement variables to foreign interest shocks we rewrite Equation 2 in terms of a vector moving average, VMA (∞) :

$$W_t = \sum_{i=1}^{\infty} B(i) V_t.$$

From the relation between reduced form residuals and structural shocks:

$$W_t = \sum_{i=1}^{\infty} B(i) DE_t \text{ or } W_t = \sum_{i=1}^{\infty} G(i) DE_t,$$

where D is the matrix of structural coefficients and E is the vector of structural shocks. In particular, E includes the USA monetary policy shock of interest, ϵ_t^{FFR}. Therefore, the impulse response of common factors vector to the shock of interest is:

3 $$\frac{\partial F_{t+s}}{\partial \epsilon_t^{FFR}} = G(s),$$

for $s = 0, 1, \ldots K$ and $G(s)$ a vector with the response of each factor in F to the structural innovation on the federal funds rate.

Our concern is on the dynamic response of observables X_t to the monetary shock, so using 1 and 3,

$$\frac{\partial X_{t+s}}{\partial \epsilon_t^{FFR}} = \Lambda \frac{\partial F_{t+s}}{\partial \epsilon_t^{FFR}} = \Lambda G(s).$$

For example, the response of variable i to the foreign interest rate shock is:

$$\frac{\partial x_{i,t+s}}{\partial \epsilon_t^{FFR}} = \lambda_{1i} \frac{\partial f_{1t+s}}{\partial \epsilon_t^{FFR}} + \lambda_{2i} \frac{\partial f_{2t+s}}{\partial \epsilon_t^{FFR}} + \ldots + \lambda_{Ki} \frac{\partial f_{Kt+s}}{\partial \epsilon_t^{FFR}}$$
$$= \lambda_{1i} g_1(s) + \lambda_{2i} g_2(s) + \ldots + \lambda_{Ki} g_K(s).$$

4.2.1 *Identifying USA Monetary Policy Shocks*

To complete the explanation of our empirical methodology, we now discuss the identification strategy of USA monetary policy shocks. To draw a coherent characterization of the transmission mechanism of interest, it is important to instrument the proper identification of this shock. Recursive (Cholesky) ordering for the foreign variables block leads to wrong measurement of the shock of interest revealed in the traditional puzzles, as discussed in Fornero et al. (2016).

Therefore, we adopt a sign restriction approach, as is common in the literature on the transmission mechanism of foreign monetary shocks. According to the theory, a contractionary foreign interest rate shock leads to a fall in output, diminishing inflation pressures, whereas exchange rate appreciates, as expected from theoretical models.[10]

We rely on this strategy popularized by Canova and De Nicoló (2003), Uhlig (2005) and Gertler and Karadi (2014) for our identification strategy.[11] Our goal is to estimate structural shocks associated with models that produce the expected response of USA variables to exogenous monetary policy movements through the FFR. In particular, we impose the following sign restrictions in the spirit of Canova and De Nicoló (2003), where prices are sluggish and output has a lagged response to monetary innovations. As in Uhlig (2005), we limit sign restrictions on the impulse responses to provide a *minimalistic identification*, therefore not imposing further views beyond the sign restrictions themselves. We impose restrictions on the foreign variables block only on impact, where the horizon for the sign restriction to hold is one period, thus:

$$\text{FFR} > 0,\ t=1$$
$$\text{USA IP growth} < 0,\ t=2$$
$$\text{USA CPI inflation} < 0,\ t=2$$
$$\text{USA real balance growth} < 0,\ t=2,$$

where t denotes the period in months where the sign restriction is imposed. The rationale for this identification strategy for the USA monetary policy shocks is that the transmission of monetary policy innovations to the economy occurs with lags.

[10] Uhlig (2005) employs an agnostic identification procedure to study the effects of monetary policy on output. He finds no clear effect of interest rate hikes on real GDP.

[11] However, as emphasized by Fry and Pagan (2011), we recognize the multiple model issue arising from the transformations of the new set of structural shocks.

5. RESULTS

In this section we discuss the response to a foreign interest rate innovation of domestic variables (through the associated factor loadings to each of the estimated factors included in the FAVAR model). The shock is calibrated by a one-time 25 basis point unexpected increase to the shadow FFR, our proxy of monetary policy rate in the USA. Table 2 summarizes the qualitative response of macroeconomic variables for each economy. Complete results in terms of impulse response function are shown in Annex B.[12]

Table 2

RESULTS OVERVIEW

Variables	*Costa Rica*	*El Salvador*	*Guatemala*	*Honduras*	*Dominican Republic*
Output	↓	↓	↓	↓	↓
Exports	↓	↓	↓	↓	↓
Imports	↓	↓	↓	↓	↓
Trade balance	↑	-	↑	↑	↑
Remittances	↓	↓	-	↓	↓
CPI inflation	↓	-	-	↓	↑
Real exchange rate	-	-	-	-	-
Nominal exchange rate	-		-	-	-
Net international reserves	↓	-	↑	↓	↓
M1	↓	↓	-	↓	↓
Private credit	↓	-	-	↓	↓
Interest rate	↑	-	↑	↑	↑
EMBI		↑			↑

Source: Author's estimation. ↑ (↓) represents a statistically significant increase (decrease).

[12] In Annex B we also include impulse responses assuming a recursive identification strategy using Cholesky decomposition. The problems to identify monetary policy shocks arise when such approach is used.

According to the estimated impulse response functions, a positive shock to the FFR has a negative impact on main real domestic variables. For all countries under analysis, output, export and import growth rates fall. In addition, financial sector variables such as interest rates and risk premium increase, while money and credit demand decrease. There is no evidence of significant nominal and real exchange rate adjustments to the shock, while we find a decrease in international reserves for three of these economies.

The empirical literature on transmission mechanisms of USA monetary policy shocks (see Canova, 2005) emphasizes the role of the exchange rate regime and the degree of financial integration in the magnitude of the pass-through to domestic macroeconomic variables (real and nominal) of these type of innovations. Therefore, countries with flexible (less-flexible) exchange rate regimes and relative high (low) integrated financial markets show less (more) volatility in domestic variables such as output and interest rates.

Despite that, impulse response results suggest depreciation pressures after a foreign interest shock in CR, GT, and HN are not statistically significant. Instead, our results illustrate that central banks react to the external shock by increasing interest rates across all countries and reducing net foreign reserves in CR, HN and the DR. Risk premium rises in ES and the DR, evidence of a tightening in foreign financial conditions.[13] Likewise, positive inflation pressures are not observed due to interest rate reaction and thus a limited exchange rate pass-through effect.

On the real side, our results show a negative effect on output growth. Similarly, export and import growth fall in all countries. These results are in line with Jannsen and Klein (2011) which emphasizes the importance of the income-absorption effect over the expenditure-switching effect in countries with active exchange rate policies oriented to stabilize this variable. Nevertheless, the fall in import growth exceeds the fall in exports; therefore, trade balance improves for most countries considered, excluding ES whose results are not significant. This finding is opposite to the prediction from theoretical open economy DSGE literature, such as Galí and Monacelli (2005), where the real depreciation induced by a foreign interest rate shock triggers an export increase. Behind this theoretical transmission mechanism is the assumption of relative flexibility in exchange rate markets.

[13] Data for the sample period are only available for these two countries

Finally, remittances are an important inflow of foreign resources to CADR economies, up to 16% of GDP for ES and HN in 2013. This inflow depends on economic and labor market conditions where domestic labor force emigrates. Our results highlight the negative response of remittances flow in all countries (excluding GT where the response is not significantly different from zero). This constitutes an additional channel through which foreign interest shocks impact domestic activity.

6. CONCLUSION

In this document we analyzed the impact of USA monetary policy shocks on the developing economies of Central America and the Dominican Republic. As we mentioned, these economies are different from other emerging economies given their lower financial deepening, their lesser exposure to capital flows and higher weight of exchange rate stability in central bank loss functions.

Using a multicountry dataset of macroeconomic variables which includes real sector and monetary indicators, we identify the transmission mechanism of foreign (USA) interest rate shocks to the domestic economy. Impulse response analysis suggests that this type of shock pushes down real output, exports and imports. In addition, a USA monetary policy shock will have low impact on nominal exchange rates, at the cost of increasing interest rates, falling net international reserves and rising risk premium.

ANNEXES

Annex A. Data Description

All series were directly taken from the *Consejo Monetario Centroamericano/Secretaría Ejecutiva* Database, except for the Miscellaneous series (sources at the end of the Annex). Format is presented as follows: Series name; data span and series description as appears in the database. Nominal variables, except NER and interest rates, were CPI deflated. As for the transformation, the interest rates are presented as year-on-year first-difference values. The rest were one year logged differentiated. All transformed variables are mean detrended and expressed in terms of their standard deviation.

Real Sector		
1. IMAE_CR	2003M01:2014M12	Monthly indicator of economic activity (IMAE): trend - cycle, index - Costa Rica
2. IMAE_SV	2003M01:2014M12	Monthly indicator of economic activity (IMAE): trend - cycle, index - El Salvador
3. IMAE_G	2003M01:2014M12	Monthly indicator of economic activity (IMAE): trend - cycle, index - Guatemala
4. IMAE_H	2003M01:2014M12	Monthly indicator of economic activity (IMAE): trend - cycle, index - Honduras
5. IMAE_RD	2003M01:2014M12	Monthly indicator of economic activity (IMAE): trend - cycle, index - Dominican Rep.
6. EXPORTS_CR	2003M01:2014M12	Exports of goods: millions of USD, total FOB - Costa Rica
7. EXPORTS_SV	2003M01:2014M12	Exports of goods: millions of USD, total FOB - El Salvador
8. EXPORTS_G	2003M01:2014M12	Exports of goods: millions of USD, total FOB - Guatemala
9. EXPORTS_H	2003M01:2014M12	Exports of goods: millions of USD, total FOB - Honduras
10. EXPORTS_RD	2003M01:2014M12	Exports of goods: millions of USD, total FOB - Dominica Republic
11. IMPORTS_CR	2003M01:2014M12	Imports of goods: millions of USD, total FOB - Costa Rica
12. IMPORTS_SV	2003M01:2014M12	Imports of goods: millions of USD, total FOB - El Salvador
13. IMPORTS_G	2003M01:2014M12	Imports of goods: millions of USD, total FOB - Guatemala
14. IMPORTS_H	2003M01:2014M12	Imports of goods: millions of USD, total FOB - Honduras
15. IMPORTS_RD	2003M01:2014M12	Imports of goods: millions of USD, total FOB - Dominica Republic
16. REMESAS_CR	2003M01:2014M12	Remittances income: millions of USD - Costa Rica
17. REMESAS_SV	2003M01:2014M12	Remittances income: millions of USD - El Salvador
18. REMESAS_G	2003M01:2014M12	Remittances income: millions of USD - Guatemala
19. REMESAS_H	2003M01:2014M12	Remittances income: millions of USD - Honduras
20. REMESAS_RD	2003M01:2014M12	Remittances income: millions of USD - Dominica Republic

Exchange Rate		
21. TCR_CR	2003M01:2014M12	Real exchange rate - Costa Rica
22. TCR_SV	2003M01:2014M12	Real exchange rate - El Salvador
23. TCR_G	2003M01:2014M12	Real exchange rate - Guatemala
24. TCR_H	2003M01:2014M12	Real exchange rate - Honduras
25. TCR_RD	2003M01:2014M12	Real exchange rate - Dominica Republic
26. TCN_CR	2003M01:2014M12	Nominal exchange rate: local currency per USD - Costa Rica
27. TCN_SV	2003M01:2014M12	Nominal exchange rate: local currency per USD - El Salvador
28. TCN_G	2003M01:2014M12	Nominal exchange rate: local currency per USD - Guatemala
29. TCN_H	2003M01:2014M12	Nominal exchange rate: local currency per USD - Honduras
30. TCN_RD	2003M01:2014M12	Nominal exchange rate: local currency per USD - Dominica Republic
Money and credit quantity aggregates		
31. BMR_CR	2003M01:2014M12	Narrow monetary base: millions of local currency - Costa Rica
32. BMR_SV	2003M01:2014M12	Narrow monetary base: millions of local currency - El Salvador
33. BMR_G	2003M01:2014M12	Narrow monetary base: millions of local currency - Guatemala
34. BMR_H	2003M01:2014M12	Narrow monetary base: millions of local currency - Honduras
35. BMR_RD	2003M01:2014M12	Narrow monetary base: millions of local currency - Dominican Republic
36. M1_CR	2003M01:2014M12	Monetary aggregate m1: millions of local currency - Costa Rica
37. M1_SV	2003M01:2014M12	Monetary aggregate m1: millions of local currency - El Salvador
38.M1_G	2003M01:2014M12	Monetary aggregate m1: millions of local currency - Guatemala
39. M1_H	2003M01:2014M12	Monetary aggregate m1: millions of local currency - Honduras
40. M1_RD	2003M01:2014M12	Monetary aggregate m1: millions of local currency - Dominican Republic

41. RIN_CR	2003M01:2014M12	Net international reserves: millions of USD - Costa Rica
42. RIN_SV	2003M01:2014M12	Net international reserves: millions of USD - El Salvador
43. RIN_G	2003M01:2014M12	Net international reserves: millions of USD - Guatemala
44. RIN_H	2003M01:2014M12	Net international reserves: millions of USD - Honduras
45. RIN_RD	2003M01:2014M12	Net international reserves: millions of USD - Dominican Republic
46. CREDITOPRIV_CR	2003M01:2014M12	Credit: private sector, millions of local currency - Costa Rica
47. CREDITOPRIV_SV	2003M01:2014M12	Credit: private sector, millions of local currency - El Salvador
48. CREDITOPRIV_G	2003M01:2014M12	Credit: private sector, millions of local currency - Guatemala
49. CREDITOPRIV_H	2003M01:2014M12	Credit: private sector, millions of local currency - Honduras
50. CREDITOPRIV_RD	2003M01:2014M12	Credit: private sector, millions of local currency - Dominican Republic
Interest Rates		
51. TASA_ACTIVA_CR	2003M01:2014M12	Interest rate: nominal, lending (per annum) - Costa Rica
52. TASA_ACTIVA_SV	2003M01:2014M12	Interest rate: nominal, lending (per annum) - El Salvador
53. TASA_ACTIVA_G	2003M01:2014M12	Interest rate: nominal, lending (per annum) - Guatemala
54. TASA_ACTIVA_H	2003M01:2014M12	Interest rate: nominal, lending (per annum) - Honduras
55. TASA_ACTIVA_RD	2003M01:2014M12	Interest rate: nominal, lending (per annum) - Dominican Republic
56. TASA_PASIVA_CR	2003M01:2014M12	Interest rate: nominal, deposit (per annum) - Costa Rica
57. TASA_PASIVA_SV	2003M01:2014M12	Interest rate: nominal, deposit (per annum) - El Salvador
58. TASA_PASIVA_G	2003M01:2014M12	Interest rate: nominal, deposit (per annum) - Guatemala
59. TASA_PASIVA_H	2003M01:2014M12	Interest rate: nominal, deposit (per annum) - Honduras
60. TASA_PASIVA_RD	2003M01:2014M12	Interest rate: nominal, deposit (per annum) - Dominican Republic

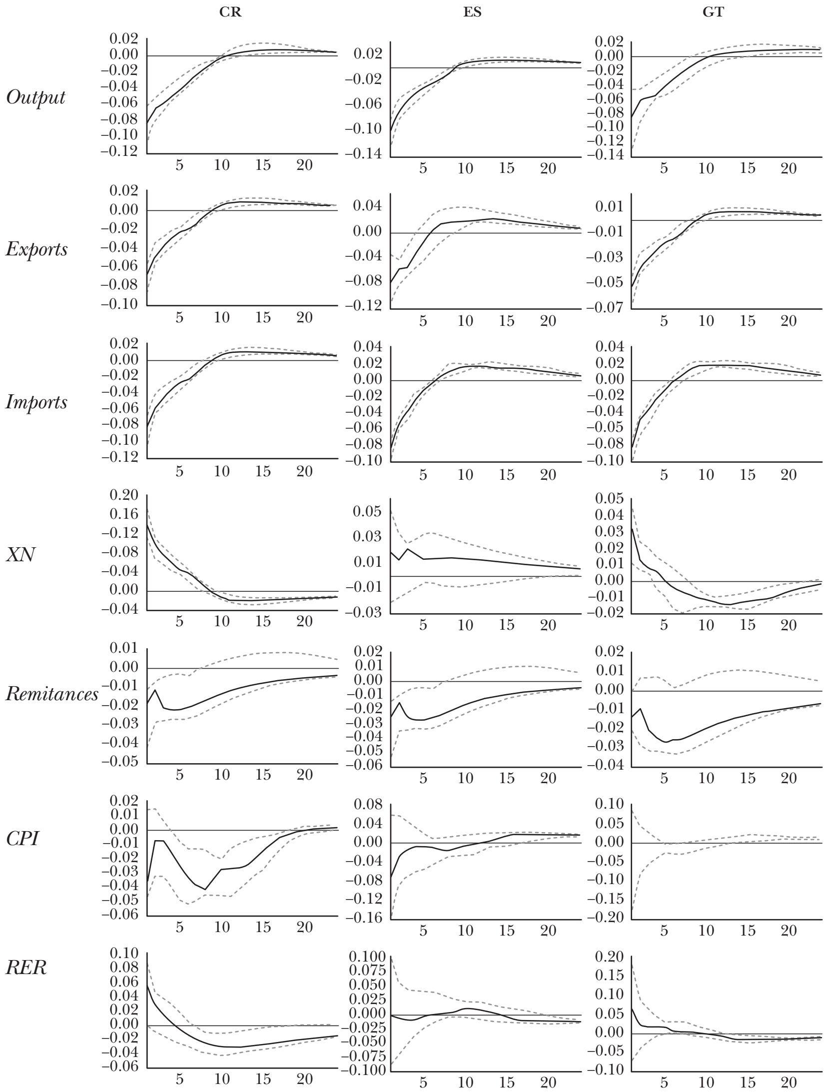
Fiscal Balance		
61. ING_FISCALES_CR	2003M01:2014M12	Government income: total, millions of local currency - Costa Rica
62. ING_FISCALES_SV	2003M01:2014M12	Government income: total, millions of local currency - El Salvador
63. ING_FISCALES_G	2003M01:2014M12	Government income: total, millions of local currency - Guatemala
64. ING_FISCALES_H	2003M01:2014M12	Government income: total, millions of local currency - Honduras
65. ING_FISCALES_RD	2003M01:2014M12	Government income: total, millions of local currency - Dominican Republic
66. GASTOS_FISCALES_CR	2003M01:2014M12	Government expenditure: total, millions of local currency - Costa Rica
67. GASTOS_FISCALES_SV	2003M01:2014M12	Government expenditure: total, millions of local currency - El Salvador
68. GASTOS_FISCALES_G	2003M01:2014M12	Government expenditure: total, millions of local currency - Guatemala
69. GASTOS_FISCALES_H	2003M01:2014M12	Government expenditure: total, millions of local currency - Honduras
70. GASTOS_FISCALES_RD	2003M01:2014M12	Government expenditure: total, millions of local currency - Dominican Republic
Miscellaneous		
71. EMBI_SV[1]	2003M01:2014M12	Emerging market bond index (JP Morgan Chase) - El Salvador
72. EMBI_RD[1]	2003M01:2014M12	Emerging market bond index (JP Morgan Chase) - Dominican Republic
73. USA_CPI_SA[2]	2003M01:2014M12	Consumer price index for all urban consumers: all items - USA
74. FFR[2]	2003M01:2014M12	Effective federal funds rate (not seasonally adjusted) - USA
75. USA_IP_SA[3]	2003M01:2014M12	Industrial production index(2007=100) - USA
76. USA_M1[3]	2003M01:2014M12	M1 money stock, billions of dollars, seasonally adjusted - USA
77. SHADOW_FFR[3]	2009M01:2014M12	Shadow federal funds rate (Wu-Xia) - USA
78. VIX[3]	2003M01:2014M12	Volatility index, VIX - USA

Sources: [1] JP Morgan Chase; [2] Bureau of Labor Statistics; [3] FRED

Annex B. Impulse Response Functions Figures

Figure B.1

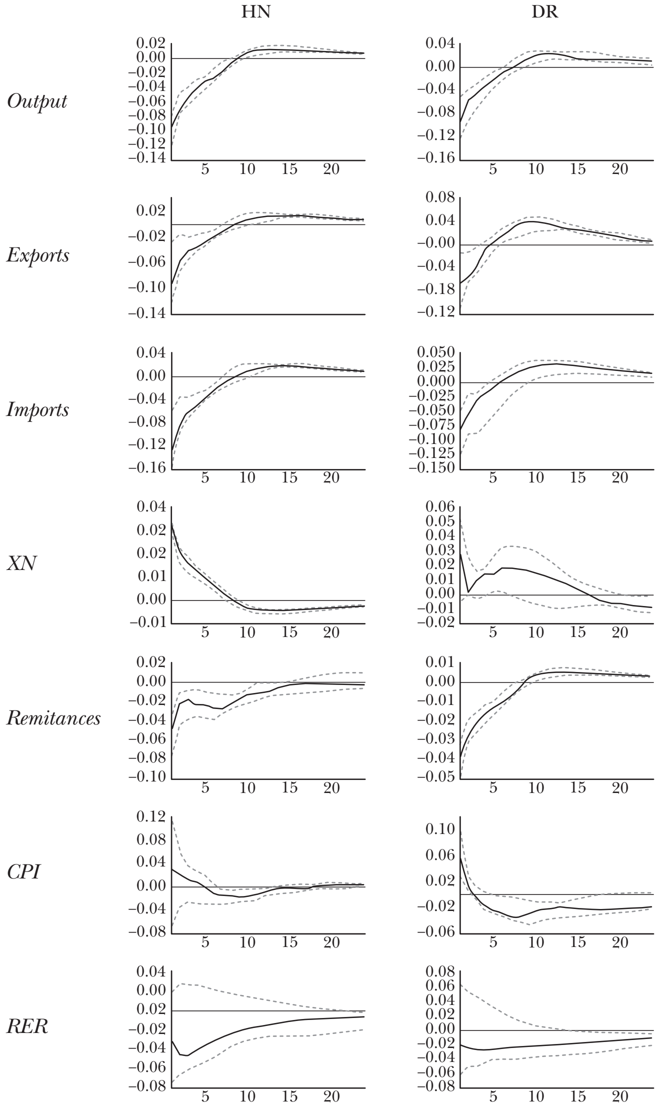
FAVAR WITH SIGN RESTRICTIONS



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

Figure B.1 (cont.)

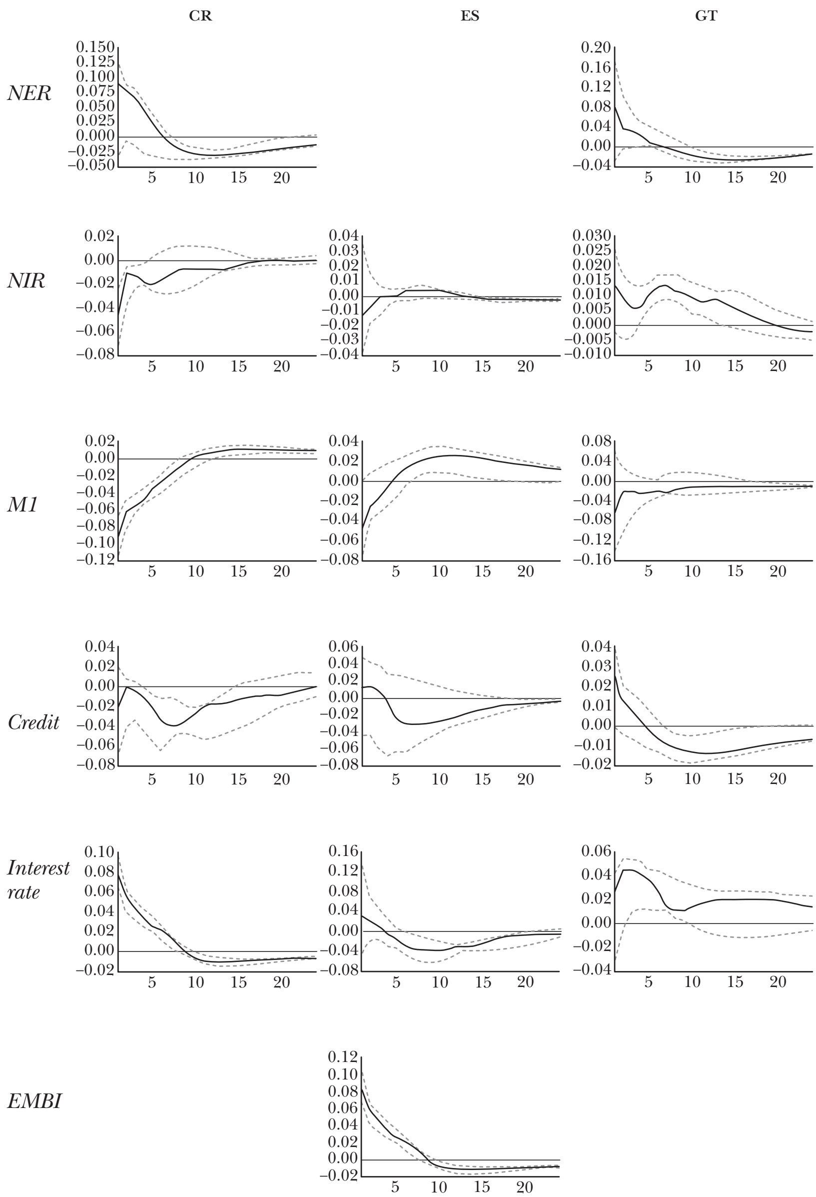
FAVAR WITH SIGN RESTRICTIONS



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

Figure B.1 (cont.)

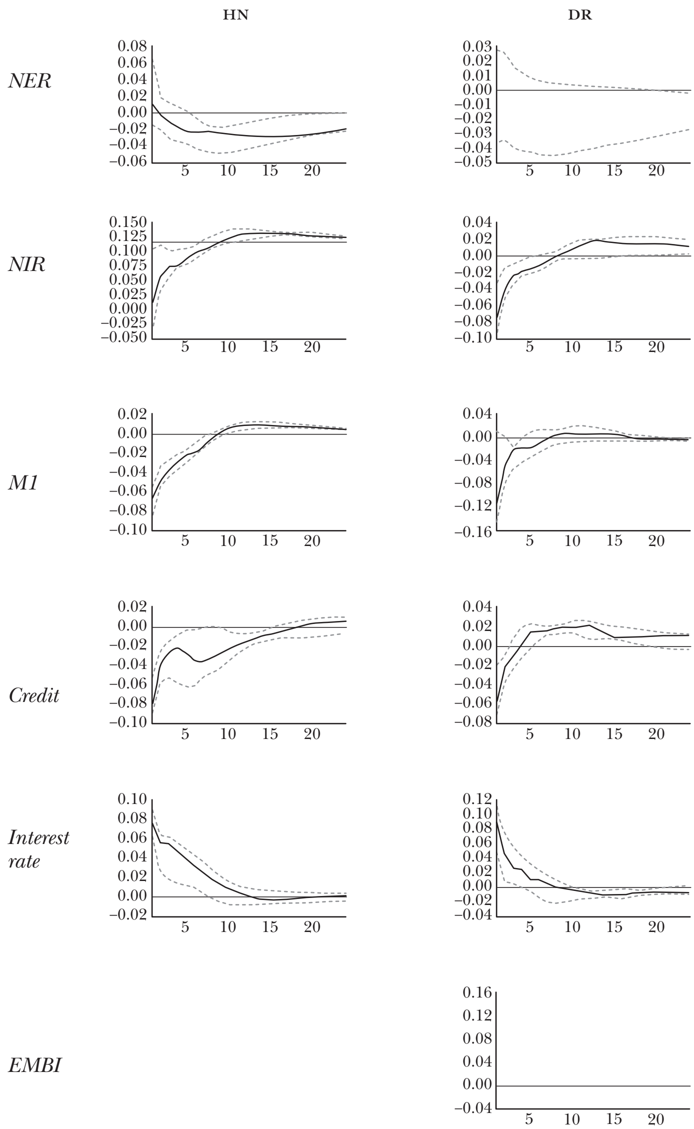
FAVAR WITH SIGN RESTRICTIONS



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

Figure B.1 (cont.)

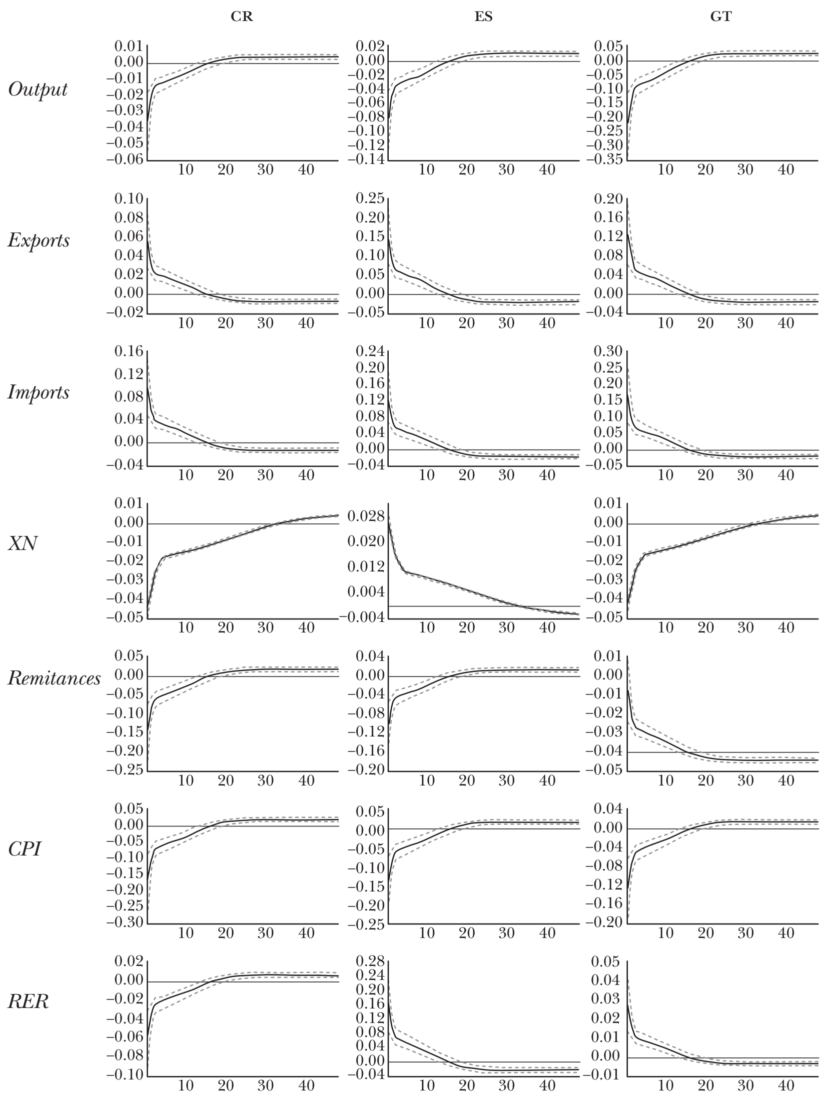
FAVAR WITH SIGN RESTRICTIONS



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

Figure B.2

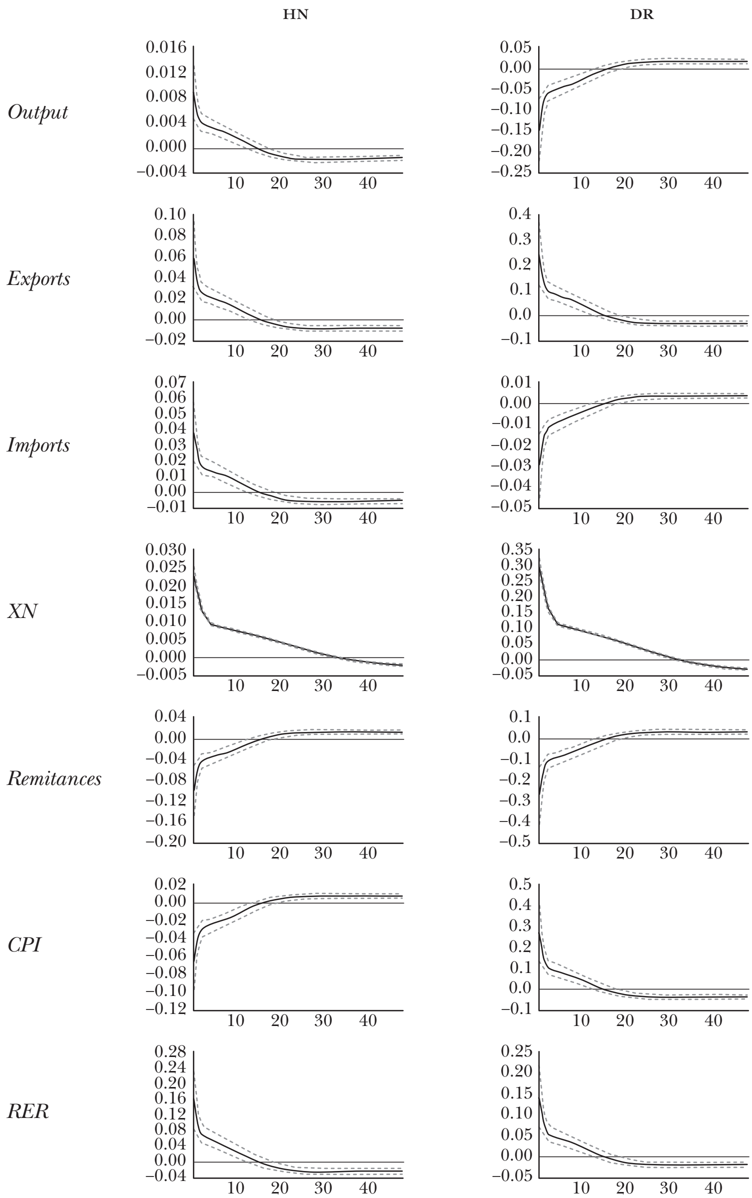
CHOLESKY DECOMPOSITION



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

Figure B.2 (cont.)

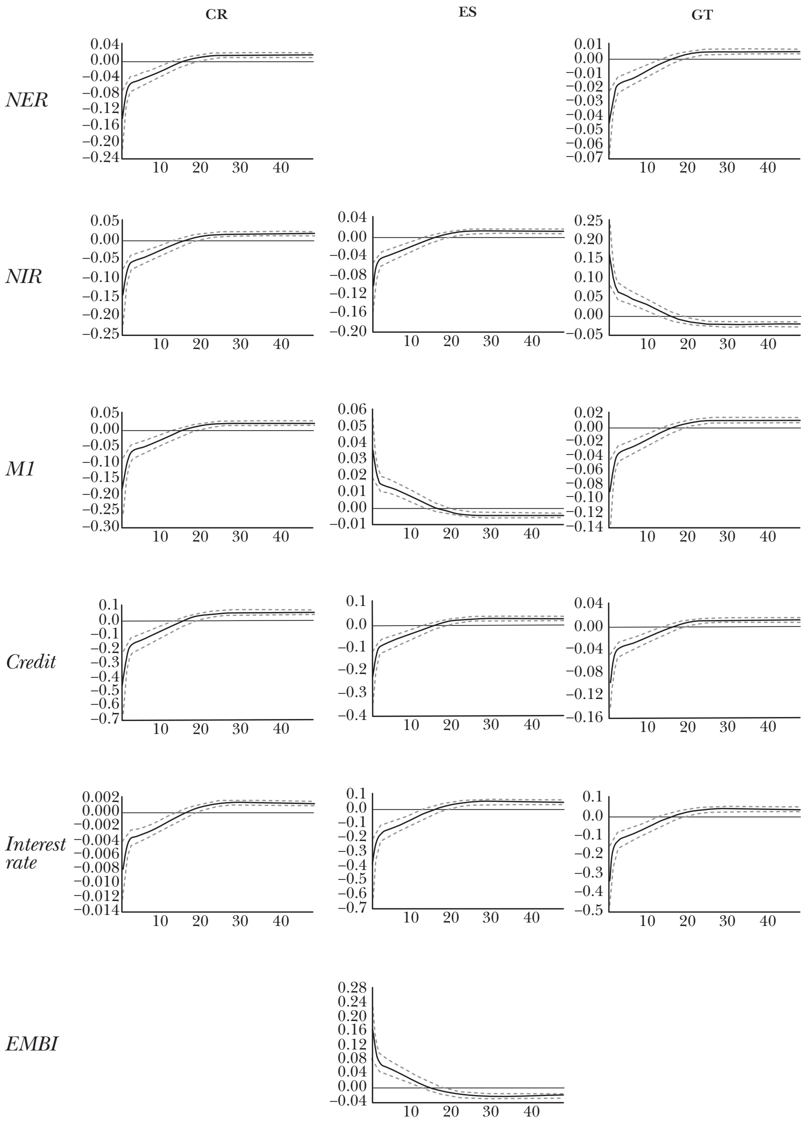
CHOLESKY DECOMPOSITION



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

Figure B.2 (cont.)

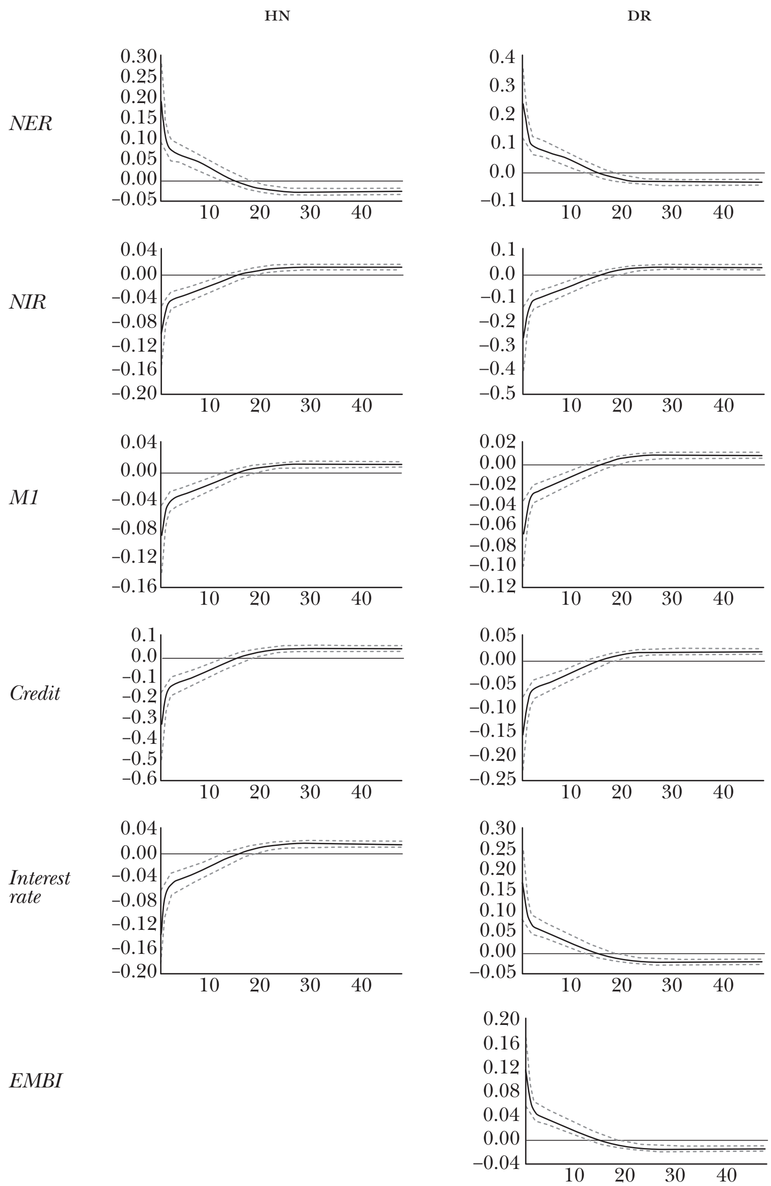
CHOLESKY DECOMPOSITION



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

Figure B.2 (cont.)

CHOLESKY DECOMPOSITION



Note: All results are expressed in terms of a 25-basis points shock to the Wu-Xia Shadow FFR.

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Country-case Studies of International Spillovers of Monetary Policy

Quantitative Easing and United States Investor Portfolio Rebalancing towards Foreign Assets

João Barata R. B. Barroso

Abstract

We show robust evidence that quantitative easing policies implemented by the Federal Reserve cause portfolio rebalancing by USA investors towards foreign assets in emerging market economies. These effects are on top of any effects such polices might have through global or specific conditions of the recipient economies. To control for such conditions, we use capital flows from the rest of the world to the same recipient economy as the counterfactual behavior for USA investors or, formally, as a proxy variable for unobserved common drivers of the flows. We gather a comprehensive dataset for Brazilian capital flows and a smaller dataset for other emerging market economies from completely independent sources. Both datasets show that more than 50% of USA flows to the recipient economies in the period is accounted for by quantitative easing policies. We use the detailed datasets to break down this overall effect on the specific asset categories and sectors of the recipient economies.

Keywords: quantitative easing; capital flows; portfolio rebalancing; USA investor; emerging markets; Brazil.

JEL classification: E52, F42, G11, G15

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1. INTRODUCTION

Regarding its large-scale asset purchase programs, the Federal Reserve has supported the view that portfolio rebalancing is an important transmission channel to the macroeconomy.[1] The basic intuition of portfolio rebalancing is that, under imperfect asset substitution, say between bonds of different maturities or between foreign and domestic bonds, asset prices are sensitive to the relative supply of the assets (Tobin, 1969 and1982). That is, the reduced supply of long-term domestic treasuries resulting from quantitative easing reduces the marginal benefit of short-term domestic treasuries, pressuring long-term bond prices and motivating investors to shift their portfolios towards other assets. The domestic and global macroeconomic environment would then respond to the asset price incentives, to the likely lower financial constraints and to the flow of capital to specific trades.

In spite of its relevance, and the several years of policy experiment, there is at best partial evidence supporting directly the portfolio rebalancing channel of quantitative easing. This includes a small macroeconomic literature that captures stylized facts with general equilibrium models featuring imperfect asset substitution (e.g., Chen et al., 2012; Sami and Kabaca, 2012), as well as an international finance literature that points to portfolio rebalancing towards foreign assets in response to unconventional monetary policies (e.g., Fratzscher et al., 2013; Ahmed and Zlate, 2014). However, from our point of view, the empirical evidence so far is not particularly convincing due to the lack of an observable counterfactual that would render possible a causal interpretation.

This paper contributes to the debate by proposing an observable counterfactual to quantitative easing policies as referring to the United States of America (USA) investor (or, for that matter, with immediate adaptations, to any similar balance sheet policy conducted by advanced or emerging market economies). By using a proper counterfactual, we hope to establish credible causality claims between unconventional policies and investor behavior. The essential idea of the paper is to consider USA capital flows to a foreign recipient economy and to use the rest of the world (ROW) capital flows to

[1] See, e.g., Ben Bernanke's speech at the Jackson Hole Symposium, August 31, 2012.

the same economy as the counterfactual, or, in other words, as the control group. Since the portfolio and wealth of USA-based investors are disproportionally affected (*vis a vis* foreign investors) by the operationalization of USA-based unconventional policies, it is natural to expect they rebalance their portfolio in distinctive manners –therefore our interpretation of a residual effect captured by comparison to the counterfactual. Just to be clear, this does not rule out that quantitative easing affects the global economy and, as result, ROW capital flows. It only requires a disproportional effect on USA-based investors. As a result, any evidence of an effect conditional on our counterfactual would be particularly strong evidence, since we are not accounting for other effects in common with ROW investors.

We formalize the exact conditions under which ROW flows to the same recipient economy as USA flows is a proper counterfactual. Our argument formally interprets ROW flows as a proxy variable to unobservable global and local conditions in the recipient economy jointly affecting USA flows and ROW flows. The parameter of interest, in this case, is the partial effect of quantitative easing policies on USA flows controlling for such global and local variables.

We show that the quality of the proxy variable counterfactual is proportional to how closely global and local variables drive ROW flows. To support the assumption, therefore, we propose to include controls in the regression that capture differences in the home environment of USA and ROW investors, since these could be residual drivers of the respective capital flows. Interestingly, the introduction of these variables leads to a capital flow regression that controls for differentials in source economies, unlike the usual regression that controls for the differential in source and recipient economies.

Even though the overall procedure is intuitive, it may well be the case that ROW flows do not provide a good counterfactual. However, in a formal sense, our proxy variable approach always brings us closer to the truth. Indeed, under weak conditions, the use of our counterfactual is guaranteed to reduce bias in estimating the parameter of interest. The crucial assumption to obtain this result is that quantitative easing should drive USA flows directly, but ROW flows only indirectly. In essence, it only requires that flows resulting from unconventional policies at home should follow the shortest path to the final destination, a weak substantive statement.

With the proper methodology in place, we collect novel datasets and estimate the causal effect of quantitative easing policies on USA flows directed to foreign assets in emerging market economies. In case of a positive effect, this is evidence of portfolio rebalancing, at least in its international dimension (perhaps, also rendering more plausible likely effects on the domestic dimension). The two novel datasets constructed for this paper are based on completely independent sources. The fact that the data comes from different sources increases the credibility of our results.

The main dataset of the paper consists of monthly capital flows with Brazil as the recipient economy and the USA and ROW as the sources. This is a unique dataset constructed for this paper over the course of several months. The data construction follows the exact same methodology of the balance of payments statistics of the country. It is worth highlighting that balance of payments statistics in Brazil (and our dataset in particular) are of above average quality due to the legal requirement of filing electronic contracts in all transactions with foreigners. The dataset is comprehensive in terms of categories of flows and distinguishes flows to the banking sector from flows to other sectors.

As a secondary dataset, we use quarterly data from the Treasury International Capital (TIC) System for USA-based portfolio flows jointly with data from the International Financial Statistics's (IFS) net capital flows for imputing ROW flows. Relative to Brazilian data, this has a lower frequency, covers a smaller subset of flow categories, and may have problems due to the differences in methodology between TIC and IFS sources. Nonetheless, by pooling the information from different capital flow recipients, it allows one to check if the results obtained with the main dataset generalize.

The paper has several contributions. The first contribution is the definition of the novel identification strategy based on observed counterfactual for investor behavior, which allows a proper assessment of the portfolio rebalancing channel of unconventional monetary policies. The second contribution is the construction of a new, high quality and detailed dataset of capital flows to Brazil resulting from USA investors and ROW investors. In particular, the dataset distinguishes flow to the banking sector, allowing us to address the importance of banks as a conduit to the transmission of portfolio rebalancing effects, illuminating relevant questions in the literature.[2]

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2 There is an ongoing debate in the literature regarding the relative size of bank flows versus bond market flows in the transmission of global liquidity after the global financial crisis. See the literature review below.

The third contribution is the mapping of available datasets for other emerging markets into the conceptual framework of our methodology, therefore expanding its applicability. The fourth contribution is the set of estimated causal effects of quantitative easing on USA investor behavior, in the sense of capital flows to emerging market foreign assets.

Our results show significant USA investor portfolio rebalancing towards emerging economies' assets in response to quantitative easing policies as measured by the monthly change in the balance sheet of the Federal Reserve. In the case of the Brazilian dataset, the estimated effect runs mostly through the USA flows into portfolio assets, particularly debt. USA direct investment, including equity capital and affiliated enterprise loans, do not respond; this is also the case for cross-border USA credit flows. Regarding USA capital flows to the banking sector, only portfolio assets are affected, and debt flows drive the results as before. Results are robust to the inclusion of controls and to measurement in real or nominal terms. They are about the same when partitioning quantitative easing into three different periods, corresponding to the first, second and third round of balance sheet expansion (QE1, QE2 and QE3).

The magnitudes are economically significant when measured relative to the recipient economies, although somewhat small relative to the size of the quantitative easing policies. Across different specifications, additional flows due to quantitative easing range from USD 54 to USD 58 billion. This corresponds to around 54% of the USA flows to Brazil accumulated over the period of the policies or 10% of foreign flows to the country over the same period. The effect on portfolio flow ranges from USD 41 billion to USD 48 billion, and portfolio debt flows from USD 28 billion to USD 31 billion. Regarding the banking sector, the effect on portfolio flow ranges from USD 10 billion to USD 12 billion (83% of USA, or 24% of total) and portfolio debt flow ranges from USD 6 billion to USD 7 billion. Additional bank portfolio flows are therefore 26% of additional total portfolio flows, and additional bank debt flows are 23% of additional total debt flows. This is consistent with the view that, after the financial crisis, market based instruments are more important.

Results for TIC-IFS dataset on portfolio flows are also consistent with a significant effect from quantitative easing on USA flows to emerging markets. The effect is economically significant and interestingly is of the same order of magnitude as obtained in the Brazilian dataset: Between 55% and 65% of USA flows to emerging markets in the sample. The effect of quantitative easing on global portfolio flow ranges from USD 111 billion to USD 130 billion. In contrast with the results using Brazilian data, most of the effect comes from portfolio equity flows (up to USD 102 billion), and debt flow effects are actually not significant.

The paper is structured as follows. The next section presents the related literature. It is followed, first, by the methodology section that formalizes the counterfactual as a proxy variable and, second, by the data section that describes the primary and secondary capital flow datasets. Results for the two datasets are presented in turn in the next section, along with a complementary appendix for additional results. The last section summarizes results and conclusions.

2. RELATED LITERATURE

As mentioned in the introduction, the portfolio rebalancing argument goes back to Tobin (1969, 1982). Unconventional monetary policies renewed the interest in the argument, stimulating theoretical and empirical research in several intertwined literatures. There is macro research focusing on real consequences of the policies, finance research studying segmented asset markets sometimes with an event study approach, and international finance research focusing on international portfolio flows.

Recent attempts to incorporate portfolio rebalancing as a transmission channel of unconventional monetary policy in calibrated general equilibrium models include, e.g., Chen et al. (2012), Flagiarda (2013), and Sami and Kabaca (2015). Imperfect substitution in these models results from financial constraints, adjustment costs or preferences for asset holdings. Sami and Kabaca (2015) come closest to this paper by considering international portfolio holdings. However, the authors assume USA-based investors hold only domestic assets, so that all the international portfolio rebalancing runs through substitution effects of foreign investors holding some share of USA assets. In spite of this limitation, which is at odds with the data and with the results of this paper, the authors do show their model is able to capture some stylized asset price spillovers. From the point of view of identifying the portfolio balance channel, however, this macroeconomic literature does nothing more than assume the effect and model the connections with the macroeconomy.

The finance literature has moved into modeling segmented asset markets to explain the impact of unconventional monetary policies on asset prices. Gromb and Vayanos (2010) survey the broader segmented markets literature, Greenwood and Vayanos (2014) apply the insights to term structure models, while Hamilton and Wu (2012) extend the argument to quantitative easing and show it contributes to lower long term rates. Bruno and Shin (2014) argue that monetary easing in the USA improves funding conditions of foreign banks and puts in motion a feedback loop between bank cross-border lending, foreign currency appreciation and balance sheet improvement that eases constraints. They argue banks drive the cycle up to the financial crisis, with the market for debt securities taking a similar role afterwards. Plantin and Shin (2014) argue that interest rate differential may lead carry traders to coordinate on the supply of excessive capital to the targeted economy.[3]

There is a related event study literature in great part motivated by the segmented markets approach. Gagnon et al. (2011) use event study methods and document that large-scale asset purchase programs led to a reduction in USA long-term interest rates for a range of securities, including those not included in the purchase programs. Neely (2015) shows that unconventional monetary policy by the Federal Reserve influences long-term interest abroad as well as bilateral exchange rates. From our perspective, the theoretical term structure papers are heavily dependent on the theoretical structure, much like the general equilibrium models. On the other hand, the event study papers face problems related to confounding events and the short run nature of the estimated effects.

The empirical international finance literature addresses the portfolio balance hypothesis in a more direct way, focusing on the substitution between domestic and foreign assets. Fratzscher et al. (2013) use panel regressions and show that flows into USA equity and bond funds go in the opposite direction of flows into funds dedicated to emerging markets conditional on the policies. There are corresponding movements in equity returns, bond yields and exchange rate

[3] It is interesting to compare this with the traditional portfolio rebalancing literature (e.g., Gohn and Tesar, 1996 Hau and Rey, 2008), which documents return chasing behavior and rebalancing to keep investment shares constant, so that, in particular, foreign currency appreciation would be a disincentive to further inflows.

returns. Ahmed and Zlate (2013) also use panel regressions to show that net portfolio flows (that is, including domestic resident flows) to emerging markets shift in composition, but not in levels in response to quantitative easing, and that such change seems to be towards bonds and equities. An important problem of these approaches is probably the presence of omitted variables in the empirical specifications. From our perspective, this also translates into the lack of a proper counterfactual for conducting causal inference.

A closely related paper that is at the crossroads of the macroeconomic and international finance literature and deals with Brazilian capital flows is Barroso et al. (2015). The authors show that USA quantitative easing influences capital inflows to the country and, through this channel, the overall economic outlook and, to some extent, financial stability. The authors also propose counterfactuals to evaluate the effect of the policy. However, the counterfactuals there are model constructs not observable in the data. This leads the authors to consider a range of possible counterfactuals and to focus only on qualitative results holding for most of the possibilities. Moreover, the counterfactuals do not speak directly to the behavior of the USA-based investor, but to the global macroeconomic conditions. Relative to that paper, therefore, this paper focus on a specific group of investors, with an observable counterfactual (based on a control group of less affected investors), and offers direct, quantitative inference on the portfolio balance channel.

3. METHODOLOGY

This section formalizes the intuition presented in the introduction. The basic idea is that ROW flows are proper counterfactual for USA flows to the same recipient economy. We formalize this idea by characterizing ROW flows as a proxy variable for unobserved global and local factors to the recipient economy. In this sense, the structural regression of interest is the following:

1 $$usflow_t = \beta qe_t + \gamma w_t + e_t,$$

where $usflow_t$ refers to the capital flows from the USA to the recipient economy in period t, qe_t measures the quantitative easing policies affecting flows in this period,[4] w_t stands for unobserved variables and e_t is the innovation to the process relative to this information set. The coefficient of interest is β which measures the partial effect of quantitative easing policies on USA flows.

The OLS estimator of β in a regression omitting the unobserved variable w_t converges to the true parameter plus a bias term. For example, if global conditions affect flows positively and correlate with quantitative easing, omitting them may overestimate the effect of quantitative easing. Similarly, if prudential regulation in the recipient economy correlates with quantitative easing this may bias downward the coefficient of interest.

It is convenient to express the bias in the context of the following auxiliary regressions:

2
$$rowflow_t = \delta w_t + v_t,$$
$$qe_t = \alpha w_t + u_t,$$

where $rowflow_t$ refers to capital flows from rest of the world to the recipient economy in period t, and $E(w_t v_t) = E(w_t u_t) = 0$. Notice, in particular, that quantitative easing may be associated with the unobserved variables, such as global conditions or domestic prudential policies. Auxiliary regressions are only *linear projections*, which only capture the correlation structure in the data. In particular, we make no assumption regarding causal relations or direction or causality in the auxiliary equations. In this framework, the probability limit of the omitted variable regression coefficient is:

3
$$p\lim \beta = \beta + \frac{\gamma \alpha E(w_t^2)}{\alpha^2 E(w_t^2) + E(u_t)}.$$

The challenge posed by the structural equation is to minimize the omitted variable bias. Controlling for some observable factors ameliorates the problem, but does not rule out still unobserved ones. The solution proposed here is to use capital flows from the ROW to the same recipient economy as a proxy for omitted factors, or, from another

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4 We measure this by the change in the Federal Reserve's balance sheet, possibly forwarded a few months if suggested by information criteria. See the data and result sections for details.

perspective, as a counterfactual for the behavior of USA flows had it not been disproportionally affected by quantitative easing policies. The fact that both variables are capital flows to the same recipient economy hopefully adds credibility to the estimator. We argue that it necessarily reduces the asymptotic bias and formalize the exact condition under which it is a perfect counterfactual.

Formally, we propose to estimate the proxy-variable regression:

4 $$usflow_t = \beta^p qe_t + \gamma^p rowflow_t + \varepsilon_t.$$

In the context of the auxiliary regressions defined in 2, the proxy variable assumption is introduced by requiring *1)* $\delta \neq 0$ and *2)* $u_t \perp v_t$. The first assumption ensures that rest of the world flows is related to the unobserved factors it should proxy. The second assumption, which is the crucial assumption in the paper, means that, *beyond indirect effects driven by the unobserved factors*, quantitative easing does not impact ROW flows to the recipient economy. Substantively, this means capital flows follow the shortest path to the recipient economy and therefore do not move from the USA to the rest of the world just before reaching their final destination. One may also simply interpret the assumption as a definition or methodological device that allows for identifying factors associated with QE that affect exclusively the USA investor. The credibility of such interpretation of a QE effect depends on properly controlling for other local factors affecting investor behavior in the USA and abroad, and we show below how to extend the framework to this case.

Substituting the structural equations into the equation for OLS proxy variable estimator $\hat{\beta}^p$, it is simple to show that[5]:

5 $$p\lim \hat{\beta}^p = \beta + \frac{\gamma \alpha E(w_t)}{\alpha^2 E(w_t^2) + E(u_t) / R^2_{rw,v}},$$

where $R^2_{rw,v}$ is the R^2 from regressing $rowflow_t$ on v_t . Intuitively, if most of the variation in the proxy variable is associated with the unobservable variable, then there is a large reduction in the asymptotic bias. In the limit, there is complete reduction in the bias and we are

[5] Apart from our substantive interpretation, the argument is essentially the one presented in Sheehan-Connor (2010),

completely safe in our assumption of a proper counterfactual.

So far results suppose a scalar unobserved variable w_t. It is simple to generalize this to a scalar *index function* of several unobserved variables, as long as the function is the same in all structural equations of the model.

It is also simple to introduce additional controls. Indeed, with such controls, the exact same results as before follow from a simple application of the Frisch-Waugh theorem. For our framework, differences in the environment between United States and rest of the world investors are observable controls, while local conditions to the recipient economy and global conditions enter in the unobserved index function. The introduction of local controls to the source economies is important if one is to interpret the results as an additional impact of QE affecting exclusively the USA investor.

Another variation of the methodology may use the residual from the candidate proxy variable regressed on quantitative easing policies as the proxy variable, with an adjustment for generated regressor. We consider this variation when using data for jurisdictions other than the Brazilian economy to control for data quality issues.

4. DATA

The data consists of: *1)* indicators of capital flows from the USA and ROW with Brazil as the recipient economy; *2)* capital flows from the USA and ROW to other emerging market economies; *3)* unconventional monetary policy by the Federal Reserve; and *4)* additional control variables. For the Brazilian data, the frequency is monthly and the sample runs from January 2003 to March 2014. For other recipient economies, the data is quarterly from the first quarter of 2005 to the first quarter of 2014. The other time series are set to monthly or quarterly accordingly.

4.1 Capital Flows for Brazil

For historical reasons, the monitoring of capital flows in Brazil is uniquely comprehensive. It relies on a system of mandatory electronic contracts for all transactions with foreigners. Based on this, the Central Bank of Brazil can maintain a data warehouse that allows, among other features, breaking down capital flows according to the nationality of the counterparty.[6] This is true for any capital flow category up to the full level of detail of balance of payments statistics. It is also possible to assign flows directed to the banking sector. All these different views of foreign capital flows to the country add up to the official balance of payments statistics because the data warehouse is the basis for its compilation. Except when made explicit in the text, all capital flow variables are in billions of dollars.

The dataset covers all gross capital flow categories, including foreign direct investment, foreign portfolio investment and foreign credit investment. Direct investment is discriminated into equity capital investment and affiliated enterprise loans.[7] Portfolio investment is decomposed into equities and debt securities, and then into debt issued in the country and debt issued abroad. Foreign credit investment is composed exclusively of direct loans.[8] The corresponding aggregated series are available at the Central Bank of Brazil online time series system with detailed metadata descriptions. The break down by nationality used in this paper was custom-made to this study with extensive checks for data quality performed by the staff responsible for balance of payments compilation.

Flows directed to the Brazilian banking sector are also available for the same categories (except affiliated enterprise loans which are treated as credit flows), both from the United States and from the rest of the world. There are two caveats here. First, we must impute portfolio equity flows and portfolio debt flows towards banks from the relative size of the banking sector in the equity and debt market, respectively (but debt issued abroad is from actual transactions). Second, we cannot assure full coverage of bank credit flows. Indeed, lines of credit between banks are exempt from electronic contracts that are the base for our dataset. For aggregate balance of payment statistics, accounting data

[6] For the record, another feature is the very fast compilation of balance of payments statistics; preliminary numbers for all the major accounts are available and monitored in almost real time.

[7] In the case of foreign direct investment, we include inflows of national corporations borrowing abroad through foreign affiliates and exclude outflows of direct investors lending to headquarters abroad. In this way, we keep track of changes in liabilities of corporations with domestic residency, in line with the latest edition of the balance of payments manual.

[8] In the case of credit flows, we choose to exclude trade credit flows because they follow trade in goods and are uninformative of portfolio decisions by foreign investors.

can complement the information available in the data warehouse, but the same solution is not available when discriminating by the nationality of the counterparty. This second caveat applies to total flows as well, since banks are a subset of the full dataset.

The correlation between ROW flows and USA flows is a first rough indicator of the credibility of the proxy variable assumption. A strong correlation is a signal of common drivers. Yet, if the correlation is too strong, it can signal there is little room for additional effects from quantitative easing. Figure 1, panels *a* to *j*, shows the corresponding flows to the recipient economy: Total flows have a correlation coefficient of 0.37, portfolio flows 0.36, portfolio equity 0.15, portfolio debt 0.17, portfolio debt in the country 0.14, portfolio debt abroad −0.11, foreign direct investment 0.46, credit 0.13, foreign equity capital investment 0.31 and affiliated enterprise loans 0.49. Figure 2, panels *a* to *h*, shows the corresponding flows to the banking sector: Total flows to banks have a correlation coefficient of 0.24, portfolio flows 0.32, portfolio equity 0.42, portfolio debt 0.16, portfolio debt in the country 0.21, portfolio debt abroad 0.04, foreign direct investment 0.09 and credit flows 0.03.

We may also compare the behavior of moving averages of ROW flows and USA flows, particularly for periods of quantitative easing policies. A distinct behavior of USA flows during policy periods is a signal of possible effects. Figures 3 and 4 show the six months moving average of ROW and USA flows to Brazil, respectively. To get a clearer picture of the other flows, we exclude foreign direct investment due to large scale and volatility differentials between ROW and USA flows. There are pronounced differences between total flows during each of the quantitative easing policy rounds, with subcategories of flows apparently reacting more strongly to certain rounds. For example, the first and third policy rounds show up more clearly in the USA flows. Debt flows respond relatively more in the third round and credit flows in the second. The general picture is consistent with the results summarized in the introduction. Figures 5 and 6 show the corresponding moving averages of ROW and USA flows to the banking sector of the recipient economy. Again, there are pronounced differences, including the relatively stronger behavior of USA flows around the first and third rounds of quantitative easing and a role for credit flows during the second round. The exact definition of the policy rounds considered in the paper are presented in the following section.

Figure 1

CAPITAL FLOWS FROM THE US AND ROW TO BRAZIL

(USD billions)

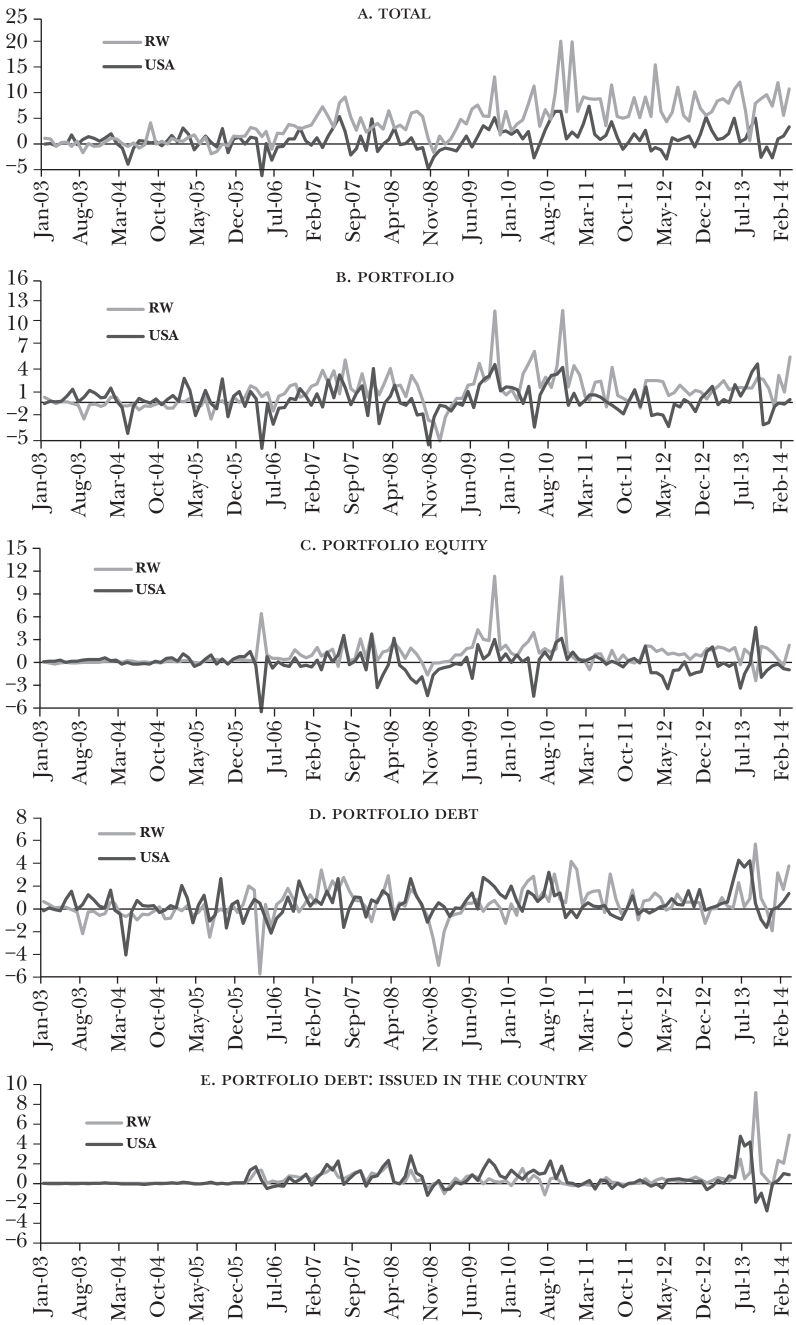


Figure 1 (cont.)

CAPITAL FLOWS FROM THE US AND ROW TO BRAZIL

(USD billions)

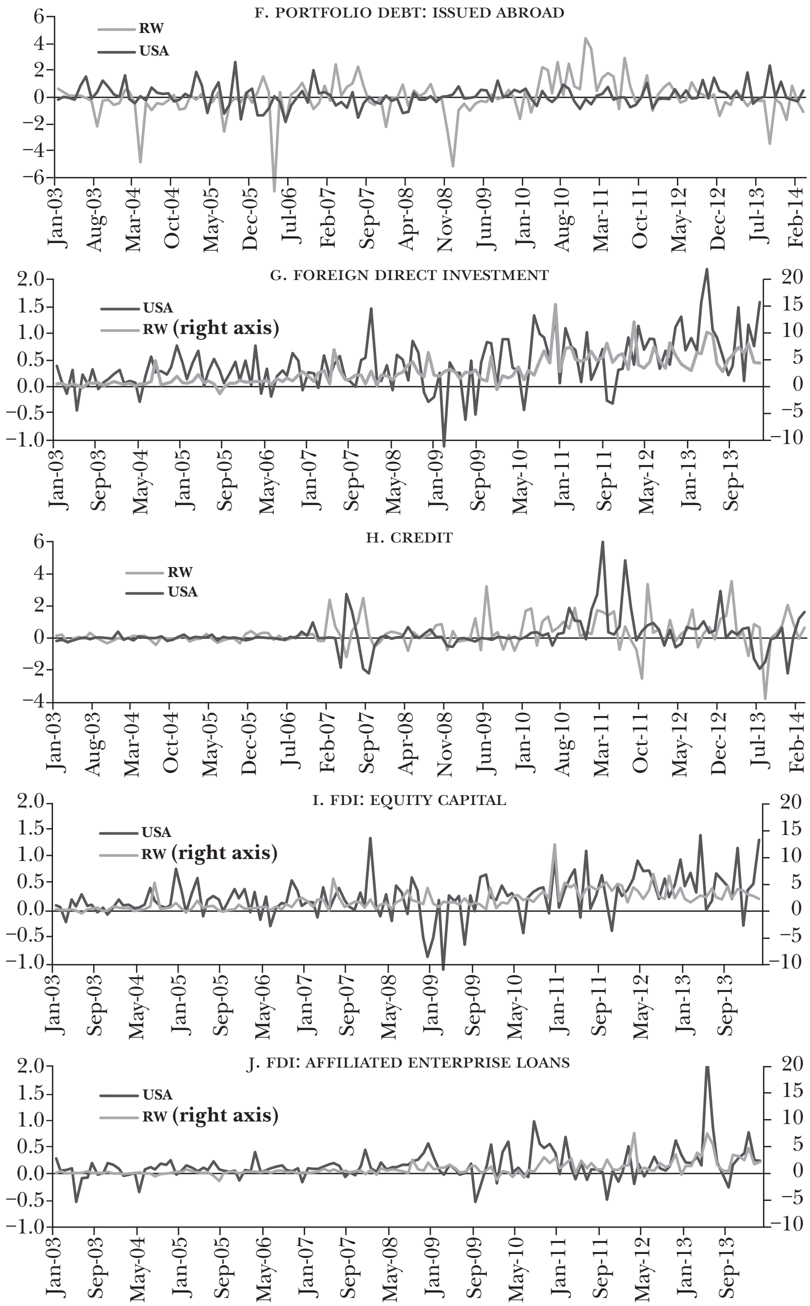


Figure 2

CAPITAL FLOWS FROM THE USA AND ROW TO THE BRAZIL'S BANKING SECTOR

(USD billions)

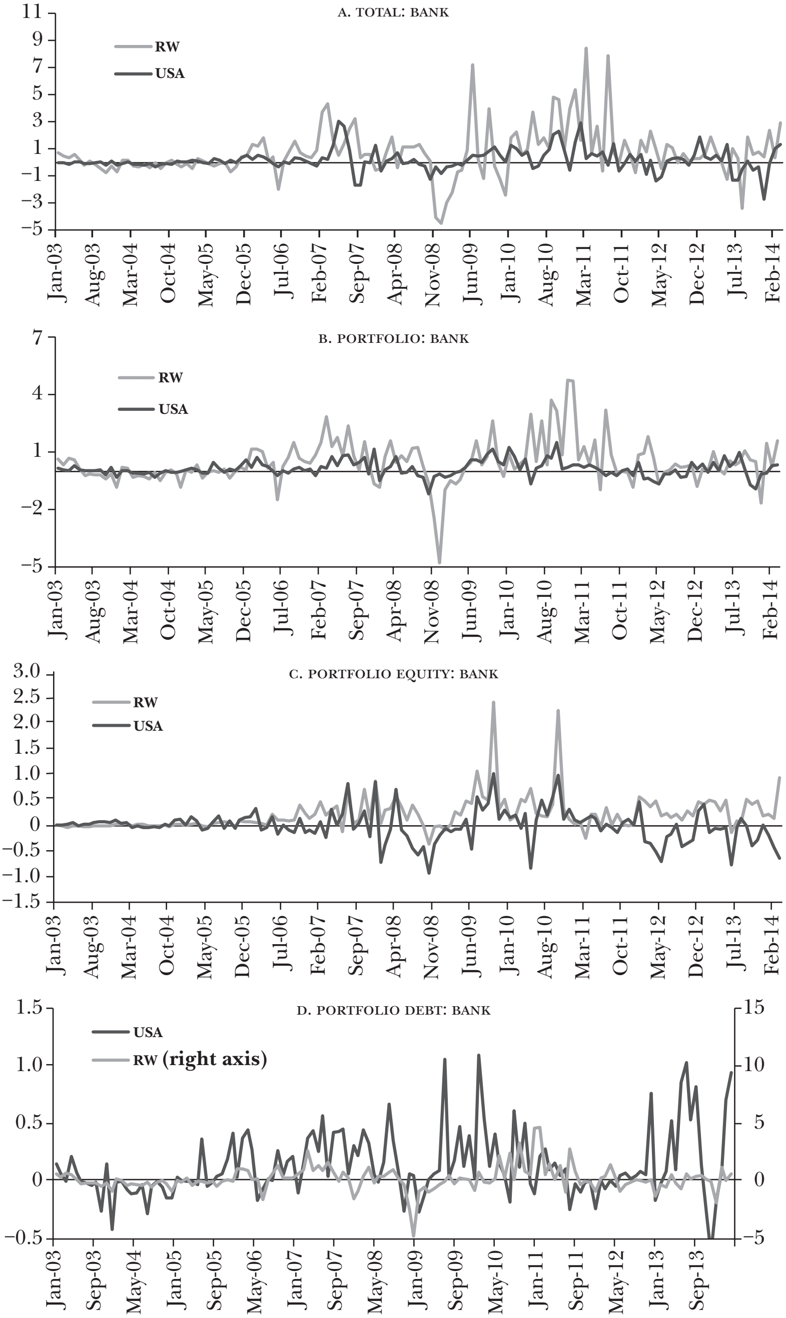


Figure 2 (cont.)

CAPITAL FLOWS FROM THE USA AND ROW TO THE BRAZIL'S BANKING SECTOR

(USD billions)

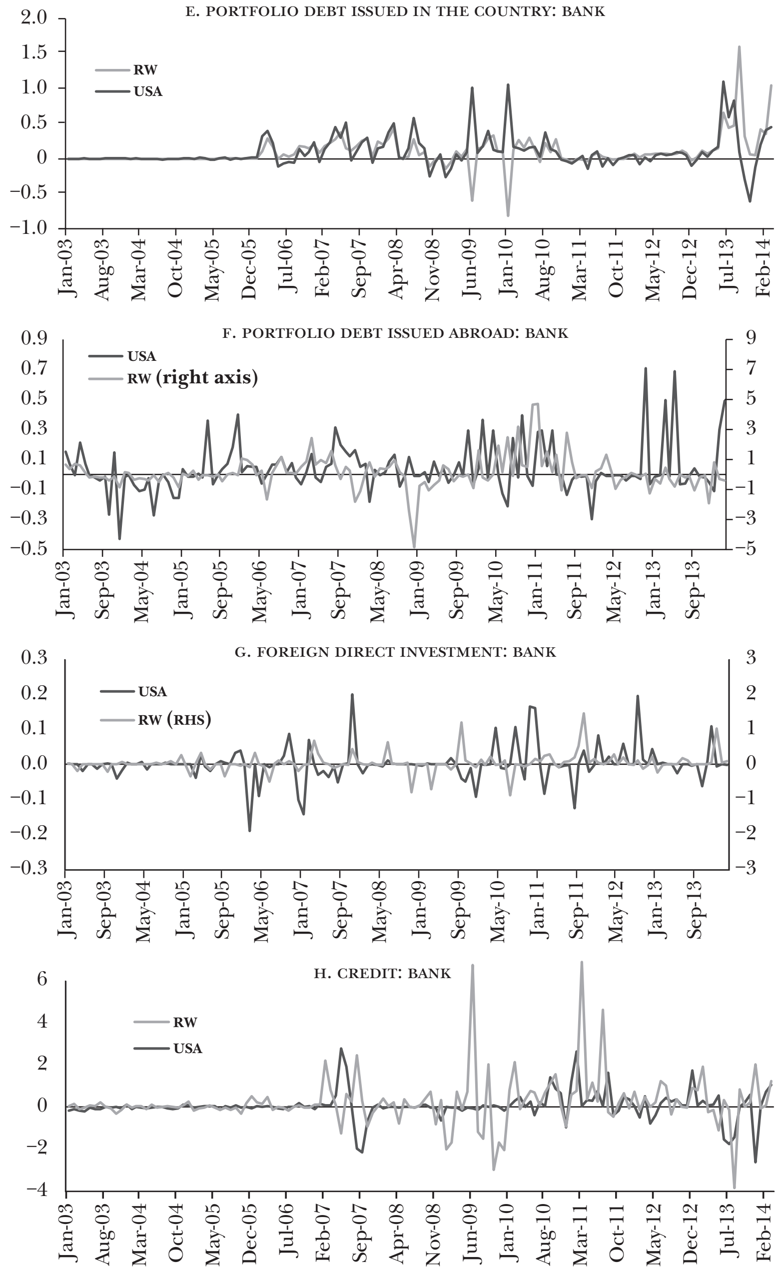


Figure 3

CAPITAL FLOWS FROM ROW TO BRAZIL AND QE PERIODS

(USD billions, six-months moving average)

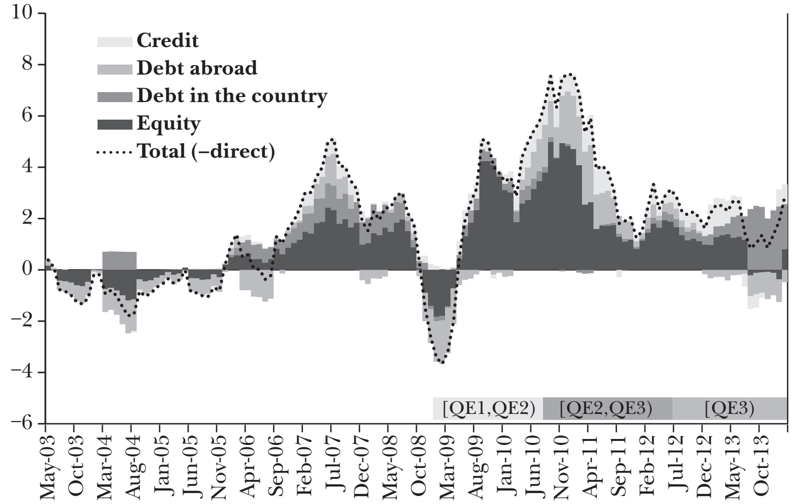


Figure 4

CAPITAL FLOWS FROM US TO BRAZIL AND QE PERIODS

(USD billions, six-months moving average)

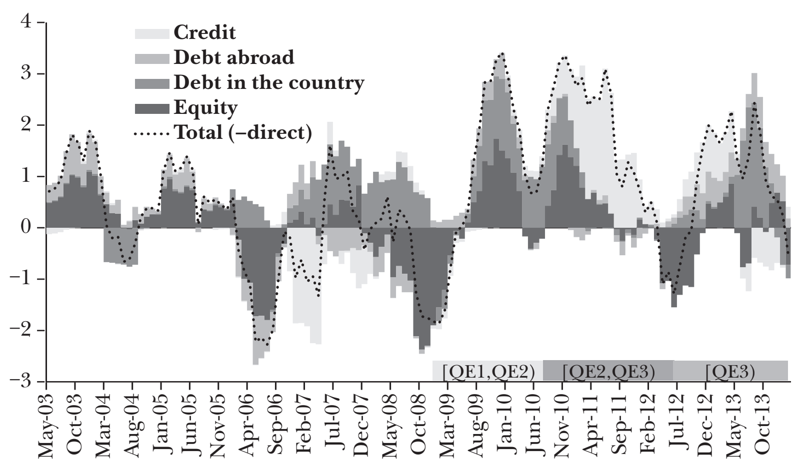


Figure 5

CAPITAL FLOWS FROM ROW TO THE BRAZIL'S BANKING SECTOR AND QE PERIODS

(USD billions, six-months moving average)

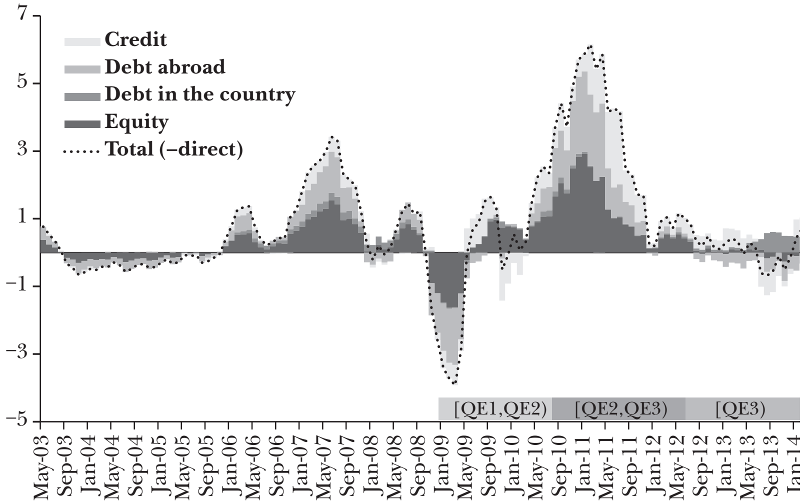
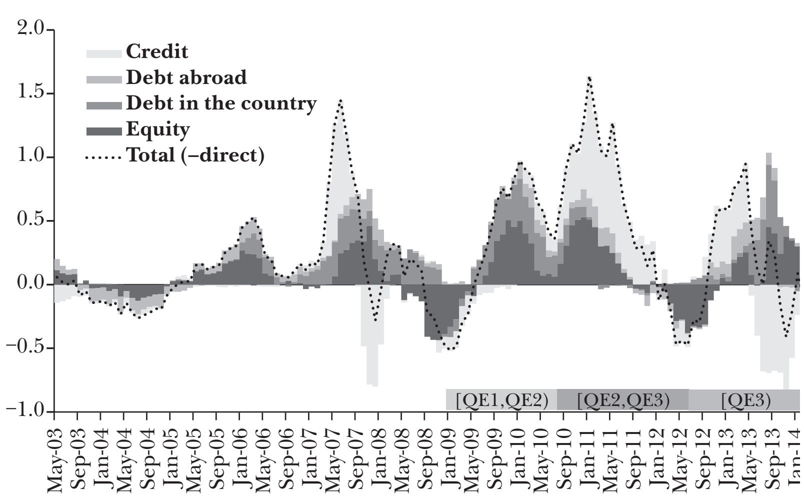


Figure 6

CAPITAL FLOWS FROM US TO THE BRAZIL'S BANKING SECTOR AND QE PERIODS

(USD billions, six-months moving average)



4.2 Capital Flows for other Jurisdictions

The Treasury International Capital (TIC) System is the source of portfolio debt and equity flows from the USA to other countries. The International Financial Statistics (IFS) database maintained by the IMF is the source of total gross debt and equity flows to the same countries. The frequency of this IFS source is quarterly and so we aggregated the monthly TIC data. The sample includes 17 emerging markets: Argentina, Brazil, Chile, China, Colombia, Hungary, Indonesia, Mexico, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, and Uruguay. Notice there is no guarantee the two datasets align as smoothly as the Brazilian dataset. For example, comparing the TIC flows data for Brazil, there are large discrepancies. On the other hand, the IFS data aligns smoothly with our dataset since it is just balance of payment statistics. Therefore, it is not recommended to subtract TIC data from IFS data to get ROW flows. Instead, we use the residuals of IFS total flows (TOT) regressed on quantitative easing policies as our proxy variable as suggested in the last paragraph of the methodology section.

4.3 Quantitative Easing

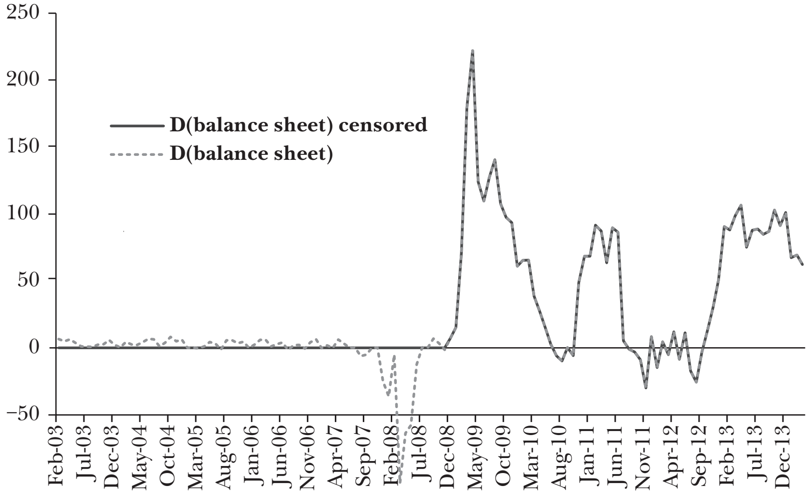
The indicator for unconventional monetary policy by the Federal Reserve is the monthly change in securities held outright in its balance sheet. As the capital flow variables, it is in billions of dollars unless stated otherwise. The source of the series is the Federal Reserve Economic Data (FRED). We censored the monthly change series to be zero before the start of the quantitative easing policies, that is, before November 2008. Figure 7 shows the resulting indicator. The main advantage of using this indicator is the transparent interpretation of its coefficient in the baseline regressions, which relates dollar amounts of policy to dollar amounts of capital flows. In some specifications, for robustness, we normalize both variables by the aggregate Brazilian import price index, but with the average of the index over the policy period normalized to one so that a similar interpretation applies.

Another robustness check is to interact the balance sheet variable with dummy variables indicating the policy round. For this paper, we consider three policy rounds of balance sheet expansion: QE1, QE2 and QE3. We use dates where the policy begins (in the case of QE1) or

Figure 7

QUANTITATIVE EASING INDICATOR

(USD billions, monthly change in securities held outright in the Federal Reserve's balance sheet)



the policy is hinted to the public (in the case of QE2 and QE3). Following the dates of Fawley and Neeley (2013), QE1 begins in November 2008, QE2 in August 2010 and QE3 in August 2013. We stipulate that the policy rounds end just before another round begins. This means we count the extension of QE1 as a phase of QE1, Operation Twist as a phase of QE2 and the tapering as a phase of QE3. In principle, it is possible to increase the granularity and capture these as separate policy rounds. However, the resulting periods would be too short, so that essentially we would run regressions with dummy variables for the policy. There are important inferential problems associated with such dummy variable regressions, so we have a strong preference for using a continuous policy variable.

4.4 Additional Controls

The trust of the paper is that ROW flows proxy for unobserved common determinants of USA flows. In principle, the index function representing the common determinants may control for observables as well, as long as the homogeneity assumption for the index function holds. For robustness, we also study regression with observable controls. For parsimony, we introduce the controls as differences between United States variables and the corresponding average values for euro area, UK and Japan, which are representative for the rest of the world capital flows to Brazil. The specific control variables are 10-year government bond yields, CITI economic surprise indexes, and monthly stock returns, all obtained from the Bloomberg terminal. We also introduced a crisis dummy variable in all regressions to avoid attributing the strong first round of negative effects from the crisis to the unconventional policies designed to address them. It is an indicator variable of the months from October 2009 to March 2009. In the appendix, we run regressions including capital flow taxes in Brazil as controls.

5. RESULTS

5.1 Brazil Dataset

All results are in Tables 1 to 12 (see the Annex). They have a similar structure, so we take some time to describe it. We always present four regressions for each capital flow category, all based in the minimal equation 4, distributed in columns of the table with the following roman labels and meaning: *1)* omits the ROW flows proxy, *2)* includes the proxy, *3)* includes the proxy and additional controls, and *4)* normalizes dollar variables by import price indexes. Notice the price indexes used to normalize the series gave unit average during the policy period, so that the scale of the coefficients is still comparable.

All regressions include a constant to capture average monthly flows. They also include a crisis dummy, introduced in the previous section, to avoid confounding it with unconventional policies. Regressions may include dummy variables to capture outliers in the USA flows. We identify an outlier automatically whenever the absolute deviation from the mean is greater than four standard deviations. This results in a couple of outliers for some capital flow categories. To save space in the tables, we do not report some coefficients. This includes the dummy variables for outliers and the additional controls.

The *baseline regressions* include the quantitative easing policy indicator described in the previous section. The *extended regressions* contain separate quantitative easing indicators for each policy round of balance sheet expansion. The last ROW of each reported regression brings the point estimate for the accumulated effect of quantitative easing – or, in the case of extended regression the accumulated effect for each policy round. For each baseline and extended regressions, we present separate results for *economy-wide flows* and for *banking sector flows*. For extended regressions we also perform additional regressions including own lag of USA flow and capital flow taxes as additional controls.

It is important to recall that the quantitative easing policy indicator refers to monthly balance sheet expansions by the Federal Reserve. To allow for anticipation of balance sheet expansion by market participants, all regressions include a lead of the policy indicator. In accordance with information criteria, we use *three months lead* of the policy indicator in all regressions.

5.1.1 *Baseline Regressions: Economy-wide*

Table 1 summarizes the results for aggregated concepts of USA flows, such as total flows, portfolio flows, direct investment flows, and credit flows. Table 2 presents results for disaggregated concepts, such as direct investment in equity capital or in affiliated enterprise loans and portfolio investment in equity, debt, debt issued in the country and debt issued abroad.

There are some common results. First, the coefficient on the quantitative easing policy is always positive and it is lower when including the proxy variable (column 2) than when omitting it (column 1). This points to a positive bias from omitting unobservable determinants of USA flows. When considering the implied accumulated effects of the policy (last ROW), the bias is economically significant.

Second, the crisis dummy is always significant, which points to an economically important reduction in flows from the USA in the most acute phase of the crisis (e.g., multiply the crisis coefficient by its duration of six months and compare this with the accumulated effect of the policy in the last ROW). Third, the ROW proxy is strongly statistically significant except for credit, debt and debt issued abroad.

Forth, including the proxy variable improves the fit significantly as judged by the adjusted R^2, but the inclusion of additional controls provides only marginal if any improvement (and coefficients are stable between the two specifications). This signals that the proxy variable is capturing most of the relevant information of the common drivers of capital flows to Brazil from different source economies.

Focusing now on Table 1, the coefficient on the QE policy indicator for the total flows regression (upper left panel) shows that each one USD billion balance sheet expansion leads to additional capital flows into Brazil in the order of USD 0.015 billion. Considering the total size of the balance sheet expansion in the period, this corresponds to additional flows in the range of USD 54 to 58 billion, or 54% of the USA flows to Brazil accumulated over the period. The flows are *additional* in the sense that they are on top of any effect quantitative easing might have through the common drivers of USA and ROW flows that are controlled for in the regression.

The analogous coefficient for the portfolio flows regression (upper right panel) shows that each one USD billion balance sheet expansion implies additional portfolio flows into Brazil in the order of USD 0.11 or 0.12 billion. This represents additional portfolio flows in the range of USD 40 to 48 billion in the period, or 140% of portfolio flows from the USA in the period (recall from Figure 1, panel c, which portfolio flows from the USA fall significantly during this period). The effects on direct investment and credit flows (lower panels) are not statistically significant. For direct investment, ROW flows are significant and therefore the result is conclusive for no additional effect. For credit flows, the proxy variable is not significant and so the result is less conclusive.

Table 2 has detailed results. As in aggregate direct investment, both equity capital and affiliated enterprise loans (upper panels) show no additional effect from quantitative easing. Portfolio equity is also not significant (middle left panel). Things change for portfolio debt (middle right panel). For each USD one billion of quantitative easing, portfolio debt flows increase by USD 0.008 billion, which represents USD 28 to 30 billion during the period, or 62% of USA debt flows to the country in the period. Further decomposing portfolio debt, only debt issued abroad (lower right panel) shows significant additional effects from quantitative easing. For the same USD 1 billion of policy easing, debt issued abroad increases by USD 0.003 billion, between USD 1 billion and USD 13 billion during the period, or 96% of USA investment in Brazilian debt issued abroad.

5.1.2 *Baseline Regressions: Banking Sector*

Mimicking the same structure of the economy-wide flows, Table 3 summarizes the results for aggregated concepts of USA flows to the Brazilian banking sector, while Table 4 reports the results for disaggregated concepts.

There are some broad results. First, as in the case of economy-wide regressions, the coefficient on the quantitative easing policy is always positive and it is lower when including the proxy variable than when omitting it. This points to a positive bias from omitting unobservable determinants of USA flows. Second, the crisis dummy is significant in some cases, but less than in the corresponding economy-wide regressions. Third, the ROW proxy is statistically significant only for total flows, portfolio flows, equity flows and debt issued in the country. Forth, including the proxy variable and additional controls improves the adjusted fit.

According to Table 3, only portfolio flows (upper right panel) show significant effects from quantitative easing. In this case, a USD one billion balance sheet expansion leads to additional portfolio flows into the Brazilian banking sector in the order of USD 0.003 billion. This corresponds to additional flows in the range of USD 10 billion to 12 billion, or 83% of the USA portfolio flows to the Brazilian banking sector over the period.

Table 4 shows that USA investment in Brazilian banks' debt (upper right panel) and, in particular, debt issued abroad (lower right panel) respond to quantitative easing. Each USD one billion balance sheet expansion is responsible for additional USD 0.002 billion of flows into debt and USD 0.001 billion of flows into debt issued abroad by Brazilian banks. This corresponds, respectively, to USD 7 billion and USD 3 billion, or 50% of USA flows into bank debt and 73% of USA flows into bank debt issued abroad. The effects of quantitative easing on portfolio equity (upper left panel) and debt issued in the country (lower left panel) are not significant.

5.1.3 *Extended Regressions: Economy-wide*

Table 5 and 6 summarizes the results.[9] The common features of the regressions are broadly in line with the corresponding baseline regressions. That is, we observe lower QE coefficients once including

[9] To check for robustness, Table 5 and 6 show the same regressions but with own lag of USA capital flows and control for capital flow taxes.

the proxy variable, generally significant proxy variables when included, gains in the adjusted fit of including the proxy variable, marginal gains if any from including other variables and significant crisis effects.

One common feature present only in the extended regression is that sometimes the sum of the effect of all quantitative easing episodes is significant even if some of them do not appear significant individually, which is possible given the correlation between the different parameter estimates. Another feature is that, relative to the estimated effects from the baseline regressions, the sum of the effects in the extended regression is of similar scale (except for affiliated enterprise loans, which is larger in the extended regression).

Table 5 shows results for aggregated flows. There is robust evidence that total flows are affected by QE2 (around USD 26 billion of accumulated additional effect, 46% of the flows in the period) and some evidence that they are affected by QE3 (around USD 16 billion effect, 42% of the flows). There is some evidence across specifications that portfolio flows are affected by QE1 (around USD 22 billion). There is some evidence that foreign direct investment by the USA is affected by QE3, and that credit flows respond to QE2.[10]

Table 6 explores flows in detail. Contrary to the baseline, for direct investment, both equity capital and affiliated enterprise loans are affected by QE3.[11] Again, in contrast with the baseline, the behavior of USA investors on foreign equity markets and debt issued abroad responds to QE2 (around USD 8 billion and USD 2.5 billion, respectively, or 300% and 50% of the corresponding USA flows). Similarly to the baseline, portfolio debt and portfolio debt issued abroad are affected by QE1 (around USD 14 and 4.5 billion, respectively, or 75% and 115% of the flows) and by QE3 (around USD 14.5 billion and USD 7 billion, respectively, or 57% and 83% of the USA flows in the period of the policy).

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[10] Result is different when including additional controls (Table 5), in which case total flows and portfolio flows show a substantially larger effect from QE3, and FDI and credit flows are no longer affected. Results from Table A.5 also suggest significant negative effects of capital flow taxes on portfolio flows, and the order of magnitude is similar to the overall effect of QE policies, which is a bit surprising given the likely bias of the tax coefficient. Most of the tax effect comes from portfolio debt flows (Table 6).

[11] Yet, the result is not robust to the inclusion of additional controls (Table A.2).

5.1.4 *Extended Regressions: Banking Sector*

The common features of the banking sector extended regressions (Tables 7 and 8) are broadly in line with the corresponding baseline regressions. In the Annex, we show this is also the case when including own lag of USA capital flows and capital flow taxes as controls (Tables 7 and 8). That is, we observe lower QE coefficients once including the proxy variable, some significant proxy variables when included, gains in the adjusted fit of including the proxy variable, and generally significant crisis effects.

Table 7 shows aggregate flows to the banking sector. Contrary to the baseline regression, total flows are now affected. Portfolio flows to the banking sector respond mostly to QE1 (around USD 7 billion or 108% of the flows). Results are similar when adding capital flow tax and own lag as controls.

Table 8 shows further details. Portfolio equity and portfolio debt issued abroad by Brazilian banks are affected by QE2 (around USD 2 and 0.7 billion, respectively, or 80% and 100% of the corresponding flows). Portfolio debt is affected by QE1 (around USD 3 billion or 65% or the flow). However, the proxy variable is not significant for the portfolio debt regressions. Results are again broadly similar when adding capital flow tax and own lag as controls.

5.2 Global Dataset

Table 9 shows the results for the TIC-IFS dataset. The columns in the table follow the same structure as before, except for column (4) that reports the regression with heterogeneous coefficients for each country in the sample.

Since TIC and IFS data do not allow for deducing ROW flows with a consistent methodology, we consider a variation of our main method.[12] We use total capital flows (TOT) from the IFS as a candidate proxy variable. This candidate is regressed on quantitative easing policy (on a country-by-country basis) and the residual from this first stage regression is used as the actual proxy variable in the regressions. Of course, this introduces a possible generated regressor bias. We

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[12] We tried just subtracting TIC from IFS but the coefficient on the implied ROW flows is negative, which is counterintuitive and suggests a problem. With our procedure, the total flow (TOT) proxy has the expected positive sign.

bootstrapped the first stage regression and the difference in the results is in the order of magnitude of numerical errors, and are therefore dismissed in the following.

Results suggest that quantitative easing affects USA flows to emerging markets. Including the proxy variable lowers the estimated effect, which is consistent with an upward bias from omitted variables. The effect of quantitative easing on global portfolio flows range from USD 111 billion to USD 130 billion, and this represents from 55% to 65% of USA flows to emerging markets in the sample. Indeed, it is a bit surprising (and reassuring) that the percentage figure is so close to the corresponding Brazilian result given the very different dataset and the adjustments to the methodology. In contrast with the results using Brazilian data, most of the effect comes from portfolio equity flows, and debt flow effects are actually not significant. Results are robust to the inclusion of controls for differences in the environment of USA and other advanced economies that may originate capital flows to emerging markets, including differences in return and economic activity. Results are also robust to allowing for heterogeneous coefficients in recipients economies.

6. CONCLUSION

There is robust evidence that quantitative easing policies by the Federal Reserve cause portfolio rebalancing by USA investors towards foreign assets in emerging market economies. These effects are on top of any effects such polices might have through global or local conditions, since they are controlled for in the regressions.

According to our main dataset, which focuses on capital flows to Brazil, the effects are concentrated into portfolio assets, particularly debt, both for economy-wide and banking sector flows. This is consistent, for example, with these assets being closer substitutes to long-term USA treasuries. There is less evidence of effects on direct investment and credit flows, except for extended regressions partitioning quantitative easing into different policy rounds. The magnitudes are economically significant and correspond to sizable shares of the accumulated USA flows during the policy period. Additional flows directed at the banking sector in response to the policy are a quarter of the economy-wide flows. This is consistent with the view that market-based instruments are more important than banks in the direct cross-border transmission in these particular events of quantitative easing. The recent reversal of fortunes of economies employing large-scale quantitative easing measures and economies receiving the resulting capital flows shows that portfolio rebalance mechanisms operating during such periods involve significant risks.

Regarding the global dataset, there is also evidence that quantitative easing causes portfolio rebalancing to emerging market economies. In contrast to the result for Brazil, most of the effect seems to be concentrated on equity flows. The magnitudes are economically significant as well, with up to 65% of total USA portfolio flows to the countries in our sample accounted for by quantitative easing. This is surprisingly similar to the 54% figure for total flows to Brazil. That is, even though flows are small relative to the overall balance sheet expansion in the USA, they are considerably large relative to the recipient economies.

The results obtained with our methodology are uniquely informative to the portfolio balance channel of unconventional policies due to the use of a proper counterfactual for USA-based investor behavior. By construction, our methodology isolates the effect of quantitative easing affecting exclusively the USA investor, that is, an effect on top of any factor that also affects global investors. It is natural to interpret such effect as resulting from portfolio rebalancing under the assumption that operationalization of USA unconventional monetary policies affects disproportionally the portfolio and wealth of USA based investors and financial intermediaries. Further work using similar data may consider other estimation strategies, such as system methods or the inclusion of several of the available proxies in each regression. The strategy proposed here is relevant for other jurisdictions if data is available, as may be the case for other economies that closely monitor capital flows for historical or other reasons. After the accumulation of pertinent data, it applies to recent episodes of quantitative easing in the euro area and Japan. More generally, it applies to any central bank accumulating unconventional assets in its balance sheet and for which bilateral capital flows data are available.

Table 1

FOREIGN CAPITAL FLOWS FROM THE USA

	Total				*Portfolio*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.6843[a]	0.1325	0.2495	0.2965	0.2265	−0.0814	−0.2185	−0.0817
	2.8955	0.4589	0.8153	0.9605	1.1589	−0.3662	−0.9837	−0.3932
QE	0.0214[a]	0.0151[a]	0.0156[a]	0.0145[b]	0.0136[a]	0.0108[b]	0.0129[a]	0.0120[a]
	3.6901	2.7831	2.7776	2.4327	2.9492	2.4763	2.8816	2.6682
CRISIS	−5.1565[a]	−3.9954[a]	−4.3873[a]	−3.6481[a]	−3.4387[a]	−2.3473[a]	−2.3836[a]	−2.0137[a]
	−6.3940	−4.7710	−4.3906	−4.2863	−4.0237	−2.8161	−2.6613	−2.8297
ROW		0.1469[a]	0.1266[c]	0.1188		0.2286[a]	0.2356[a]	0.2266[a]
		2.7643	1.8905	1.5909		2.9716	3.0691	2.8029
R^2	0.348	0.385	0.392	0.387	0.142	0.205	0.228	0.186
Adjusted R^2	0.332	0.366	0.363	0.357	0.129	0.186	0.198	0.153
QE (USD)	79.90[a]	56.64[a]	58.19[a]	54.23[b]	50.92[a]	40.54[b]	48.34[a]	45.01[a]

	Direct				Credit			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
C	0.3442[a]	0.1719[a]	0.1394[c]	0.1568[a]	0.0469	0.0074	0.1710	0.1091
	7.2261	3.9746	1.9783	2.8810	0.2862	0.0429	1.1675	0.8458
QE	0.0033[c]	0.0011	0.0012	0.0008	0.0035	0.0030	0.0007	0.0010
	1.7764	0.8224	0.8900	0.6429	0.8690	0.8075	0.2067	0.3008
CRISIS	−0.8755[a]	−0.6728[b]	−0.6512[b]	−0.5339[b]	−0.6631	−0.5587	−0.7230[c]	−0.5996[c]
	−2.6774	−2.3579	−2.1673	−2.0675	−1.3886	−1.3577	−1.7795	−1.8319
ROW		0.0797[a]	0.0869[a]	0.0778[a]		0.1725	0.1253	0.1054
		4.1335	4.3737	4.2142		1.3348	1.0618	0.7891
R^2	0.752	0.796	0.797	0.730	0.472	0.480	0.515	0.571
Adjusted R^2	0.744	0.788	0.786	0.715	0.460	0.464	0.491	0.550
QE (USD)	12.21[c]	4.08	4.34	2.83	13.28	11.19	2.77	3.64

Results from USA flows to Brazil regressions for aggregate flow categories. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table 2

FOREIGN CAPITAL FLOWS FROM THE USA, DETAIL

	Direct: Equity capital				*Direct: Affiliated enterprise loans*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.2572[a]	0.1502[a]	0.1743[a]	0.1735[a]	0.0866[a]	0.0533[b]	0.0353	0.0379
	7.8396	5.1422	3.5710	4.2557	4.4405	2.5210	1.2856	1.5360
QE	0.0011	0.0004	0.0003	0.0000	0.0015[b]	0.0006	0.0007	0.0006
	1.2476	0.3942	0.2718	−0.0525	2.1804	0.7476	0.9192	0.8452
CRISIS	−0.7886[a]	−0.7043[a]	−0.7176[a]	−0.5836[a]	−0.0098	0.0604	0.0621	0.0494
	−3.3126	−3.1336	−3.1220	−3.3270	−0.0774	0.5190	0.5092	0.5021
ROW		0.0626[a]	0.0556[a]	0.0459[a]		0.0714[a]	0.0802[a]	0.0762[a]
		4.8891	3.9783	3.0437		2.6375	3.3323	3.3051
R^2	0.575	0.619	0.620	0.557	0.899	0.908	0.910	0.861
Adjusted R^2	0.565	0.607	0.602	0.536	0.896	0.904	0.905	0.853
QE (USD)	4.26	1.33	0.95	−0.17	5.56[b]	2.13	2.57	2.30
	Portfolio: Equity				*Portfolio: Debt*			
	(1)	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*
C	−0.0385	−0.2592	−0.4174[c]	−0.2968[c]	0.3286[a]	0.2474[c]	0.2376[c]	0.2354[c]
	−0.2451	−1.5357	−1.8884	−1.8329	2.6753	1.8690	1.7172	1.7650
QE	0.0034	0.0001	0.0019	0.0018	0.0077[b]	0.0077[b]	0.0082[b]	0.0076[b]
	0.8103	0.0191	0.3865	0.4141	2.2044	2.1656	2.1431	2.0084
CRISIS	−1.7413[b]	−1.0964	−0.9199	−0.7623	−1.4559[a]	−1.0772[a]	−1.3072[a]	−1.0891[a]
	−2.0416	−1.3025	−1.0064	−1.1015	−3.6483	−3.0952	−3.3361	−3.0537

ROW		0.2617[a]	0.2866[a]	0.2902[a]		0.1619	0.1314	0.1274
		3.1099	3.4900	3.7293		1.4623	1.2038	1.2413
R^2	0.059	0.149	0.193	0.205	0.347	0.365	0.381	0.347
Adjusted R^2	0.044	0.129	0.161	0.173	0.327	0.340	0.346	0.310
QE (USD)	12.77	0.32	7.15	6.62	28.65[b]	28.84[b]	30.81[b]	28.49[b]

	Portfolio: Debt in the country				*Portfolio: Debt abroad*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.3637[a]	0.0930	0.0913	0.0796	0.0033	0.0171	0.0339	0.0605
	4.2247	1.0846	0.9683	1.0025	0.0441	0.2259	0.5004	0.8592
QE	0.0029	0.0019	0.0021	0.0024	0.0038[a]	0.0037[a]	0.0034[a]	0.0028[b]
	1.0951	0.7786	0.8115	0.9605	2.8598	2.9740	2.8313	2.2451
CRISIS	−1.0738[a]	−0.5401[c]	−0.6411[c]	−0.5680[b]	−0.3073[c]	−0.4160[b]	−0.4425[b]	−0.3631[c]
	−3.0301	−1.7346	−1.8866	−2.0705	−1.8878	−2.1836	−2.0212	−1.9499
ROW		0.8754[a]	0.8670[a]	0.8620[a]		−0.0682	−0.0736	−0.0738
		7.1249	6.8665	7.0339		−1.0383	−1.0971	−0.9863
R^2	0.295	0.503	0.511	0.497	0.494	0.499	0.500	0.531
Adjusted R^2	0.273	0.483	0.484	0.469	0.478	0.479	0.472	0.505
QE (USD)	10.74	7.18	8.01	8.93	14.39[a]	13.72[a]	12.75[a]	10.62[b]

Results from USA flows to Brazil regressions for disaggregate flow categories. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*–values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table 3

FOREIGN CAPITAL FLOWS FROM THE USA TO BANKS

	Total				*Portfolio*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.1970[c]	0.0999	0.1190	0.1008	0.1052[b]	0.0634	0.0285	0.0316
	1.8482	1.1464	1.1347	1.1840	2.1707	1.5440	0.6611	0.8999
QE	0.0035	0.0034	0.0032	0.0032	0.0029[a]	0.0028[a]	0.0033[a]	0.0032[a]
	1.5202	1.4378	1.2147	1.3635	2.7287	2.7965	3.2424	3.2558
CRISIS	−1.3658[a]	−0.9679[a]	−0.9768[a]	−0.8105[a]	−0.8244[a]	−0.6254[a]	−0.6027[a]	−0.4663[a]
	−4.8145	−3.0069	−3.1698	−3.6033	−4.6951	−3.5257	−3.1260	−3.0441
ROW		0.1364[b]	0.1343[b]	0.1293[b]		0.0830[b]	0.0838[b]	0.0998[b]
		2.3376	2.4062	2.5968		2.1669	2.1286	2.5306
R^2	0.278	0.319	0.321	0.294	0.377	0.410	0.431	0.397
Adjusted R^2	0.261	0.298	0.288	0.260	0.363	0.392	0.404	0.368
QE (USD)	13.24	12.86	11.81	11.94	10.99[a]	10.37[a]	12.39[a]	12.05[a]

	Direct				Credit			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	−0.0017	−0.0027	0.0000	−0.0006	0.0432	0.0409	0.0783	0.0565
	−0.3462	−0.5506	−0.0082	−0.1299	0.5961	0.5519	1.0599	0.9022
QE	0.0001	0.0001	0.0001	0.0001	−0.0001	−0.0001	−0.0007	−0.0005
	1.2867	1.2655	0.8807	0.8006	−0.0558	−0.0559	−0.3283	−0.2564
CRISIS	−0.0190	−0.0183	−0.0240	−0.0193	−0.1604	−0.1514	−0.1301	−0.1226
	−1.1947	−1.1494	−1.3923	−1.2980	−0.6254	−0.5839	−0.4909	−0.5977
ROW		0.0256	0.0228	0.0241		0.0143	0.0055	−0.0113
		1.2314	1.0762	1.0642		0.1752	0.0681	−0.1497
R^2	0.836	0.838	0.842	0.819	0.408	0.409	0.418	0.363
Adjusted R^2	0.825	0.826	0.827	0.802	0.390	0.385	0.385	0.327
QE (USD)	0.55	0.56	0.43	0.38	−0.45	−0.45	−2.72	−1.86

Results from USA flows to Brazilian banking sector regression for aggregate flow categories. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy in the period.[a] 1%, [b] 5%,[c] 10 percent.

Table 4

FOREIGN CAPITAL FLOWS FROM THE USA TO BANKS, DETAIL

	Portfolio: Equity				*Portfolio: Debt*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.0016	−0.0669[c]	−0.1037[b]	−0.0755[b]	0.1036[a]	0.0937[a]	0.0838[a]	0.0690[a]
	0.0461	−1.7444	−2.0506	−1.9879	3.8071	3.4979	2.9765	3.0231
QE	0.0012	0.0002	0.0006	0.0006	0.0016[b]	0.0016[b]	0.0018[b]	0.0017[b]
	1.2461	0.2125	0.6266	0.6339	2.0912	2.1055	2.1868	2.2594
CRISIS	−0.4247[b]	−0.2287	−0.1956	−0.1643	−0.3843[a]	−0.3265[b]	−0.3352[b]	−0.2448[b]
	−2.3793	−1.4143	−1.1043	−1.2033	−3.3609	−2.5489	−2.4094	−2.1792
ROW		0.3783[a]	0.4049[a]	0.4106[a]		0.0305	0.0278	0.0447
		4.2291	4.8070	5.3168		1.1075	0.9866	1.5632
R^2	0.067	0.226	0.269	0.287	0.526	0.532	0.536	0.469
Adjusted R^2	0.052	0.207	0.240	0.258	0.515	0.518	0.514	0.443
QE (USD)	4.39	0.73	2.38	2.21	6.11[b]	6.17[b]	6.84[b]	6.54[b]

	Portfolio: Debt in the country				*Portfolio: Debt abroad*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.0732[a]	−0.0162	−0.0165	−0.0122	0.0228	0.0205	0.0171	0.0129
	3.3508	−1.3674	−1.3538	−1.2512	1.4887	1.2760	1.0192	0.8155
QE	0.0002	−0.0004	−0.0003	−0.0003	0.0007[b]	0.0007[b]	0.0008[b]	0.0007[c]
	0.4318	−1.2547	−1.1020	−1.1249	1.9820	2.0267	2.0664	1.9325
CRISIS	−0.1976[a]	−0.0065	−0.0114	−0.0151	−0.0990[c]	−0.0820	−0.0572	−0.0246
	−2.8363	−0.1739	−0.3099	−0.5296	−1.7998	−1.3325	−0.8850	−0.4611
ROW		1.1151[a]	1.1083[a]	1.0837[a]		0.0099	0.0131	0.0245[c]
		11.4810	10.6037	12.2958		0.8408	1.1485	1.7168
R^2	0.330	0.688	0.689	0.683	0.695	0.697	0.701	0.627
Adjusted R^2	0.309	0.676	0.671	0.665	0.683	0.682	0.682	0.603
QE (USD)	0.90	−1.37	−1.29	−1.18	2.72[b]	2.76[b]	2.86[b]	2.56[c]

Results from USA flows to Brazilian banking sector regressions for disaggregate flow categories. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table 5

FOREIGN CAPITAL FLOWS FROM THE USA, EACH EPISODE

	Total				*Portfolio*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.6640[a]	0.2581	0.4590	0.4583	0.2436	−0.0544	−0.1891	−0.0542
	2.7590	0.8913	1.4707	1.4337	1.2525	−0.2410	−0.8337	−0.2507
QE1	0.0143[c]	0.0125[c]	0.0124	0.0115	0.0170[b]	0.0144[c]	0.0164[b]	0.0146[b]
	1.8157	1.6653	1.6002	1.5276	2.0797	1.9520	2.1553	2.0257
QE2	0.0477[a]	0.0375[a]	0.0387[a]	0.0378[b]	0.0188[c]	0.0125	0.0138	0.0126
	4.1059	2.9966	2.6222	2.4072	1.7041	1.3076	1.5571	1.3959
QE3	0.0171[a]	0.0121[c]	0.0122[c]	0.0109	0.0081	0.0069	0.0093	0.0082
	2.8227	1.7925	1.8166	1.5610	1.2306	1.1569	1.5129	1.2455
CRISIS	−4.2571[a]	−3.7359[a]	−4.1898[a]	−3.4622[a]	−3.8162[a]	−2.7865[b]	−2.8188[b]	−2.2949[b]
	−3.7291	−3.3791	−3.4649	−3.5807	−3.0560	−2.4100	−2.2760	−2.3819
ROW		0.1106[c]	0.0786	0.0721		0.2199[a]	0.2275[a]	0.2192[a]
		1.9259	1.0510	0.8621		2.8229	2.9385	2.6453
R^2	0.392	0.411	0.419	0.407	0.159	0.215	0.237	0.191
Adjusted R^2	0.368	0.383	0.381	0.369	0.132	0.184	0.194	0.146
QE1 (USD)	22.46[c]	19.54[c]	19.45	18.00	26.55[b]	22.58[c]	25.71[b]	22.82[b]
QE2 (USD)	25.87[a]	20.34[a]	20.96[a]	20.48[b]	10.180[c]	6.792	7.455	6.843
QE3 (USD)	23.40[a]	16.47[c]	16.62[c]	14.93	11.05	9.43	12.67	11.15
QE (USD)	71.72[a]	56.34[a]	57.03[a]	53.41[a]	47.787[a]	38.799[b]	45.832[a]	40.817[b]

	Direct				Credit			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.3249[a]	0.2023[a]	0.1961[a]	0.1928[a]	0.0354	0.0126	0.1876	0.1177
	7.1759	4.7755	2.8603	3.4604	0.2044	0.0692	1.2245	0.8649
QE1	−0.0015	−0.0017	−0.0017	−0.0016	−0.0007	−0.0008	−0.0029[b]	−0.0024[b]
	−1.2376	−1.3973	−1.2811	−1.2732	−0.5270	−0.6242	−2.4187	−2.1451
QE2	0.0063[a]	0.0032	0.0031	0.0035	0.0216[b]	0.0206[b]	0.0187[c]	0.0186[b]
	4.3707	1.3699	1.3981	1.5748	2.3318	2.1382	1.8799	1.9895
QE3	0.0069[a]	0.0045[a]	0.0045[a]	0.0042[b]	0.0000	−0.0001	−0.0030	−0.0028
	3.6840	2.6512	2.7058	2.5006	0.0064	−0.0285	−0.6361	−0.5856
CRISIS	−0.2878	−0.3081	−0.3092	−0.2802	−0.1450[b]	−0.1075	−0.2878	−0.2464[c]
	−1.0574	−1.1765	−1.1232	−1.2233	−2.1092	−1.0386	−1.6221	−1.6649
ROW		0.0592[a]	0.0607[a]	0.0540[a]		0.1011	0.0468	0.0335
		3.1106	3.2939	3.0813		0.9439	0.4529	0.2754
R^2	0.795	0.816	0.816	0.751	0.522	0.525	0.561	0.602
Adjusted R^2	0.785	0.805	0.802	0.732	0.503	0.502	0.533	0.576
QE1 (USD)	−2.34	−2.72	−2.65	−2.48	−1.06	−1.28	−4.57[b]	−3.77[b]
QE2 (USD)	3.42[a]	1.71	1.69	1.89	11.727[b]	11.144[b]	10.110[c]	10.061[b]
QE3 (USD)	9.45[a]	6.19[a]	6.19[a]	5.80[b]	0.05	−0.19	−4.14	−3.86
QE (USD)	10.52[a]	5.19	5.22	5.21	10.711	9.677	1.397	2.437

Results from USA flows to Brazil regressions for aggregate flow categories and each policy round. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy round in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table 6

FOREIGN CAPITAL FLOWS FROM THE USA, EACH EPISODE, DETAIL

	Direct: Equity capital				*Direct: Affiliated enterprise loans*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.2469[a]	0.1518[a]	0.1811[a]	0.1723[a]	0.0005	0.0086	0.0222	0.0525
	7.2137	4.8430	3.4531	4.0105	0.0066	0.1078	0.3186	0.7209
QE1	−0.0014	−0.0014	−0.0016	−0.0015	0.0034[a]	0.0032[a]	0.0030[a]	0.0027[b]
	−1.2106	−1.1669	−1.2776	−1.2427	3.7234	3.0371	2.7980	2.3873
QE2	0.0017[c]	−0.0003	−0.0002	0.0000	−0.0001	0.0006	0.0005	0.0001
	1.9263	−0.2229	−0.1337	0.0331	−0.0519	0.2086	0.1695	0.0220
QE3	0.0035[a]	0.0026[a]	0.0025[a]	0.0022[a]	0.0059[a]	0.0056[a]	0.0053[a]	0.0047[b]
	5.4086	3.4301	3.1957	2.8279	3.3748	3.0086	2.6897	2.0722
CRISIS	−0.4787[b]	−0.4889[b]	−0.4931[b]	−0.4308[b]	−0.2440[c]	−0.2938[c]	−0.3198[c]	−0.2993[c]
	−2.3817	−2.3596	−2.2378	−2.2948	−1.9496	−1.8951	−1.7068	−1.8420
ROW		0.0572[a]	0.0481[a]	0.0408[b]		−0.0410	−0.0462	−0.0523
		3.6359	2.7474	2.2826		−0.5581	−0.6170	−0.6170
R^2	0.610	0.643	0.645	0.578	0.503	0.505	0.505	0.534

Adjusted R^2	0.595	0.626	0.622	0.550	0.479	0.477	0.469	0.500
QE1 (USD)	−2.16	−2.18	−2.50	−2.28	5.35[a]	4.97[a]	4.68[a]	4.20[b]
QE2 (USD)	0.93[c]	−0.15	−0.08	0.02	−0.08	0.35	0.29	0.04
QE3 (USD)	4.78[a]	3.56[a]	3.41[a]	3.02[a]	8.09[a]	7.60[a]	7.23[a]	6.39[b]
QE (USD)	3.55	1.23	0.82	0.76	13.36[a]	12.92[a]	12.20[a]	10.63[b]

	Portfolio: Equity				*Portfolio: Debt*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	−0.0115	−0.2172	−0.3687[c]	−0.2512	0.3279[b]	0.2246[c]	0.2099	0.2211
	−0.0773	−1.3392	−1.7078	−1.5417	2.4714	1.6675	1.4176	1.5548
QE1	0.0087	0.0046	0.0058	0.0042	0.0078[a]	0.0089[a]	0.0097[a]	0.0091[a]
	1.6433	0.8843	1.0454	0.8719	2.7615	2.9920	2.9232	2.6725
QE2	0.0161[b]	0.0131[a]	0.0149[a]	0.0140[a]	0.0019	−0.0015	−0.0011	−0.0015
	2.4807	2.7168	3.1661	3.3266	0.6369	−0.5224	−0.3741	−0.4355
QE3	−0.0071	−0.0090	−0.0069	−0.0074	0.0101[b]	0.0106[b]	0.0111[b]	0.0103[c]
	−1.3128	−1.6097	−1.0869	−1.1818	2.0946	2.2536	2.1734	1.8128
CRISIS	−2.3760[b]	−1.6745[c]	−1.4266	−1.0540	−1.4499[a]	−1.0829[a]	−1.3201[a]	−1.1489[a]
	−2.4327	−1.7516	−1.3858	−1.3704	−4.4390	−3.1063	−3.3580	−3.4223

ROW		0.2372[a]	0.2626[a]	0.2659[a]		0.2128[b]	0.1844[b]	0.1684[c]
		2.9519	3.3343	3.4777		2.1948	2.0336	1.9339
R^2	0.163	0.236	0.275	0.271	0.356	0.384	0.401	0.361
Adjusted R^2	0.136	0.205	0.234	0.230	0.326	0.349	0.356	0.314
QE1 (USD)	13.54	7.24	9.07	6.61	12.17[a]	13.98[a]	15.11[a]	14.30[a]
QE2 (USD)	8.716[b]	7.105[a]	8.058[a]	7.611[a]	1.039	−0.799	−0.597	−0.795
QE3 (USD)	−9.69	−12.33	−9.45	−10.13	13.80[b]	14.48[b]	15.22[b]	14.05[c]
QE (USD)	12.562	2.007	7.671	4.096	27.015[a]	27.653[a]	29.737[a]	27.550[a]

	Portfolio: Debt in the country				*Portfolio: Debt abroad*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.3691[a]	0.0865	0.0910	0.0855	0.0005	0.0086	0.0222	0.0525
	4.3887	0.8655	0.8565	0.9343	0.0066	0.1078	0.3186	0.7209
QE1	0.0041	0.0037	0.0040	0.0037	0.0034[a]	0.0032[a]	0.0030[a]	0.0027[b]
	1.5777	1.3092	1.3002	1.2468	3.7234	3.0371	2.7980	2.3873
QE2	0.0016	0.0048[b]	0.0045[b]	0.0044[b]	−0.0001	0.0006	0.0005	0.0001
	0.4756	2.4654	2.4707	2.4584	−0.0519	0.2086	0.1695	0.0220

QE3	0.0021	−0.0019	−0.0016	−0.0017	0.0059[a]	0.0056[a]	0.0053[a]	0.0047[b]
	0.3620	−0.4719	−0.3580	−0.3781	3.3748	3.0086	2.6897	2.0722
CRISIS	−1.2115[a]	−0.7328[b]	−0.8423[b]	−0.7029[b]	−0.2440[c]	−0.2938[c]	−0.3198[c]	−0.2993[c]
	−3.4594	−2.1334	−2.2086	−2.1885	−1.9496	−1.8951	−1.7068	−1.8420
ROW		0.9321[a]	0.9221[a]	0.9032[a]		−0.0410	−0.0462	−0.0523
		6.3642	6.2798	6.3200		−0.5581	−0.6170	−0.6170
R^2	0.298	0.519	0.527	0.511	0.503	0.505	0.505	0.534
Adjusted R^2	0.264	0.492	0.492	0.475	0.479	0.477	0.469	0.500
QE1 (USD)	6.35	5.84	6.20	5.84	5.35[a]	4.97[a]	4.68[a]	4.20[b]
QE2 (USD)	0.871	2.579[b]	2.417[b]	2.386[b]	−0.077	0.348	0.288	0.041
QE3 (USD)	2.84	−2.53	−2.24	−2.33	8.09[a]	7.60[a]	7.23[a]	6.39[b]
QE (USD)	10.059	5.890	6.376	5.900	13.362[a]	12.921[a]	12.199[a]	10.631[b]

Results from USA flows to Brazil regressions for disaggregate flow categories and each policy round. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy round in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table 7

FOREIGN CAPITAL FLOWS FROM THE USA TO BANKS, EACH EPISODE

	Total				Portfolio			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
C	0.1992[c]	0.1343	0.1620	0.1328	0.1115[b]	0.0750[c]	0.0410	0.0427
	1.8246	1.6412	1.4873	1.4737	2.2984	1.7961	0.9317	1.1839
QE1	0.0029[c]	0.0031	0.0027	0.0025	0.0040[b]	0.0041[b]	0.0046[a]	0.0043[a]
	1.6606	1.4657	1.1818	1.1931	2.3588	2.5502	2.7986	2.8284
QE2	0.0150[a]	0.0123[a]	0.0122[b]	0.0123[a]	0.0053[b]	0.0036	0.0041[c]	0.0034
	2.6263	2.6839	2.2821	2.8213	2.2961	1.5131	1.8059	1.4637
QE3	0.0000	0.0006	0.0001	−0.0001	0.0007	0.0010	0.0016	0.0014
	−0.0113	0.2660	0.0477	−0.0194	0.3652	0.5451	0.8744	0.7298
CRISIS	−1.2835[a]	−1.0469[a]	−1.0606[a]	−0.8446[a]	−0.9473[a]	−0.8039[a]	−0.7754[a]	−0.5882[a]
	−5.3645	−3.5177	−3.7858	−3.9288	−3.8637	−3.5463	−3.1953	−3.1564
ROW		0.0909	0.0870	0.0874[b]		0.0732[c]	0.0740[c]	0.0941[b]
		1.4664	1.5274	1.9973		1.9742	1.8930	2.3697
R^2	0.331	0.347	0.350	0.324	0.409	0.431	0.450	0.413
Adjusted R^2	0.305	0.316	0.308	0.280	0.386	0.403	0.414	0.375
QE1 (USD)	4.53[c]	4.81	4.20	3.98	6.25[b]	6.44[b]	7.15[a]	6.68[a]
QE2 (USD)	8.13[a]	6.67[a]	6.59[b]	6.65[a]	2.861[b]	1.943	2.203[c]	1.868
QE3 (USD)	−0.05	0.87	0.19	−0.08	0.91	1.32	2.16	1.85
QE (USD)	12.61[c]	12.35[b]	10.98	10.56	10.020[b]	9.696[b]	11.518[a]	10.397[a]

	Direct				Credit			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
C	−0.0025	−0.0036	−0.0009	−0.0016	0.0420	0.0425	0.0843	0.0613
	−0.5087	−0.7553	−0.1899	−0.4013	0.6047	0.5975	1.1210	0.9643
QE1	−0.0001	−0.0001	−0.0001	−0.0001	−0.0011[b]	−0.0011[c]	−0.0018[a]	−0.0016[b]
	−0.7875	−0.7599	−0.9597	−0.9284	−1.9853	−1.9653	−2.6534	−2.4263
QE2	0.0007	0.0007[c]	0.0006	0.0006	0.0097[a]	0.0097[a]	0.0095[a]	0.0097[a]
	1.5837	1.7393	1.3995	1.3919	2.9381	2.9182	2.9220	3.2024
QE3	0.0002	0.0002	0.0001	0.0001	−0.0028	−0.0028	−0.0036	−0.0036
	1.3055	1.3390	1.0179	1.0722	−0.6820	−0.6781	−0.8659	−0.8618
CRISIS	0.0106	0.0126	0.0060	0.0047	−0.0500	−0.0519	−0.0107	−0.0126
	0.9549	0.9487	0.4544	0.4200	−1.2455	−0.8981	−0.1145	−0.1692
ROW		0.0278	0.0245	0.0256		−0.0032	−0.0146	−0.0291
		1.3572	1.2114	1.1892		−0.0439	−0.1988	−0.3961
R^2	0.844	0.847	0.850	0.827	0.459	0.459	0.473	0.420
Adjusted R^2	0.831	0.833	0.833	0.808	0.433	0.429	0.434	0.377
QE1 (USD)	−0.10	−0.12	−0.15	−0.14	−1.64[b]	−1.65[b]	−2.80[a]	−2.51[b]
QE2 (USD)	0.37	0.37[c]	0.34	0.35	5.263[a]	5.270[a]	5.164[a]	5.258[a]
QE3 (USD)	0.23	0.24	0.18	0.20	−3.76	−3.77	−4.87	−4.93
QE (USD)	0.49	0.50	0.38	0.40	−0.142	−0.143	−2.510	−2.185

Results from USA flows to Brazilian banking sector regressions for aggregate flow categories and each policy round. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy round in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table 8

FOREIGN CAPITAL FLOWS FROM THE USA TO BANKS, EACH EPISODE, DETAIL

	Portfolio: Equity				Portfolio: Debt			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.0084	−0.0579[c]	−0.0932[b]	−0.0659[c]	0.1033[a]	0.0894[b]	0.0793[b]	0.0657[b]
	0.2709	−1.7169	−1.9924	−1.8284	2.8893	2.5504	2.1951	2.0894
QE1	0.0024[c]	0.0011	0.0014	0.0011	0.0016[b]	0.0018[b]	0.0019[b]	0.0020[a]
	1.7632	0.9375	1.1117	0.8801	2.2172	2.3853	2.5625	2.8106
QE2	0.0041[b]	0.0033[a]	0.0037[a]	0.0035[a]	0.0012	0.0002	0.0004	0.0000
	2.4926	3.2607	3.6908	3.8418	1.3619	0.1805	0.3322	−0.0297
QE3	−0.0013	−0.0019[b]	−0.0014	−0.0015	0.0019	0.0022	0.0023	0.0023
	−1.3513	−1.9948	−1.3142	−1.3737	1.0215	1.1770	1.2280	1.1753
CRISIS	−0.5768[a]	−0.3491[c]	−0.3000	−0.2199	−0.3704[a]	−0.3114[a]	−0.3163[a]	−0.2455[a]
	−2.7746	−1.8276	−1.4339	−1.3532	−5.2557	−4.4273	−4.1900	−3.8082
ROW		0.3555[a]	0.3824[a]	0.3878[a]		0.0448	0.0421	0.0607
		4.6118	5.1763	5.3988		1.2748	1.1732	1.6291
R^2	0.175	0.313	0.351	0.352	0.527	0.538	0.541	0.477
Adjusted R^2	0.149	0.286	0.315	0.316	0.509	0.516	0.511	0.443
QE1 (USD)	3.81[c]	1.79	2.25	1.66	2.43[b]	2.80[b]	3.05[b]	3.19[a]
QE2 (USD)	2.231[b]	1.803[a]	2.022[a]	1.915[a]	0.628	0.120	0.226	−0.021
QE3 (USD)	−1.83	−2.61[b]	−1.92	−2.04	2.62	2.95	3.21	3.10
QE (USD)	4.212	0.980	2.352	1.533	5.685[c]	5.871[b]	6.484[b]	6.269[b]

	Portfolio: Debt in the country				*Portfolio: Debt abroad*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.0739[a]	−0.0169	−0.0169	−0.0120	0.0202	0.0195	0.0155	0.0103
	2.8766	−1.2961	−1.2732	−1.1300	1.2891	1.1674	0.9085	0.6479
QE1	0.0004	−0.0002	−0.0002	−0.0002	0.0001	0.0001	0.0001	0.0002
	1.2008	−1.2864	−1.1995	−1.3992	0.4674	0.4937	0.4479	0.7538
QE2	−0.0002	0.0001	0.0001	0.0000	0.0015[a]	0.0014[b]	0.0014[b]	0.0011
	−0.3728	0.3825	0.3162	0.1245	3.0436	2.3822	2.3145	1.4364
QE3	0.0002	−0.0007	−0.0007	−0.0007	0.0010	0.0010	0.0011	0.0011
	0.2251	−1.0035	−0.9404	−0.8763	1.4884	1.4820	1.5737	1.5183
CRISIS	−0.2221[a]	−0.0211	−0.0255	−0.0240	−0.0222	−0.0184	0.0119	0.0220
	−4.7935	−0.7677	−0.9502	−1.1672	−0.6032	−0.4521	0.2553	0.5030
ROW		1.1323[a]	1.1270[a]	1.0953[a]		0.0034	0.0068	0.0213
		10.586	9.784	11.392		0.2298	0.4707	1.2323
R^2	0.332	0.693	0.693	0.686	0.702	0.702	0.708	0.632
Adjusted R^2	0.300	0.675	0.670	0.663	0.685	0.683	0.684	0.601
QE1 (USD)	0.70	−0.38	−0.35	−0.37	0.18	0.21	0.21	0.36
QE2 (USD)	−0.110	0.040	0.038	0.015	0.792[a]	0.753[b]	0.769[b]	0.597
QE3 (USD)	0.31	−1.02	−1.00	−0.95	1.36	1.39	1.49	1.55
QE (USD)	0.899	−1.354	−1.309	−1.299	2.332[b]	2.356[b]	2.470[b]	2.511[b]

Results from USA flows to Brazilian banking sector regressions for disaggregate flow categories and each policy round. Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last row shows the total effect of QE policy round in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table 9

FOREIGN CAPITAL FLOWS FROM THE USA

(Panel data: 17 EME)

	Portfolio: Total				*Portfolio: Equity*				*Portfolio: Debt*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
QE	0.0025[a]	0.0017[a]	0.0021[a]	0.0020[a]	0.0016[a]	0.0013[b]	0.0015[a]	0.0016[a]	0.0008[c]	0.0003	0.0005	0.0053
	3.9116	2.8019	3.1814	3.5073	3.3868	2.8259	3.1434	3.5192	1.8660	0.8119	1.0248	1.3171
CRISIS	−1.4386[a]	−0.5167	−0.5402	−0.6239	−0.833[a]	−0.4464	−0.5392c	−0.5184	−0.6191[b]	0.0085	0.0807	−0.0484
	−3.8858	−1.2941	−1.3008	median	−2.9605	−1.6007	−1.8620	median	−2.3337	0.0334	0.3117	median
TOT		0.1279[a]	0.1291[a]	0.0716		0.1400[a]	0.1381[a]	0.0426		0.1340[a]	0.1377[a]	0.1521
		3.9539	4.0068	median		3.1002	3.0592	median		4.8664	5.0090	median
R^2	0.052	0.132	0.137	0.312	0.027	0.094	0.099	0.194	0.044	0.138	0.141	0.299
Adjusted R^2	0.050	0.127	0.131	0.269	0.026	0.090	0.095	0.167	0.042	0.133	0.136	0.257
QE (%)	79.92[a]	55.57[a]	65.60[a]	64.69[a]	74.15[a]	60.05[a]	70.10[a]	74.32[a]	85.59[b]	35.38	46.54	54.28
QE (USD)	158.64[a]	111.22[a]	131.29[a]	129.47[a]	102.39[a]	82.93[b]	96.81[a]	102.62[a]	53.10[b]	21.95	28.87	33.67

Results from USA portfolio flows (TIC data) to 17 emerging market economies. Proxy variable TOT is the country specific residual of total flows (IFS data) regressed on QE policy. QE policy is the change in Federal Reserve balance sheet. All regressions allow for heterogeneous intercepts. Column (1) omits the TOT proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown) and (4) allows heterogeneity in all coefficients except QE effect. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from White robust standard errors. All results robust to generated regressors, as verified by bootstrapping the TOT regression. The last row show the total global effect of QE policy in the period as a percentage of USA portfolio flows to the countries in the sample and in dollars.[a] 1%,[b] 5%,[c] 10 percent.

ANNEX

The following tables report additional results for Brazil's capital flow dataset. The tables here follow the same structure as Tables 5-8. The only difference is that we now include own lag of the dependent variable as control, as well as dummy variables representing the duration of the capital flow taxes on debt flow, equity flows except American depositary receipts (ADR) and ADR flows. To facilitate cross-referencing with the tables in the main text, we number the tables from hereon as A.5 to A.8. As mentioned in the results section of the main text, results with the additional controls are broadly consistent with the ones without such controls. Yet, some effects are no longer significant, particularly for foreign direct investment and credit flows.

For portfolio flows, QE3 gains importance relative to the QE1, particularly for portfolio flows.

Table A.5

FOREIGN CAPITAL FLOWS FROM THE USA, EACH EPISODE, WITH OWN LAG AND IOF CONTROLS

	Total				*Portfolio*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.3564	0.2071	0.4707	0.5206	0.3173	0.1152	0.3009	0.3987
	1.2373	0.6807	1.3311	1.4772	1.4932	0.4728	0.9140	1.2272
QE1	0.0138[b]	0.0125[b]	0.0110[c]	0.0092	0.0141[b]	0.0122[c]	0.0116	0.0095
	2.2512	1.9840	1.6605	1.4642	2.0345	1.7330	1.5153	1.3467
QE2	0.0327[b]	0.0296[b]	0.0320[b]	0.0314[c]	0.0152[c]	0.0128	0.0146[c]	0.0144[c]
	2.3509	2.2148	2.0807	1.9304	1.7125	1.6549	1.8267	1.7308
QE3	0.0221a	0.0209b	0.0235b	0.0240b	0.0245[a]	0.0236[a]	0.0257[a]	0.0260[a]
	2.7160	2.4512	2.4376	2.3092	3.1547	3.3681	3.5590	3.4131
CRISIS	−3.7014[a]	−3.4682[a]	−3.8327[a]	−3.1277[a]	−3.4654[a]	−2.7112[b]	−3.1155[b]	−2.5519[b]
	−3.8967	−3.4711	−3.4508	−3.6900	−2.9659	−2.2938	−2.4355	−2.5623
ROW		0.0622	0.0542	0.0512		0.2078[a]	0.1959[a]	0.1893[b]
		0.8861	0.7234	0.6649		2.8846	2.6466	2.5244
R^2	0.433	0.437	0.442	0.434	0.235	0.279	0.289	0.235
Adjusted R^2	0.391	0.390	0.385	0.377	0.184	0.226	0.223	0.165
QE1 (USD)	21.61[b]	19.57[b]	17.23[c]	14.35	22.08[b]	19.08[c]	18.08	14.91
QE2 (USD)	17.70[b]	16.02[b]	17.33[b]	17.01[c]	8.219[c]	6.942[c]	7.920[c]	7.792[c]
QE3 (USD)	30.16[a]	28.59[b]	32.13[b]	32.85[b]	33.48[a]	32.30[a]	35.16[a]	35.52[a]
QE (USD)	69.46[a]	64.18[a]	66.68[a]	64.21[a]	63.784[a]	58.322[a]	61.163[a]	58.221[a]
IOF (USD)	23.98	11.43	−11.22	−27.55	−30.57[c]	−40.23[b]	−58.00[b]	−71.48[b]

	Direct				Credit			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
C	0.2482[a]	0.1842[a]	0.1184	0.1251[c]	−0.1759	−0.1795	0.0112	−0.0069
	6.6048	4.7608	1.4605	1.7637	−0.9569	−0.9416	0.1093	−0.0767
QE1	−0.0009	−0.0013	−0.0008	−0.0008	0.0004	0.0004	−0.0015	−0.0013
	−0.6962	−0.9854	−0.5190	−0.5421	0.3206	0.2972	−1.3467	−1.1885
QE2	0.0051[a]	0.0037	0.0032	0.0034	0.0117	0.0115	0.0129	0.0130
	2.8463	1.6084	1.3254	1.3554	1.0814	1.0434	1.2089	1.3339
QE3	0.0032	0.0025	0.0018	0.0013	0.0007	0.0008	0.0023	0.0026
	1.3789	1.1836	0.8563	0.5565	0.1893	0.2016	0.5192	0.5479
CRISIS	−0.2917	−0.3221	−0.2730	−0.2375	−0.0390	−0.0297	−0.1126	−0.1037
	−1.0499	−1.2001	−0.9647	−1.0103	−0.3617	−0.2497	−0.6809	−0.6895
ROW		0.0488[b]	0.0521[a]	0.0478[a]		0.0282	0.0178	0.0136
		2.4306	2.7296	2.7274		0.2925	0.1801	0.1064
R^2	0.813	0.821	0.823	0.759	0.604	0.604	0.610	0.643
Adjusted R^2	0.797	0.805	0.803	0.732	0.575	0.571	0.570	0.607
QE1 (USD)	−1.38	−2.01	−1.21	−1.20	0.68	0.60	−2.34	−2.10
QE2 (USD)	2.77[a]	2.01	1.71	1.82	6.330	6.209	6.965	7.023
QE3 (USD)	4.34	3.37	2.48	1.71	0.98	1.04	3.09	3.55
QE (USD)	5.73	3.37	2.98	2.33	7.996	7.851	7.711	8.470
iof (USD)	12.35[a]	5.12	10.94	12.97	24.88[b]	24.41[b]	7.15	5.72

Results from USA flows to Brazil regressions for aggregate flow categories and each policy round. All regressions include own lag of USA flows and dummy variables indicating a tax on capital flow tax for some category, including American Depositary Receipts (coefficients not shown; total effect of IOF last row). Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. *t*-values below coefficient estimates are from HAC standard errors. The last rows show the total effect of QE policy round in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table A.6

FOREIGN CAPITAL FLOWS FROM THE USA, EACH EPISODE, DETAIL, WITH OWN LAG AND IOF CONTROLS

	Direct: Equity capital				*Direct: Affiliated enterprise loans*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.2200[a]	0.1791[a]	0.1679[b]	0.1665[a]	0.0631[a]	0.0466[b]	0.0050	0.0056
	6.4059	4.9433	2.5224	2.9584	3.1774	2.2303	0.0910	0.1086
QE1	−0.0015	−0.0016	−0.0015	−0.0015	0.0000	−0.0003	0.0001	0.0001
	−1.1789	−1.2161	−1.0807	−1.1161	−0.0134	−0.7649	0.1744	0.2613
QE2	0.0002	−0.0003	−0.0004	−0.0003	0.0050[a]	0.0041[a]	0.0038[b]	0.0039[b]
	0.2062	−0.2726	−0.3521	−0.2372	4.2143	2.9652	2.5882	2.5186
QE3	0.0018	0.0019	0.0018	0.0017	0.0000	−0.0008	−0.0012	−0.0014
	1.0096	1.0587	0.9778	0.9075	0.0074	−0.5871	−0.8882	−1.0713
CRISIS	−0.4497[a]	−0.4678[b]	−0.4477[a]	−0.3998[b]	0.1830[a]	0.1723[b]	0.1935[b]	0.1649[a]
	−1.9699	−2.0484	−1.8886	−2.0251	1.6681	2.1568	2.1568	1.9614
ROW		0.0372[b]	0.0374[a]	0.0337[a]		0.0612[b]	0.0636[b]	0.0557[a]
		1.9822	1.9698	1.8447		2.0106	2.1294	1.7961
R^2	0.650	0.658	0.659	0.592	0.919	0.923	0.925	0.882
Adjusted R^2	0.623	0.630	0.624	0.550	0.912	0.916	0.916	0.869
QE1 (USD)	−2.38	−2.50	−2.41	−2.31	−0.01	−0.49	0.13	0.19

QE2 (USD)	0.12	−0.19	−0.24	−0.16	2.69[a]	2.24[a]	2.07[a]	2.13[b]
QE3 (USD)	2.46	2.60	2.45	2.31	0.01	−1.04	−1.61	−1.93
QE (USD)	0.21	−0.09	−0.20	−0.16	2.69	0.71	0.59	0.39
IOF (USD)	11.88[a]	7.43	8.56	7.65	3.49[a]	1.42	5.31	6.70

	Portfolio: Equity				*Portfolio: Debt*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.0812	−0.0803	−0.3884	−0.2567	0.3007[b]	0.2421[a]	0.4635[a]	0.4627[b]
	0.5317	−0.4858	−1.1271	−0.8839	2.4815	1.9636	2.6746	2.4824
QE1	0.0070	0.0034	0.0058	0.0044	0.0063[a]	0.0074[a]	0.0063[b]	0.0057[a]
	1.4774	0.6755	1.0399	0.8544	2.8057	2.8823	2.1223	1.7494
QE2	0.0128[b]	0.0120[a]	0.0100[a]	0.0103[a]	0.0013	−0.0006	0.0015	0.0015
	2.0086	2.7003	1.8602	1.8525	0.4027	−0.1785	0.3828	0.3469
QE3	0.0085	0.0056	0.0029	0.0023	0.0106	0.0118[a]	0.0145[b]	0.0150[b]
	1.0789	0.7042	0.3576	0.2823	1.4979	1.7045	2.2641	2.2648
CRISIS	−2.2171[b]	−1.6209[a]	−1.3817	−1.0818	−1.2233[a]	−0.9367[a]	−1.3452[a]	−1.1974[a]
	−2.3757	−1.7823	−1.4529	−1.4390	−4.6689	−3.3151	−4.0735	−3.8036
ROW		0.2303[a]	0.2461[a]	0.2520[a]		0.1944[b]	0.1772[b]	0.1676[a]
		3.0173	3.0292	3.1898		2.0280	1.9998	1.8451

	Portfolio: Equity				*Portfolio: Debt*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
R^2	0.235	0.299	0.316	0.304	0.401	0.422	0.440	0.395
Adjusted R^2	0.185	0.247	0.253	0.239	0.351	0.369	0.378	0.328
QE1 (USD)	11.01	5.25	9.02	6.81	9.84[a]	11.59[a]	9.80[b]	8.94[a]
QE2 (USD)	6.949[b]	6.517[a]	5.442[a]	5.563[a]	0.729	−0.342	0.820	0.817
QE3 (USD)	11.64	7.67	3.92	3.17	14.48	16.14[a]	19.85[b]	20.54[b]
QE (USD)	29.601[b]	19.434	18.380	15.545	25.048[b]	27.389[a]	30.471[a]	30.295[a]
IOF (USD)	−30.42[b]	−35.20[b]	−7.43	−9.29	−3.58	−7.95	−29.16[b]	−37.09[b]

	Portfolio: Debt in the country				*Portfolio: Debt abroad*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.2308[a]	0.0466	0.1925[a]	0.1511	−0.0053	−0.0056	0.0644	0.1465
	3.0514	0.8189	1.6589	1.6009	−0.0493	−0.0539	0.4430	0.9233
QE1	0.0025	0.0026	0.0018	0.0018	0.0034[a]	0.0032[a]	0.0026[a]	0.0018
	1.1975	1.1134	0.7103	0.7297	3.3976	2.9565	1.7562	1.0419
QE2	−0.0005	0.0010	0.0022	0.0020	0.0006	0.0010	0.0015	0.0018
	−0.2240	0.5172	1.0366	0.9143	0.2148	0.3597	0.5059	0.5788
QE3	0.0023	0.0014	0.0030	0.0030	0.0042[b]	0.0038[a]	0.0045[a]	0.0047
	0.7894	0.4331	0.8892	0.8456	2.1698	1.8493	1.7675	1.6447

CRISIS	−0.7750[b]	−0.5265[a]	−0.7300[b]	−0.5940[b]	−0.2388[a]	−0.2805[a]	−0.3343	−0.3388[a]
	−2.0235	−1.6849	−2.0837	−2.0586	−1.7968	−1.7768	−1.5984	−1.8237
ROW		0.7062[a]	0.6893[a]	0.6908[a]		−0.0382	−0.0363	−0.0350
		4.0659	4.1426	4.6242		−0.4875	−0.4655	−0.3944
R^2	0.507	0.607	0.616	0.599	0.508	0.509	0.511	0.540
Adjusted R^2	0.465	0.570	0.573	0.555	0.467	0.464	0.456	0.488
QE1 (USD)	3.98	4.14	2.76	2.75	5.36[a]	5.06[a]	4.11[a]	2.81
QE2 (USD)	−0.262	0.547	1.184	1.075	0.299	0.538	0.807	0.971
QE3 (USD)	3.18	1.89	4.04	4.10	5.71[b]	5.22[a]	6.11[a]	6.49
QE (USD)	6.899	6.574	7.982	7.929	11.371[a]	10.816[a]	11.028[a]	10.273[b]
IOF (USD)	−6.361	−3.466	−16.984	−16.804	2.925	4.048	−2.691	−11.850

Results from USA flows to Brazil regressions for disaggregate flow categories and each policy round. All regressions include own lag of USA flows and dummy variables indicating a tax on capital flow tax for some category, including American Depositary Receipts (coefficients not shown; total effect of IOF last row). Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. Outlier dummy variable included for USA flows greater than four standard deviations (coefficients not shown). *t*-values below coefficient estimates are from HAC standard errors. The last rows show the total effect of QE policy round in the period.[a] 1%, [b] 5%, [c] 10 percent.

Table A.7

FOREIGN CAPITAL FLOWS FROM THE USA TO BANKS, EACH EPISODE, WITH OWN LAG AND IOF CONTROLS

	Total				*Portfolio*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.0975	0.0617	0.0378	0.0210	0.1321[a]	0.1096[b]	0.0800	0.0684
	1.1284	0.7733	0.3461	0.2429	2.7792	2.5146	1.2371	1.2249
QE1	0.0026[b]	0.0027[b]	0.0028[c]	0.0028[c]	0.0034[b]	0.0035[b]	0.0038[b]	0.0036[b]
	2.3541	2.0056	1.7407	1.9435	2.3787	2.5101	2.5082	2.5292
QE2	0.0081	0.0065	0.0063	0.0063	0.0043[c]	0.0032	0.0030	0.0023
	1.2013	0.9878	0.8734	0.9273	1.9286	1.3934	1.2531	0.9265
QE3	0.0066	0.0075[c]	0.0073[c]	0.0066	0.0056[a]	0.0058[a]	0.0056[a]	0.0052[a]
	1.6270	1.9479	1.6728	1.4848	3.0071	3.2397	2.9859	2.7231
CRISIS	−1.0249[a]	−0.8622[a]	−0.8161[a]	−0.6352[a]	−0.8867[a]	−0.7878[a]	−0.7711[a]	−0.5729[a]
	−5.6101	−3.6229	−3.4114	−3.7707	−3.7323	−3.2983	−3.0414	−2.9468
ROW		0.0672	0.0686	0.0654		0.0635[c]	0.0620[c]	0.0819[b]
		1.1804	1.2428	1.3718		1.8504	1.7111	2.2425
R^2	0.436	0.444	0.445	0.428	0.478	0.493	0.494	0.450
Adjusted R^2	0.394	0.398	0.388	0.369	0.439	0.450	0.442	0.394
QE1 (USD)	4.14[b]	4.24[b]	4.42[c]	4.41[c]	5.26[b]	5.52[b]	5.95[b]	5.58[b]
QE2 (USD)	4.41	3.51	3.39	3.40	2.305[c]	1.733	1.630	1.264
QE3 (USD)	9.03	10.24[c]	9.96[c]	8.96	7.70[a]	7.99[a]	7.61[a]	7.15[a]
QE (USD)	17.57[a]	17.99[a]	17.77[a]	16.77[b]	15.261[a]	15.236[a]	15.188[a]	13.999[a]
IOF (USD)	−0.06	−1.80	0.76	1.25	−8.66[b]	−9.49[b]	−6.63	−6.64

	Direct				*Credit*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	−0.0048	−0.0055	0.0003	0.0003	−0.0049	−0.0021	−0.0345	−0.0338
	−0.8065	−0.9688	0.0468	0.0521	−0.0674	−0.0292	−0.4270	−0.4909
QE1	0.0000	0.0000	−0.0001	−0.0001	−0.0005	−0.0005	−0.0005	−0.0003
	−0.2099	−0.5297	−0.7296	−0.8483	−0.8523	−0.8157	−0.5508	−0.3090
QE2	0.0008	0.0008	0.0008	0.0008	0.0068	0.0070	0.0068	0.0070
	1.4965	1.6041	1.6338	1.5527	1.1043	1.0881	1.0770	1.1491
QE3	−0.0003[b]	−0.0003[b]	−0.0002	−0.0002	−0.0004	−0.0006	−0.0010	−0.0015
	−2.4596	−2.4740	−1.6358	−1.3387	−0.1195	−0.1692	−0.2911	−0.4296
CRISIS	0.0070	0.0087	−0.0001	−0.0003	−0.0382	−0.0520	0.0451	0.0202
	0.9949	0.9221	−0.0087	−0.0278	−0.5849	−0.6041	0.3939	0.1964
ROW		0.0318	0.0309	0.0309		−0.0211	−0.0219	−0.0421
		1.3612	1.3492	1.3551		−0.2835	−0.2923	−0.5590
R^2	0.852	0.855	0.857	0.833	0.539	0.539	0.544	0.507
Adjusted R^2	0.834	0.836	0.835	0.808	0.500	0.497	0.493	0.452
QE1 (USD)	−0.03	−0.08	−0.12	−0.15	−0.83	−0.81	−0.77	−0.44
QE2 (USD)	0.41	0.43	0.45	0.46	3.712	3.794	3.669	3.817
QE3 (USD)	−0.42[b]	−0.43[b]	−0.34	−0.31	−0.55	−0.81	−1.38	−2.10
QE (USD)	−0.04	−0.08	−0.01	−0.01	2.337	2.173	1.525	1.278
IOF (USD)	0.88[c]	0.85[c]	0.24	0.14	1.03	1.24	5.11	5.72

Results from USA flows to Brazil bank sector for aggregate flow categories and each policy round. All regressions include own lag of USA flows and dummy variables indicating a tax on capital flow tax for some category, including American Depositary Receipts (coefficients not shown; total effect of IOF last row). Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. *t*-values below coefficient estimates are from HAC standard errors. The last rows show the total effect of QE policy round in the period. [a] 1%, [b] 5%, [c] 10 percent.

Table A.8

FOREIGN CAPITAL FLOWS FROM THE USA TO BANKS, EACH EPISODE, DETAIL, WITH OWN LAG AND IOF CONTROLS

	Portfolio: Equity				*Portfolio: Debt*			
	(1)	*(2)*	*(3)*	*(4)*	*(1)*	*(2)*	*(3)*	*(4)*
C	0.0230	−0.0296	−0.0875	−0.0599	0.1065[a]	0.0980[b]	0.1000	0.0738
	0.7150	−0.8678	−1.1478	−0.9419	2.6425	2.5216	1.5981	1.3980
QE1	0.0020[c]	0.0008	0.0013	0.0010	0.0013[b]	0.0016[b]	0.0016[c]	0.0018[b]
	1.6904	0.6960	0.9637	0.7629	2.0376	2.1785	1.8291	2.0629
QE2	0.0031[c]	0.0029[a]	0.0026[b]	0.0026[b]	0.0011	0.0003	0.0004	−0.0001
	1.9692	3.2207	2.3793	2.3584	0.9143	0.2271	0.2536	−0.0679
QE3	0.0025	0.0016	0.0011	0.0010	0.0029	0.0032[c]	0.0032[c]	0.0029
	1.3805	1.0211	0.7024	0.6393	1.5795	1.7180	1.7990	1.6572
CRISIS	−0.5262[a]	−0.3341[c]	−0.2898	−0.2230	−0.3469[a]	−0.2996[a]	−0.3140[a]	−0.2379[a]
	−2.6853	−1.7201	−1.3996	−1.3425	−5.4730	−4.6269	−4.2729	−3.5064
ROW		0.3378[a]	0.3505[a]	0.3579[a]		0.0420	0.0403	0.0572
		4.4667	4.5680	4.8113		1.2012	1.1380	1.5568
R^2	0.264	0.383	0.395	0.386	0.538	0.547	0.547	0.483
Adjusted R^2	0.216	0.338	0.339	0.330	0.504	0.509	0.501	0.430
QE1 (USD)	3.10[c]	1.27	2.00	1.50	2.11[b]	2.49[b]	2.51[c]	2.77[b]
QE2 (USD)	1.663[b]	1.597[a]	1.400[b]	1.397[b]	0.577	0.185	0.215	−0.061
QE3 (USD)	3.35	2.21	1.52	1.40	4.00	4.31[c]	4.34[c]	3.93[c]
QE (USD)	8.113[b]	5.075[c]	4.917	4.301	6.692[b]	6.982[b]	7.063[b]	6.631[b]
IOF (USD)	−6.26[c]	−7.54[b]	−2.28	−2.66	−2.26	−2.60	−2.86	−1.90

	Portfolio: Debt in the country				Portfolio: Debt abroad			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
C	0.0551[a]	−0.0112	0.0093	0.0084	0.0198	0.0195	−0.0127	−0.0164
	2.9278	−0.7224	0.3057	0.3546	1.0406	0.9900	−0.4592	−0.6057
QE1	0.0003	−0.0003	−0.0004	−0.0004	0.0001	0.0001	0.0003	0.0004
	0.7206	−1.1221	−1.3090	−1.3970	0.4718	0.4646	0.9202	1.1080
QE2	0.0000	0.0001	0.0003	0.0003	0.0013[c]	0.0013[c]	0.0010	0.0007
	−0.0064	0.4319	0.7591	0.7352	1.8575	1.6854	1.2570	0.7316
QE3	0.0002	−0.0003	0.0000	−0.0001	0.0014[c]	0.0014[c]	0.0011	0.0010
	0.3551	−0.4164	−0.0565	−0.0672	1.8631	1.8549	1.4584	1.1651
CRISIS	−0.1524[b]	−0.0198	−0.0453	−0.0402	−0.0224	−0.0204	0.0296	0.0395
	−2.1315	−0.5646	−1.0036	−1.1627	−0.6092	−0.5034	0.6339	0.8666
ROW		1.1020[a]	1.0890[a]	1.0541[a]		0.0019	0.0027	0.0166
		8.125	7.839	9.645		0.1271	0.1839	0.9603
R^2	0.478	0.706	0.709	0.700	0.706	0.706	0.715	0.640
Adjusted R^2	0.434	0.679	0.677	0.666	0.678	0.676	0.680	0.596
QE1 (USD)	0.43	−0.40	−0.60	−0.59	0.19	0.20	0.52	0.67
QE2 (USD)	−0.001	0.071	0.155	0.150	0.717[c]	0.698[c]	0.543	0.364
QE3 (USD)	0.31	−0.35	−0.05	−0.07	1.96[c]	1.97[c]	1.53	1.37
QE (USD)	0.748	−0.672	−0.502	−0.504	2.860[b]	2.874[b]	2.595[b]	2.407[c]
IOF (F)	−1.779	−1.935	−3.805	−3.728	−0.466	−0.482	2.858	3.529

Results from USA flows to Brazil bank sector for aggregate flow categories and each policy round. All regressions include own lag of USA flows and dummy variables indicating a tax on capital flow tax for some category, including American Depositary Receipts (coefficients not shown; total effect of IOF last row). Column (1) omits the ROW flows proxy, (2) includes the proxy, (3) includes the proxy and additional controls (coefficients not shown to save space) and (4) normalizes dollar variables by import price indexes. *t*-values below coefficient estimates are from HAC standard errors. The last rows show the total effect of QE policy round in the period. [a] 1%, [b] 5%, [c] 10 percent.

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Investigating Monetary Policy Spillovers from the United States of America to Jamaica

André Murray

Abstract

This paper investigates the evidence of monetary policy spillovers from the United States of America (USA) to financial conditions and monetary policy decisions in Jamaica. It utilizes the method developed by Lombardi and Zhu (2014) to derive shadow policy interest rates for Jamaica as well as the shadow policy rate for the USA derived by Wu and Xia (2016), then employs a standard structural vector auto regressive (SVAR) model to identify the monetary policy shocks. Utilizing shadow policy rates is key to identifying the true monetary policy stance in both countries given their extensive use of unconventional monetary policy tools following the 2008 global financial crisis (GFC), albeit for different reasons. The results suggest that there are direct monetary policy spillovers from the USA to Jamaica. However, the largest spillover was indirectly through the response of the monetary authority in Jamaica to the US policy's impact on relative prices.

Keywords: monetary policy, international spillovers, Taylor rule

JEL classification: E52, E58, F33

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1. INTRODUCTION

Since the 2008 global financial crisis (GFC), most advanced economies, and in particular the USA, have been faced with a challenging monetary policy environment to stimulate output growth in the face of a global recession. In that regard, having initially reduced their policy interest rates close to their zero lower bound (ZLB), many have had to resort to unconventional monetary policy (UMP) tools, which primarily included large scale financial asset purchasing programs, usually referred to as quantitative easing (QE) programs. This new monetary policy environment has stimulated much research into the impact of these UMPs by advanced economies on monetary policy decisions in emerging market economies, typically referred to as spillovers.

Most of the studies on the effects of monetary policy actions in advanced economies since the 2008 GFC on other advanced as well as developing countries have found evidence of spillovers, primarily through changes in bond yields and asset prices resulting in changes in capital flows. However, there has been very little evidence of the impact from changes in the actual policy rate of the advanced economy. These findings were not surprising given that interest rates in advanced economies were approximately zero and not changing, which therefore meant they had very little informational content. However, this empirical challenge was addressed by Lombardi and Zhu (2014) as well as Wu and Xia (2016) who created shadow policy rates for the USA which were not bounded below by zero and incorporated the impact of these UMPs on the central bank's balance sheet, as well as changes in maturity structures of key assets into a single, easy-to-understand indicator.

During this period of generally loose monetary policy by central banks in advanced economies, some developing countries like Jamaica were faced with the difficult and sometimes conflicting objectives of building their international reserve positions while stimulating domestic output growth. Specifically, following the 2008 GFC Jamaica faced a major balance of payments challenge and implemented a stand-by arrangement (SBA) supported economic structural reform program primarily aimed at improving the country fiscal sustainability while reducing systemic financial sector risk. This program was discontinued in 2011 but was followed by an Extended Fund Facility (EFF) supported economic program in February 2014 also aimed at improving fiscal sustainability and improving price and non-price competitiveness while boosting growth and employment. Over the life of these programs the monetary authority in Jamaica, the Bank of Jamaica (BOJ), was challenged with meeting its inflation objectives and monetary targets while creating an environment supportive of the growth required to allow the country to emerge from a prolonged and severe recession and to become placed on a sustained higher growth path.[1] In order to meet these sometimes conflicting objectives, the BOJ employed numerous UMPs, including the issuing of US dollar denominated certificates of deposit (CD) to build international reserves without having to significantly increase interest rates on domestic currency denominated securities.

The monetary policy environment in Jamaica, therefore, was being significantly influenced by domestic factors following the financial crisis, which may have been exacerbated by policy initiatives in the advanced economies. Therefore, the purpose of this study is to ascertain to what extent international monetary policy spillovers have affected the policy decisions at the BOJ historically by properly measuring the monetary policy stance in both countries during the post-crisis period.

The rest of the paper is organized as follows: Section 2 examines the literature on international spillovers and monetary policy transmission in Jamaica; Section 3 gives a brief description of the data utilized; Section 4 explains the models and methodology; and Section 5 the results and conclusions.

2. LITERATURE REVIEW

Although the literature on monetary policy spillovers has grown significantly since 2008, the idea is not new. Aizenman, Chinn, and Ito (2015) opine that in the mid-1990s, when advanced economies significantly increased their policy rates after an extended period of negative real rates, there was a significant impact on emerging Latin American and East Asian economies. The authors note that the difference in the impact was primarily a function of the exchange

1 The BOJ operates a monetary policy regime referred to by Stone (2003) as *inflation targeting lite*. In this operational structure, the monetary authority, though without a formal mandate, announces an inflation forecast for the year and then utilizes monetary policy to achieve that target.

rate regime. That hypothesis is consistent with the Mundell (1963) hypothesis of a monetary trilemma where the policy trade-offs involve monetary autonomy, exchange rate stability and financial openness. The authors find that the exchange rate regime and financial openness have a direct influence on the magnitude of the spillovers.

Many of the papers on spillovers since 2008 use proxies for monetary policy stance, which include event studies on announcement dates to measure the impact on financial conditions and monetary policy responses in emerging market economies. These studies typically follow the works of Gürkaynak, Sack, and Swanson (2005), and Gürkaynak, Sack, and Swanson (2007), using event analysis to measure the impact of monetary policy. Studies of this nature include the works of Wright (2011), Hausman and Wongswan (2011) and Bowman, Londono, and Sapriza (2014), which examine the impact of policy changes pre-UMP in the USA. Other authors examine the UMP period looking at changes in actual US asset prices and their impact on policy spillovers. These include works by De Pooter et al. (2014), Moore, Nam, and Tepper (2013), and Ahmed and Zlate (2013).

Whilst previous authors have used indicators and proxies of monetary policy, another group of researchers developed shadow prices of the actual policy rate of the US economy to provide a metric that is robust to and easily identifiable with the history of monetary policy actions in the selected developed countries. These works include those of Kim and Singleton (2012), Bauer and Rudebusch (2013), and Wu and Xia (2016) which exploited the information content in various interest rate term structures to derive the shadow policy rate. These works are complemented by Lombardi and Zhu (2014) who utilized a large dataset where changes in the Federal Reserve balance sheet as well as selected interest rate are used to capture the implied impact of the UMPs in the US policy rate. By using this approach, the authors' results allow for the continued utilization of the policy rate as the measure of the monetary policy stance in the USA. Although these papers were not utilized to measure monetary policy spillovers, their ability to capture UMPs lends itself well to the body of research. In addition, given the limited interest rate data available in small developing states like Jamaica, the work of Lombardi and Zhu (2014) lends itself well to application with other available information.

To the best of this author's knowledge the only study of monetary policy spillovers from the USA to Jamaica was conducted indirectly in Murray (2009). It found a weak direct impact of changes in the policy rate in the USA on the policy rate in Jamaica. The main channel of the spillovers was the impact of changes in the policy rate on US inflation and the impact of the changes in US inflation on the Jamaica dollar to US dollar exchange rate. This change then resulted in a domestic monetary policy response. Indeed, many of the studies on the monetary policy transmission mechanism in Jamaica, such as Allen and Robinson (2004), have found strong evidence of an exchange rate channel that has led to a monetary policy reaction function that is heavily weighted toward exchange rate changes. It should be noted that the study by Murray (2009) was conducted on data up to 2005 and therefore would not have captured the post 2008 financial crisis response.

3. UNCONVENTIONAL MONETARY POLICY

3.1 Unconventional Monetary Policy in the USA

In October 2008, the Federal Funds Rate (FFR) fell below 1%, effectively reaching its ZLB as the Federal Reserve tried to counter the recessionary impact of the 2008 GFC and stimulate the US economy. By November, the Federal Reserve began the first round of liquidity injection through the unconventional means of large scale direct purchase of Treasury notes and mortgage-backed securities. This phase of the program, referred to as QE1, led to the stock of these securities on its balance sheet increasing from between 700 billion USD and 800 billion USD in 2008 to approximately 1.75 trillion USD of bank debt, mortgage-backed securities, and Treasury notes by March 2009.

The second round of this program, QE2, was announced in November 2010, when the Fed targeted the purchase of an additional 600 billion USD of Treasury securities by the end of the second quarter of 2011. This was followed by QE3 in September 2012 which targeted a 40 billion USD per month open-ended bond purchasing program of agency mortgage-backed securities. This target was increased to 85 billion USD per month in December 2012. Additionally, the Federal Open Market Committee (FOMC) announced that it would likely maintain the FFR near zero at least through 2015.

By 2013 the US economy had begun to record strong economic growth with low inflation and on June 19, 2013, the Fed Chairman announced a *tapering* of some aspects of the program should the positive developments continue. Specifically, bond purchases would be reduced to 65 billion USD from 85 billion USD per month. This tapering actually began in February 2014, before ending completely on October 29, 2014. At the end of the program the Fed accumulated approximately 4.5 trillion USD in these assets, an increase of nearly 600 percent.

3.2 Unconventional Monetary Policy in Jamaica

Jamaica's financial market was significantly affected by the 2008 GFC, resulting in a sharp reduction in foreign currency flows and a spike in the pace of depreciation of the domestic currency against its main trading counterparts. In addition, during the March 2009 quarter there were significant maturities of government debt, which exacerbated the domestic financial challenges. In response the monetary authority in Jamaica initially implemented swift and aggressive conventional monetary policy actions which included sharp increases in interest rates as well as raising the cash reserve requirements for both foreign and domestic deposits.

In order to weather the post-GFC the Government of Jamaica (GOJ) signed two International Monetary Fund (IMF) supported economic reform programs: the first a 27-month Stand-by Arrangement approved in February 2010 and the second a four-year Extended Fund Facility (EFF) agreement approved in May 2013.[2] Both programs were aimed at improving the country's growth prospects whilst reducing its vulnerability to external shocks. In that regard, the reforms included two debt restructuring exercises of the country's public debt, with the first launched in January 2010 and the second in February 2013.[3] Both exercises resulted in a significant change in the maturity

[2] See <https://www.imf.org/external/np/sec/pr/2010/pr1024.htm> and <https://www.imf.org/external/np/sec/pr/2013/pr13150.htm>.

[3] The Jamaica debt exchange (JDX) launched in January 2010 and the national debt exchange (NDX) implemented in February 2013 represented 700 billion Jamaican dollars –JMD– (65% of GDP) and 860 billion JMD (64% of GDP), respectively, of the full amount of the marketable debt of the Goverment of Jamaica.

profile of a major portion of the debt obligations and hence the available liquidity of the financial sector.

In the context of the resulting global and domestic economic environment coupled with the challenges of meeting the targets under both economic programs, the BOJ implemented a number of UMPs. These policies can be broadly grouped into three main categories: foreign currency market operations, open market operations and other operations.

3.2.1 Foreign Currency Market Operations

Jamaica operates a floating exchange rate regime in which it intervenes occasionally to reduce unusually large changes in the value of the domestic currency relative to the US dollar. These episodes to buy or sell foreign currency are required primarily due to the size and openness of the market. In addition, given the level of development, the market is susceptible to substantial changes in value due to the actions of a few large players. In that regard the BOJ operates a surrender arrangement in which authorized dealers are required to *surrender* or sell a proportion of their foreign currency market purchases at the weighted average purchase rate of all banks for the previous day.[4] However, following the 2008 GFC there was increased volatility in the market for foreign currencies, which was attributed to the effect of the *lumpy* demand episodes of a few large public sector entities. In order to reduce this impact on the market, on February 03 the Bank implemented an additional surrender requirement, the public sector entities (PSE) foreign exchange facility, which consolidated the foreign exchange demand of these entities and coordinated foreign currency payments to minimize volatility in the market.

3.2.2 Open Market Operations

Given the need to build foreign currency reserves without adversely impacting domestic credit expansion prospects under the IMF EFF-supported economic program, the BOJ introduced foreign currency denominated certificates of deposit in November 2013. This approach was due to the provisions outlined in the IMF's Balance of Payments Manual that foreign currency liabilities with more than

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4 The foreign currency surrender requirement has been in effect since September 1990., see <http://www.boj.org.jm/pdf/foreign_exchange.pdf>.

one year to maturity would not be included in the calculation of the net international reserves (NIR).

Following the introduction of these instruments and in light of the generally tight liquidity environment that existed since the implementation of the debt exchanges, the BOJ provided liquidity support to the market at a six-month tenor for institutions that purchase the BOJ US dollar-denominated CDs for tenors in excess of two years. This lending tenor, which was the longest allowable under the Bank of Jamaica Act, allowed deposit-taking institutions that were holding strong foreign currency positions to access longer term liquidity without having to liquidate their hedges in an uncertain economic environment with bouts of sharp depreciation of the domestic currency.

3.2.3 Other Operations

During the December 2009 quarter the Bank also extended credit to the Government to assist in closing its financing gap in a context of reduced investor appetite for GOJ debt. The demand for GOJ instruments waned as a result of heightened uncertainty in the domestic market surrounding the terms and timing of the IMF agreement and associated Government debt management initiatives. This support to the GOJ included temporary advances of 5.1 billion JMD in November and the purchase of securities totalling 18 billion JMD on December 15. The Government repaid 2.5 billion JMD of the advance in December and the remaining 2.6 billion JMD was converted to GOJ securities. The Bank's secondary market sales of its holdings of GOJ securities reabsorbed 14.8 billion JMD from the financial market during the June 2010 quarter.

3.3 Justification for Shadow Interest Rates

While the justification for the use of the shadow interest rate for the US is obvious given the ZLB condition and implementation of relatively unpresented UMPs, the justification for its use for Jamaica is less clear. Jamaica's policy rate remained well above zero. However, in real terms, the policy rate had become negative and in nominal terms had reached the lowest level since the country started operating a floating exchange rate in 1991. The main rational for using a shadow interest rate was that the BOJ kept the policy rate unchanged from February 2013 until the end of the period reviewed in this study. During that period the BOJ introduced a suite of UMPs, some of which had never been utilized in the country's history. This effectively resulted in changing money market conditions and a perceived breakdown in the relation of the policy rate with market rates. It is therefore anticipated that the estimated shadow policy rate will show that the perceived breakdown in the relation between market rates and the policy rate only reflects the reduced information content in the actual policy rate and not a breakdown in the transmission of monetary policy.

4. DATA

In order to measure the spillover of monetary policy, this study utilizes three sets of data, including real and monetary variables for both the USA and Jamaican economies. The Federal Reserve shadow interest rate used is from Wu and Xia (2016), available online at the Federal Reserve Bank of Atlanta's website.[5] Monthly as well as quarterly data for Jamaica is used to estimate the shadow policy rate for that country. This is then incorporated with monthly data from the USA in VAR models to measure the monetary policy spillovers of the policy action in the USA to the Jamaican economy.

The trends in the balance sheets of the Federal Reserve and the Bank of Jamaica suggest that, in general, both institutions followed a similar pattern of expansion in their balance sheets in the post-2008 GFC. For the USA there was a sharp expansion in the non-government securities assets of the balance sheet in 2009, before some normalization in the proportion of government securities to total securities occurred in 2010. There was also a reduction in the pace of expansion in the balance sheet in the second half of 2012 before the pace of expansion increased again in 2014. For Jamaica, the pace of expansion in 2009 was not as sharp as in the USA. There was also a contraction in the BOJ's balance sheet between March 2011 and November 2012. Within the liabilities there was a reversal in the pace of expansion between foreign liabilities and deposits. These changes in the respective balance sheets hint at the UMPs pursued in each country.

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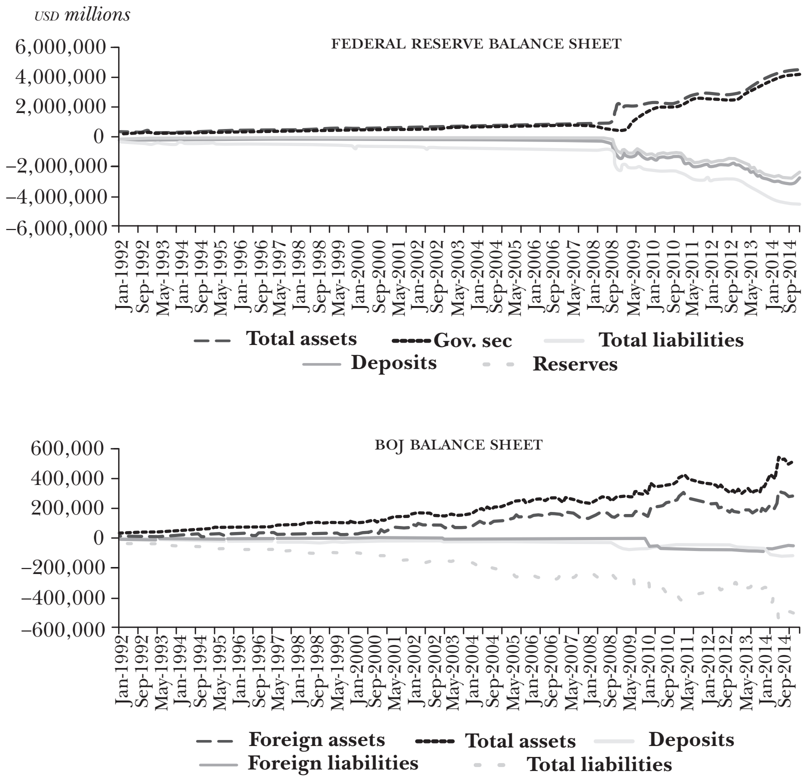
5 See <https://www.frbatlanta.org/cqer/research/shadow_rate.aspx?panel=1>.

Figure 1

TREND IN FEDERAL RESERVE'S AND BANK OF JAMAICA'S BALANCE SHEETS



4.1 Monthly Data for the Jamaican Economy

The data for Jamaica was compiled to capture the similar information on monetary policy as estimated for the US economy in Lombardi and Zhu (2014). The variables are listed in Table 1 and span January 1992 to December 2014. It should be noted that the data on Jamaica is much more limited than the USA due to availability. In addition, Jamaica transitioned to a floating exchange rate in 1991 from fixed rates and auctioning regimes in prior periods and therefore limiting the data to post-1992 will allow for a purer examination of monetary policy spillovers in the domestic economy. In addition, utilizing a single exchange rate regime data set will avoid issues of the trilemma as outlined in Aizenman, Chinn and Ito (2015).

It should be noted that a key difference between the balance sheets of the BOJ and those of the Federal Reserve is the inclusion of foreign assets and liabilities. This is important as Jamaica is a small country and the central bank holds a sizable amount of foreign assets. In addition, a key aspect of the UMPs employed by the BOJ was the issuance US dollar-denominated CD. These CDs were introduced in the context that the sixth edition of the International Monetary Fund's Balance of Payments Manual classifies foreign liabilities in excess of one year to maturity as part of the net international reserves. Therefore, the BOJ was able to build the net international reserves through these instruments by borrowing foreign currency directly from residents without having to raise domestic interest rates to induce holders to sell foreign currency for Jamaican currency.

Another important insight that should be derived from this approach is that a key component of the economic reform program was a major fiscal adjustment that would have resulted in a significant tightening of domestic currency liquidity despite little adjustment in the policy rate. Therefore, monetary policy could have been tighter than evident in the policy rate, but should be reflected in the monetary aggregates as well as the Treasury bill rates.

Table 1

MONTHLY DATA ON JAMAICA

Block I: Interest rates
- 30 day CD
- Rates on GOJ T-bills with maturities of one, three and six months

Block II: Monetary aggregates
- Monetary base or M0
- M1, M2 and M2F

Block III: BOJ balance sheet (assets)
- Total assets
- Net claims on the public sector

Block IV: BOJ balance sheet (liabilities)
- Currency in circulation
- Total liabilities
- Cash reserves

4.2 Other Data for the Jamaican and US Economies

In order to measure the spillovers from the USA to Jamaica, the study included monthly and quarterly macroeconomic variables for both countries. The data spanned January 1992 to December 2014. Monthly data on inflation, exchange rates, interest rate and the monetary base were utilized. In addition, quarterly real GDP for each country was included. The quarterly data was interpolated to a monthly frequency using a linear match to the last data point. All data, with the exception of the interest rates, were then logged and seasonally adjusted using the US Census Bureau X-13 seasonal adjustment tools. The full list of variables and descriptions utilized in the study are in Table 2 below.

Table 2

SVAR VARIABLE LIST AND DESCRIPTIONS

Variable	*Symbol*	*Description*
US variables		
US GDP	y^*	Real GDP of the US
US policy rate	r^*	Estimated shadow policy rate of the US, the FFR
US inflation	p^*	Annual change in the consumer price index (CPI) of the US
Domestic variables		
Real GDP	y	Real GDP of Jamaica
Inflation	p	Annual change in the consumer price index of Jamaica
Depreciation	s	Annual change in the weighted average selling rate of the JMD per USD.[1]
Policy interest rate	r	Estimated shadow policy rate of the BOJ, the 30-day CD (BOJ30D)
Monetary base	mb	The monetary base stock in Jamaica

[1]Therefore, an increase in s implies a depreciation in the Jamaican dollar.

5. MODELS AND METHODOLOGIES

5.1 Dynamic Factor Models with Missing Variables

The shadow policy rates for Jamaica were estimated using the process outlined in Lombardi and Zhu (2014). This process was chosen for Jamaica instead of the method utilized by Wu and Xia (2016) for the USA as Jamaica does not have a rich enough set of instruments to derive the shadow price from these yields. An attempt was made to derive the shadow price for both economies using the method utilized by Lombardi and Zhu (2014). However, given some challenges in completing the dataset for the USA it was decided to utilize the Wu and Xia (2016) dataset as the resulting shadow policy rates are quite similar in magnitude and direction.

Estimating the shadow price for Jamaica using the method outlined in Lombardi and Zhu (2014) first employs the estimation of dynamic factor models (DFMs) with missing data for both countries using the dataset given in Table 1. DFMs, which date back to the work of Geweke (1977) have been widely utilized in macroeconomics as they allow for the reduction in the dimensionality of large data sets by extracting a small number of common, latent or unobserved components out of the information in the dataset. These common components are chosen to maximize the proportion of variability in the data they explain.

In order to estimate the DFM, let $\left\{X_t,\ t=1,\ldots,T\right\}$ be a stationary N-dimensional multiple time series with T observations. These observations are determined by a set of unobserved factors F_t such that:

1 $$X_t = \Lambda F_t + e_t,$$

where F_t is an $r \times 1$ vector of factors, Λ is an $N \times r$ matrix of the factor loadings and e_t the residuals assumed to be i. i. d. and Gaussian. It is assumed that the unobserved factors, F_t, follow a vector autoregressive (VAR) process of order p, given by:

2 $$F_t = \sum_{i=1}^{p} A_i F_{t-i} + u_t,$$

where A_i are the coefficient matrices for the p lags of the factors and u_t is the residuals which are also assumed to be i. i. d. and Gaussian. Equations 1 and 2 can be estimated as a state-space using the Kalman filter as outlined in Engel and Watson (1981). The system is estimated using the expectation maximization (EM) algorithm which was first proposed by Dempster, Laird and Rubin (1977) and Watson and Engel (1983) for estimating unobserved variables models. This algorithm works by iteratively replacing unobserved variables with their expected values based on the specified law of motion in equation 2 conditioned on the observed series and then maximizing the likelihood conditional of these expected values.

The algorithm was extended by Banbura and Modungo (2014) to not only estimate the unobserved factor loadings, but also to estimate missing data from the observed series X_t, even for cases where the missing data has an arbitrary pattern. This is achieved by writing the likelihood as if the dataset were complete, then using the estimated factor loading to *fill in* the missing data. This process is then iterated and the authors prove that under a regularity condition the EM algorithm converges to a local maximum of the likelihood. This method was then exploited in Lombardi and Zhu (2014) where the factor loadings were determined by the monetary aggregates, balance sheet and interest rate data, and the US interest rate was treated as missing when they seemed to reach their ZLB. These include the federal funds rate and Treasury bill rates which have been approximately zero since 2008. In addition, the dataset included a number of missing data points, particularly interest rates in periods when no issues occurred.

A similar process was applied to the Jamaican data. However, although interest rates in Jamaica did not reach their actual ZLB, BOJ's policy rate reached historic lows and movements in the policy rate may have had less information content than in prior periods. In that regard, similar to the US policy rate, interest rates in those periods were treated as missing.

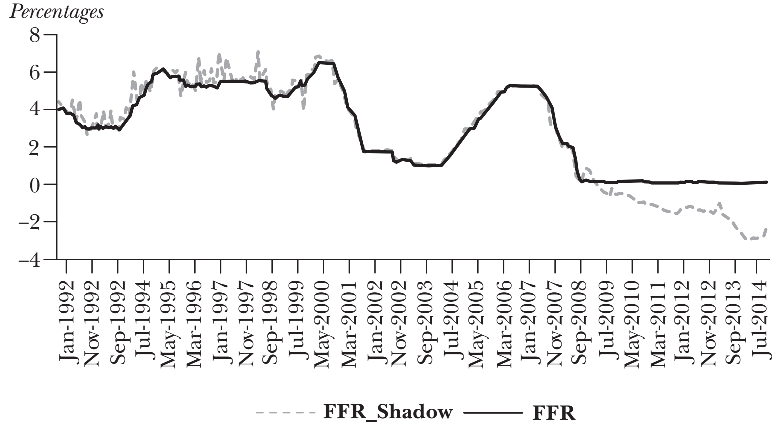
To satisfy the estimation criteria that the observed series be stationary, data in blocks II, III and IV were expressed in 12-month changes. Using 12-month changes also reduced the pattern of seasonality that may have been evident in the series. In order to capture the full impact of the UMPs in Jamaica, the policy rate was treated as missing data over the period February 2012 to December 2014.

5.1.1 Shadow Policy Rate for the USA

The shadow policy rate from Wu and Xia (2016), is plotted against the actual rate in Figure 1. This shadow policy rate suggests a significant easing of the Federal Reserve policy rate since 2009 where the rate has been generally negative. However, the pace of easing has been gradually reduced since December 2013, consistent with the tapering in the QE programs.

Figure 2

UNITED STATES: SHADOW POLICY RATE FROM WU AND XIA (2016) AND ACTUAL RATE



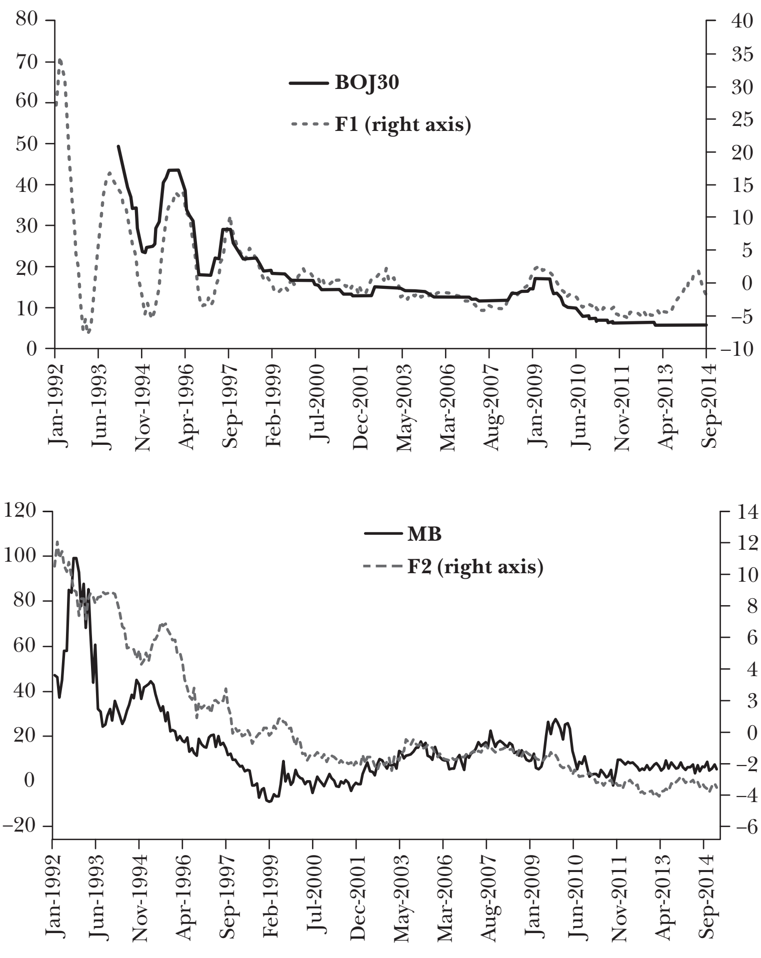
5.1.2 Shadow Policy Rate for Jamaica

For the estimation for Jamaica, the selected specification was three factors *(r = 3)* and three lags *(p = 3)*. As was done in the case for the USA in Lombardi and Zhu (2014), two of the estimated factors are plotted against policy rate and the monetary base to illustrate the comovement between the observed data and the estimated factors. The results, shown in Figure 3, show a strong comovement, with the three factors accounting for approximately 90% of the variation in the data.

Figure 3

JAMAICA: SHADOW POLICY RATE, POLICY RATE AND MONETARY BASE

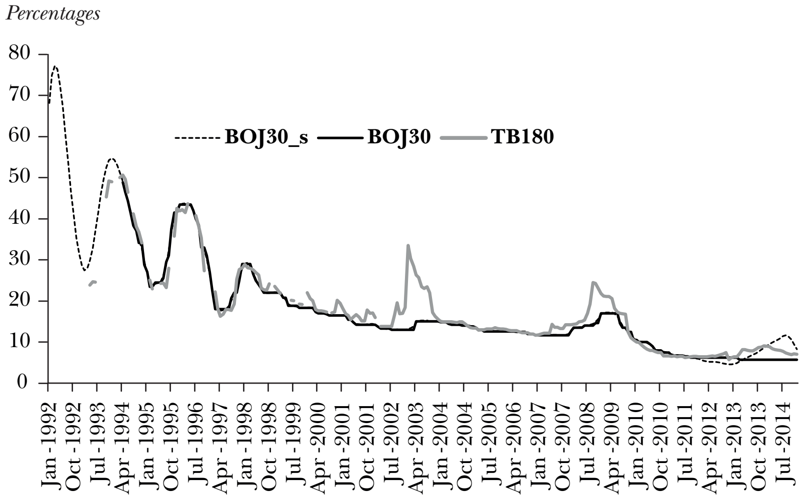
Percentages



The shadow policy rate is then plotted against the actual rate in Figure 4. The results indicate that though policy eased greater than suggested by the policy rate in 2012, there was a sharp tightening in monetary policy in 2013, which continued into the latter half of 2014 when there was a sharp easing in policy by the end of the year.

Figure 4

JAMAICA: SHADOW POLICY RATE AND ACTUAL RATE



5.2 Structural Vector Autoregressive Model

The model estimated consisted of eight variables outlined in Table 3 to capture the monetary policy transmission from the USA into the Jamaican economy. Each variable was analysed in changes to ensure stationarity of the system. All variables except the interest rates were expressed as logged differences while interest rates are expressed as differences.

The model takes the form of a standard structural VAR specified as outlined in Amisano and Giannini (1997) and Hamilton (1994) expressed as:

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \upsilon_t , \quad (3)$$

where A_i are $k \times k$ matrices, the variables y_{t-i} and ε_t are $k \times 1$ vectors for $i = 0, 1, 2, ...p$ and $\upsilon_t \sim N(0, \Sigma_\upsilon)$. This is the reduced form of the specification and can therefore be estimated by ordinary least squares for the appropriate lag length. In order to obtain the structural innovations, the model can be transformed by pre-multiplying the system with the matrix of contemporaneous relations between the variables A_0 to transform the VAR model in equation 3 into the structural vector autoregressive (SVAR) model:

4
$$A_0 y_t = \sum_{i=1}^{p} A_i^* y_{t-i} + A_0 \upsilon_t ,$$

where $A_i^* = A_0 A_i$, for $i = 1, 2, ..., p$. The notation of the model can be further simplified, assuming $A = A_0$ such that equation 4 can be rewritten as

4'
$$AA(L)\, y_t = A\upsilon_t ,$$

and $A\upsilon_t = B\epsilon_t$ with $\epsilon_t \sim N(0, I_k)$. The reduced form or observed residuals are given by ϵ_t, while υ_t is the unobserved structural innovations which are assumed to be orthonormal. Therefore,

5
$$E\left[\upsilon_t \upsilon_t'\right] = I_k \text{, and}$$

6
$$A\Sigma_\upsilon A' = BB' .$$

This structure, called the AB-model by Amisano and Giannini (1997) can then be estimated by maximum likelihood by imposing the appropriate restrictions on A and B. Given both sides of equation 6 are symmetric, there are $k(k+1)/2$ restrictions on the $2k^2$ elements of A and B. Therefore, the system can be estimated by imposing at least $2k^2 - k(k+1)/2 = k(3k-1)/2$ restrictions.

This paper uses the identification approach for modelling the interactions between a relatively large and small economy by applying block exogeneity restrictions as introduced by Cushman and Zha (1997) and Dungey and Pagan (2000) on A. There are essentially two blocks of data for the foreign and domestic economies. The identifying restrictions are essentially two sets of ordering restrictions based on Cholesky ordering. However, the domestic block is connected to the foreign block using theories such as uncovered interest and purchasing power parity conditions for the exchange rate. In

Table 3

Dependent	*Explanatory*							
	y^*	r^*	p^*	y	p	r	s	mb
y^*	■							
r^*	■	■						
p^*	■	■	■					
y				■				
p				■	■			
r				■	■	■		
s		■	■	■	■	■	■	
mb				■	■	■	■	■

addition, other variables such as foreign output, y_t^*, are assumed to have a direct impact on their domestic counterparts. The resulting identifying matrix A is given in Table 3.[6]

This model is essentially a smaller scale version of the model estimated in Murray (2009) and therefore provides some insight as to whether there has been a change in the spillovers before and after the GFC. Also, in order to establish the efficacy of the shadow policy rate, the model was estimated using both the shadow policy rate and the actual policy rates, and the results were compared.

Two models were estimated, one using the shadow policy rates for each economy and the other with the actual rates. Both models were estimated with two lags based on the selection criteria (see Table A.1). The results of the estimation with the shadow rates as well as the actual policy rate are provided in the impulse responses below. They suggest, for the most part, that using the actual interest rates would have resulted in counter intuitive responses for many of the variables while the shadow policy rates provide responses that are more intuitive and in keeping with previous findings.

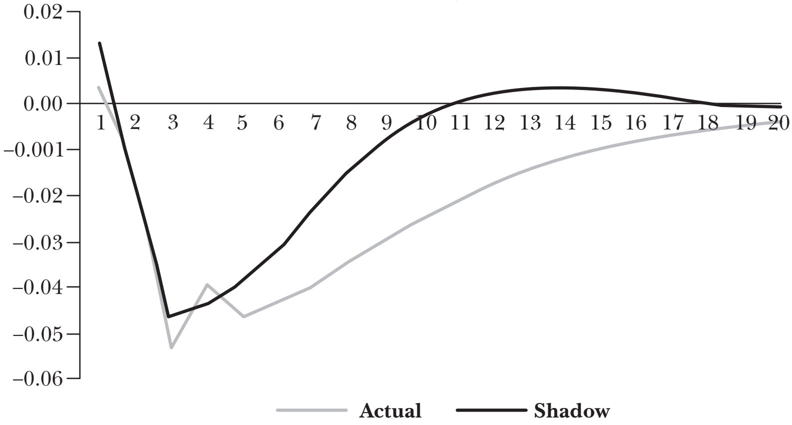
In Figure 5, the impulse responses show that a change in the FFR has a direct impact on the policy rate in Jamaica. However, following

[6] Alternative orderings of the domestic variables were examined. While they did result in some changes in the magnitudes of the impulses, there was no impact on the directions and timing of the impulses of the key variables of interest.

Figure 5

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO THE FFR

IMPULSE RESPONSE OF BOJ30D TO FRR



IMPULSE RESPONSE OF INFLATION TO FRR

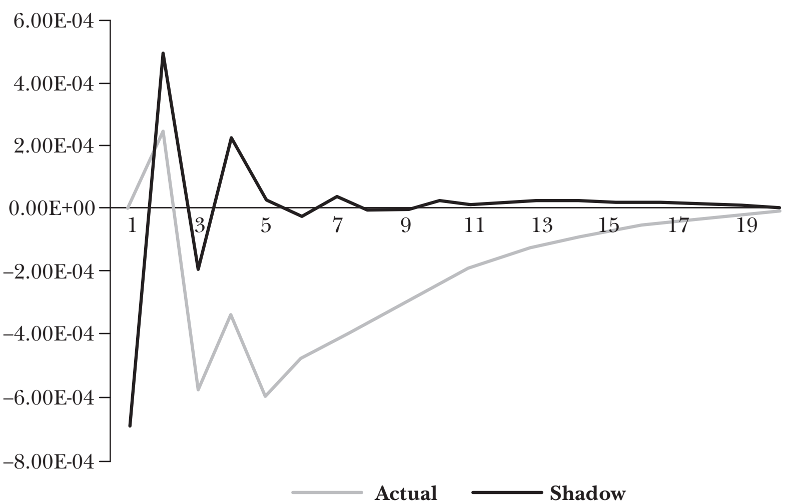
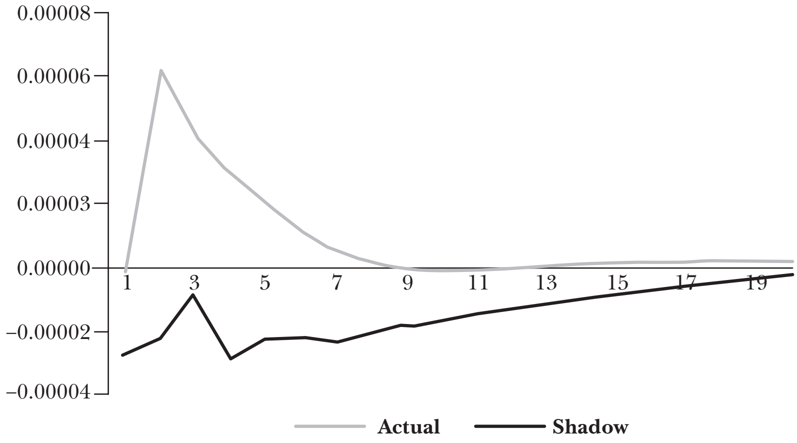


Figure 5

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO THE FFR

IMPULSE RESPONSE OF GDP TO FRR



IMPULSE RESPONSE OF DEPRECIATION TO FRR

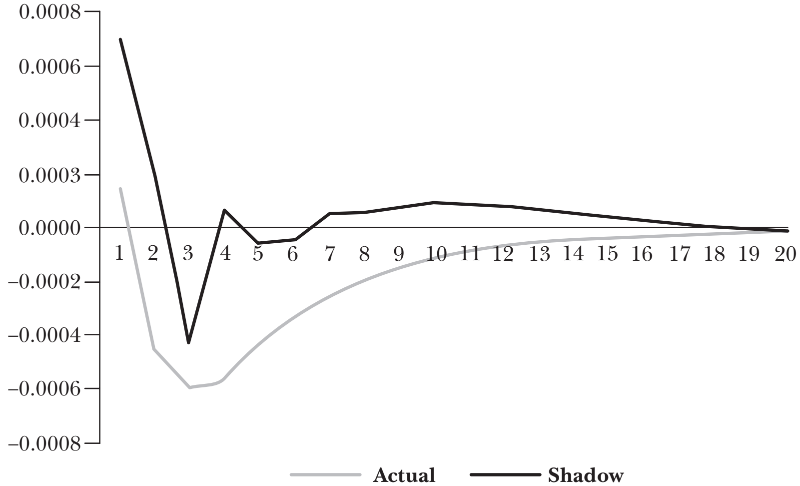
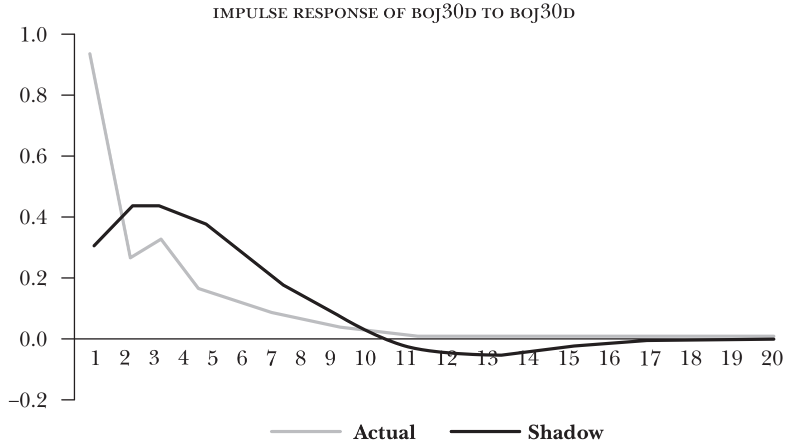


Figure 6

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO THE BOJ30D RATE



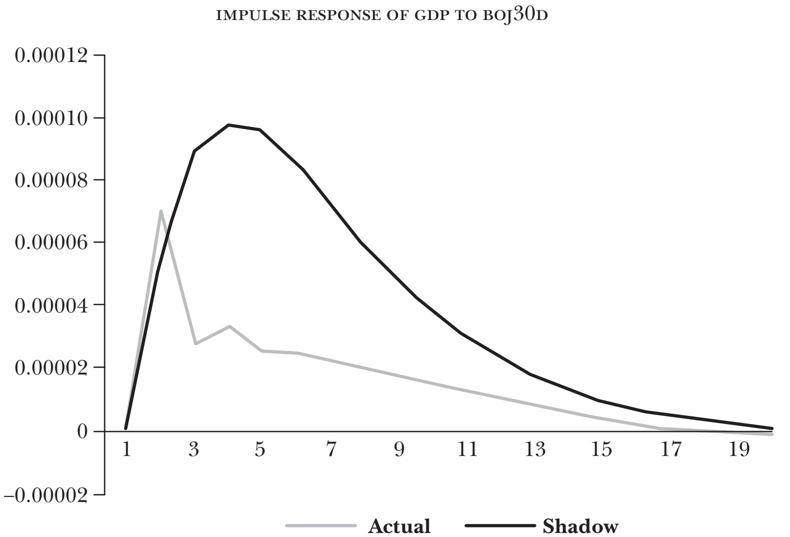
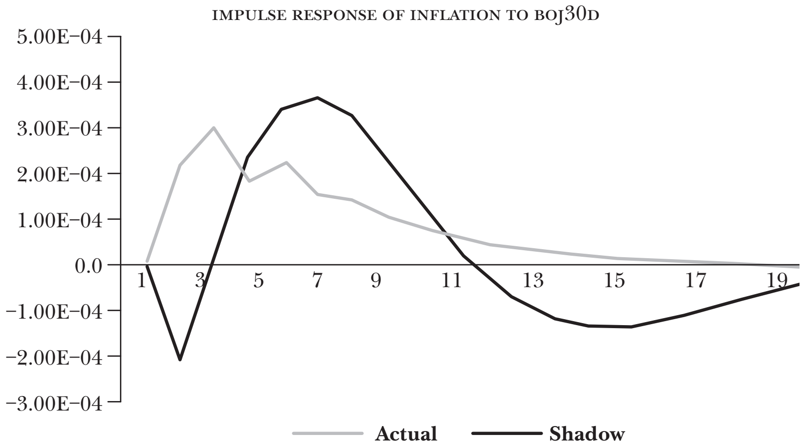
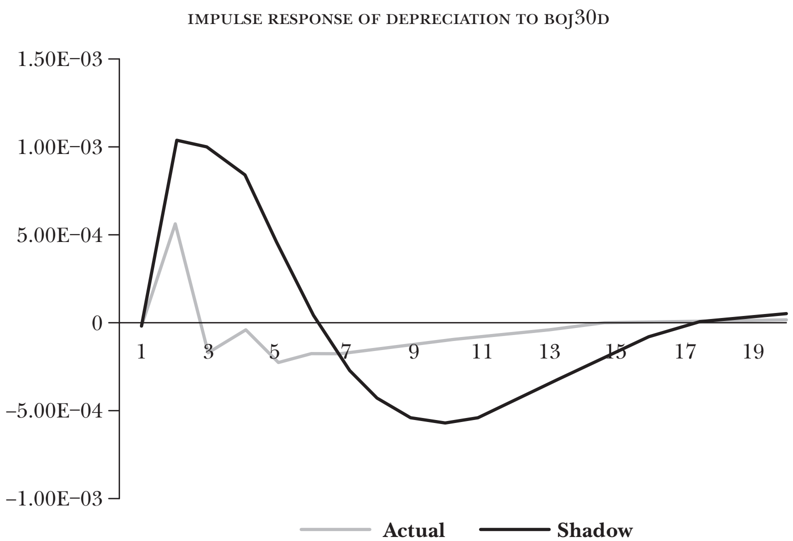


Figure 6

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO THE BOJ30D RATE





the initial positive response of the BOJ to this innovation, there is a reduction in the third month in response to a sharp appreciation of the Jamaican dollar, possibly due to a stronger than initially required policy response. The BOJ then responds to the appreciation by lowering the policy. This response is consistent with previous assessments of Jamaica, such as Allen and Robinson (2004) and Murray (2009), which show a strong response of the BOJ to the exchange rate changes. The impulse response of Jamaica's output to the shadow policy rate changes in the USA is also consistent with a priori expectations as well as the findings of Murray (2009). The policy action in the USA reduces that country's demand, which in turn reduces the output in Jamaica.

With regards to the domestic monetary policy transmission mechanism process, the shadow policy rates give more plausible responses than the actual policy rate based on the direction of the impulses. However, the results differ somewhat from previous studies. Changes in the shadow policy rate have the expected impact on domestic inflation, output and the exchange rate. However, the impulse response of output to the actual rate is counterintuitive. With the exception of output, the domestic variables response to the adjustments in the shadow policy rates have a similar direction; however, the magnitude of the initial response to the shadow policy innovation is much larger and in general dies out much faster.

With regards to the responses of domestic variables to shocks to changes in the domestic policy rate, again the impulse responses of the model with the shadow policy rate provide more intuitive results than the actual rate (see Figure 6). In particular, the impulse of inflation to an increase in the actual policy rate results in an increase in inflation. However, using the shadow policy rate results in an expected fall in inflation. Interestingly, the shadow policy rate models suggest a smaller policy response yields a larger than expected response of domestic variables to the innovation. Therefore, the actual policy rate would have underestimated the size of the required policy response. However, it should be noted that the size and duration of the impact of the shadow rates differs from previous studies like Allen and Robinson (2004) and Murray (2009) that suggest that the greatest impact of the policy innovation on inflation occurs six to eight quarters after the action. These results may be due to the use of a model in changes on monthly data with an interpolated measure of GDP. This approach would ignore the long-run impact of the policy changes on the variables.

Again, the impulse responses of the other domestic variables to innovations from inflation and depreciation are more plausible based on the shadow policy rate molds (see Figures A.1 and A.2 in the Annex). However, the domestic policy response to inflation suggests that the BOJ's initial response would be to reduce the policy rate. The response increased depreciation, however, is consistent with *a priori* expectations. The clear and strong response to depreciation is consistent with previous studies on Jamaica which suggests that historically there has been a stronger focus and policy response of the BOJ to depreciation than inflation given that depreciation has played a strong role as a nominal inflation anchor to the public.

6. CONCLUSION

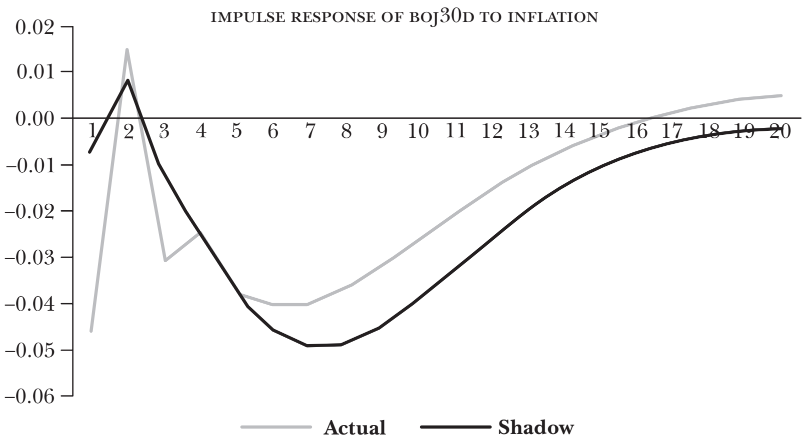
The paper investigated the evidence of spillovers of monetary policy innovations in the USA to the Jamaican economy. Utilizing the approach by Lombardi and Zhu (2014) provided a useful measure of the true policy stance in Jamaica, allowing for a reasonable assessment of domestic policy changes to domestic as well as international factors. The results point to evidence of direct policy spillovers as the BOJ responds immediately and in the same direction as the Fed in order to maintain some interest rate parity. However, subsequent to this initial response, the largest domestic policy interest rate adjustment is to the impact of the Fed policy rate changes to relative prices in the two countries. In particular, the subsequent domestic interest rate response to exchange rate changes far outweighs the initial response to adjust to maintain parity between the foreign and domestic interest rate.

In addition to identifying the direct spillovers, the shadow policy rate approach also provided more intuitive responses than the actual policy rate model. Of note, using the actual policy rate model leads to an underestimation of the domestic monetary policy transmission mechanism and the measured impact on prices. There were, however, some counterintuitive impulse responses from the exercise which may be a result of the data frequency and the methodology. This would suggest a better measure of domestic and foreign output could be examined as well as a methodology to measure the long-run impact of the monetary policy innovations.

References

Figure A.1

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO INFLATION



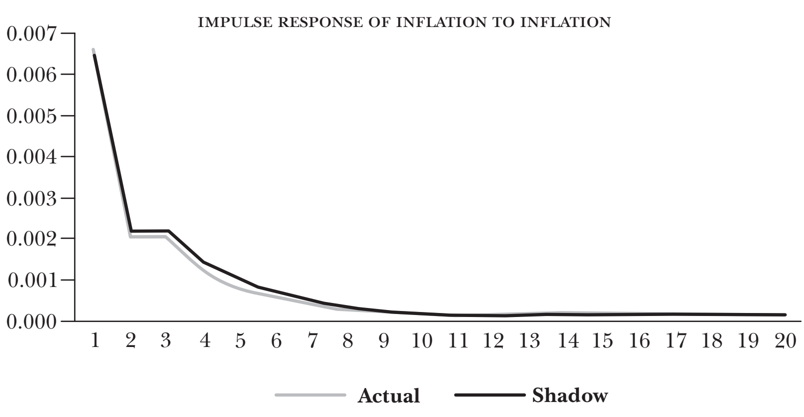
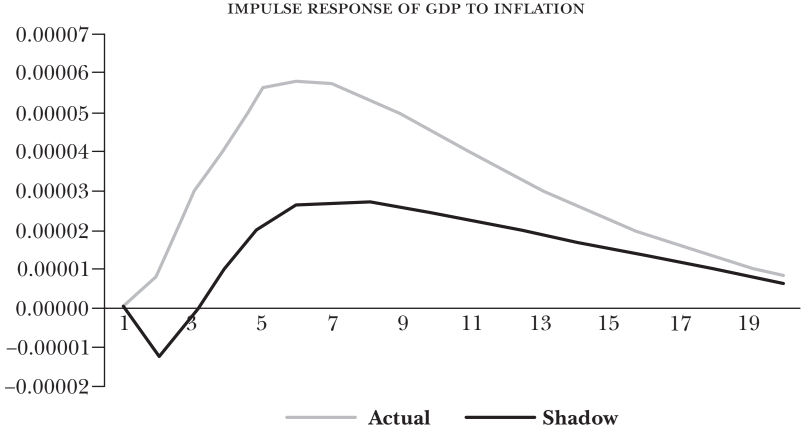


Figure A.1

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO INFLATION



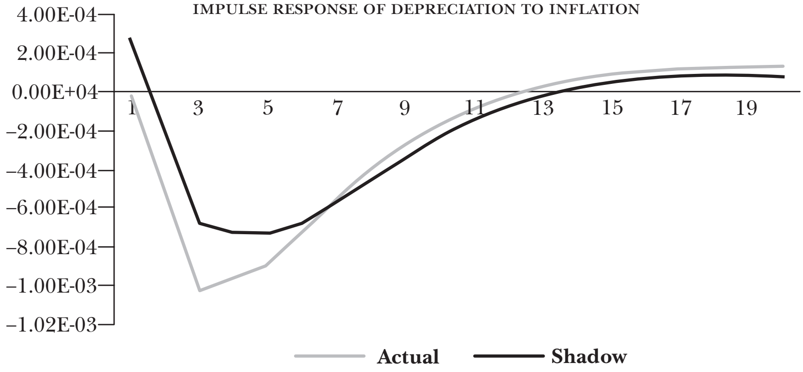
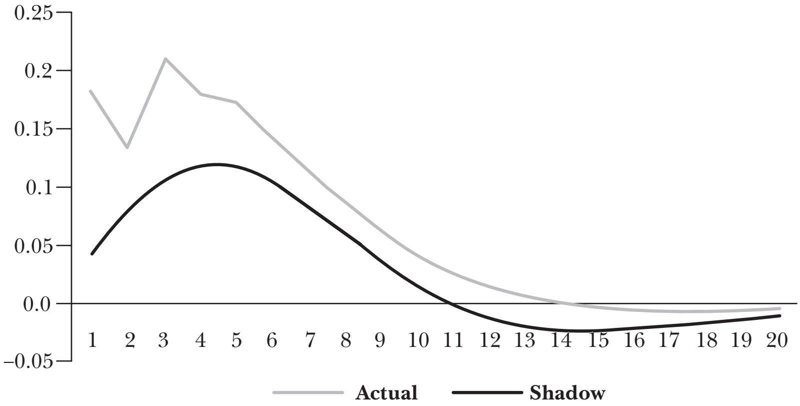


Figure A.2

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO DEPRECIATION

IMPULSE RESPONSE OF BOJ30D TO DEPRECIATION



IMPULSE RESPONSE OF INFLATION TO DEPRECIATION

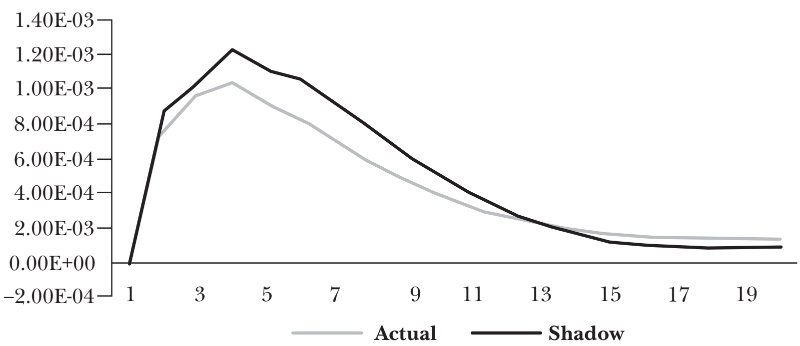
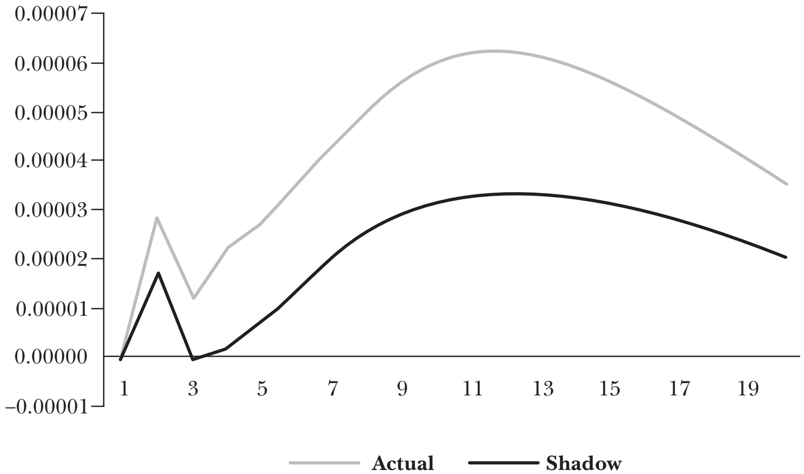


Figure A.2

IMPULSE RESPONSE TO ONE STRUCTURAL STANDARD DEVIATION SHOCK TO DEPRECIATION

IMPULSE RESPONSE OF GDP TO DEPRECIATION



IMPULSE RESPONSE OF DEPRECIATION TO DEPRECIATION

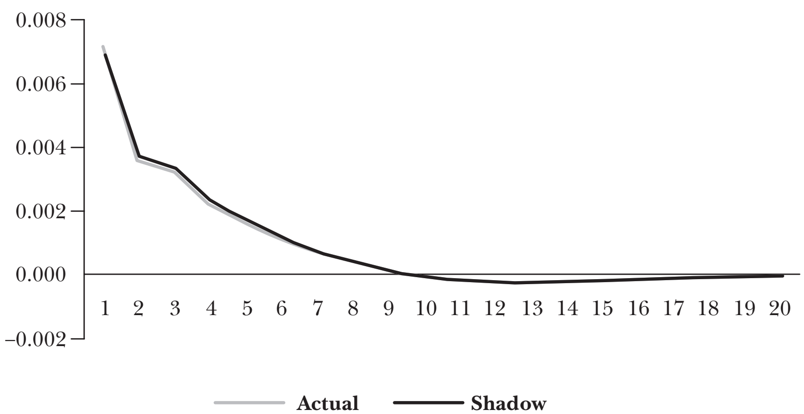


Table A.1

VAR LAG ORDER SELECTION CRITERIA

Endogenous variables: DLUSRGDP1 DFFR_USA DLUSCPI DLRGDP1 DLCPI DLEXRATE DJAM_30D DLMB
Exogenous variables: JDX NDX DFC DFC2
Sample: 1994M02-2015M07
Included observations: 244

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	5110.725	NA	1.23e-28	−41.56332	−40.99001	−41.33242
1	6276.316	2206.981	1.47e-32	−50.59276	−49.10216	−49.99243
2	6477.609	367.9372	4.80e-33	−51.71811	−49.31022[a]	−50.74835[a]
3	6575.525	172.5560	3.65e-33[a]	−51.99611[a]	−48.67093	−50.65691
4	6613.432	64.31846	4.57e-33	−51.78223	−47.53977	−50.07360
5	6666.286	86.21230	5.08e-33	−51.69087	−46.53111	−49.61281
6	6708.918	66.74320	6.19e-33	−51.51572	−45.43867	−49.06822
7	6769.749	91.24727	6.55e-33	−51.48975	−44.49541	−48.67282
8	6830.998	87.85702[a]	6.97e-33	−51.46720	−43.55557	−48.28083

Notes: [a] indicates lag order selected by the criterion. LR stands for sequential modified LR test statistic (each test at 5% level); FPE, for final prediction error; AIC, for Akaike information criterion; SC, for Schwarz information criterion; and HQ, for Hannan-Quinn information criterion.

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Impact of International Monetary Policy in Uruguay: A FAVAR Approach

Elizabeth Bucacos

Abstract

This study analyzes the Uruguayan economy's vulnerability to foreign monetary policy in the last 20 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.

Keywords: tapering, emerging economies, housing prices, Uruguay.

JEL classification: E42, R31, E62.

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1. INTRODUCTION

On May 22th, 2013, in his testimony to Congress, the chairman of the Federal Reserve announced the possibility of a decrease in security purchases from 85 billion dollar 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).

The 2014 Regional Economic Outlook (REO) reports:

> Overall, the results presented so far suggest that a gradual and orderly normalization of US monetary conditions should affect emerging market bond markets in a relatively moderate fashion. Local yields have historically tended to respond to US monetary shocks, but less than one for one. Other news shocks, which include positive US 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.[1]

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.[2] 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.

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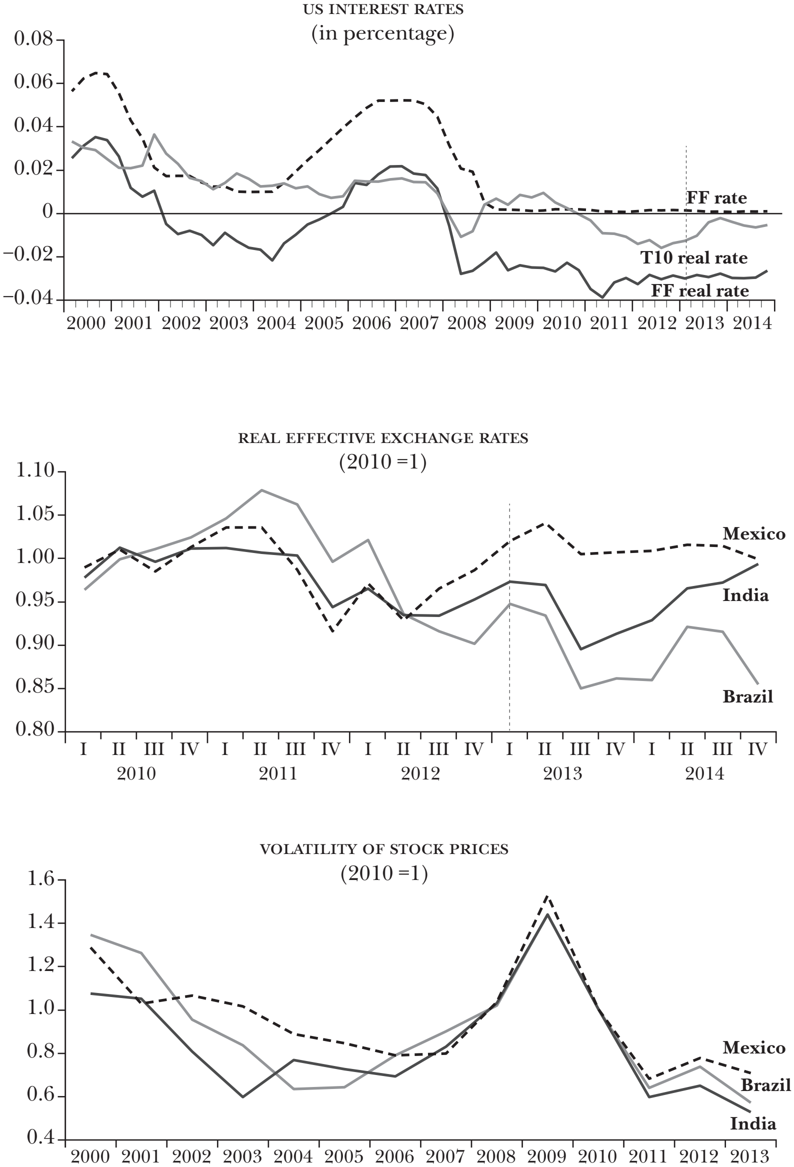
[1] According to the simulations reported by the IMF, gross inflows decline markedly, falling by almost two percent of GDP over six quarters in response to a 100-basis-point increase in the real Treasury rate. When controlling for output growth in the US –the counter face of the normalization of US monetary 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.

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

Figure 1

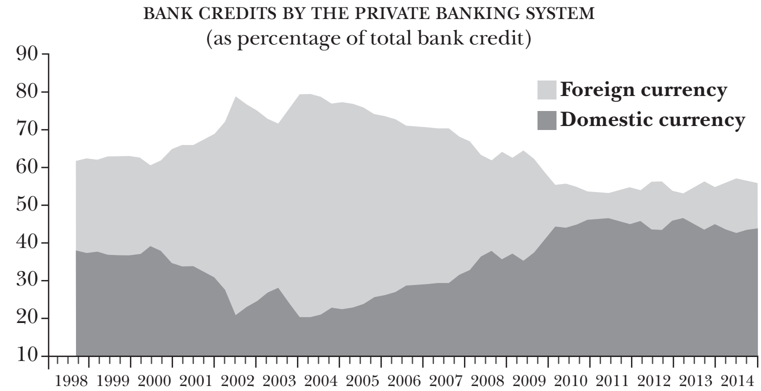
US INTEREST RATES, AND EXCHANGE RATES AND STOCK PRICES FOR SELECTED EMERGING MARKETS



Source: FRED and own calculations for US interest rates. FRED for exchange rate and stock prices.

Figure 2

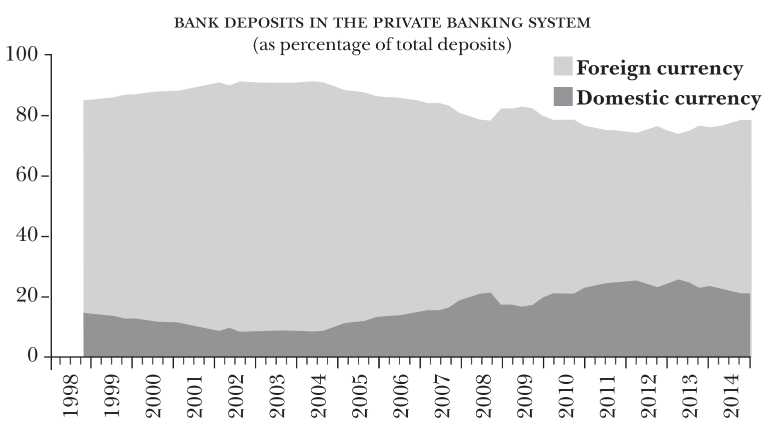
URUGUAY: DOLLARIZATION



Source: BCU and author's calculations.

Figure 3

URUGUAY: DOLLARIZATION

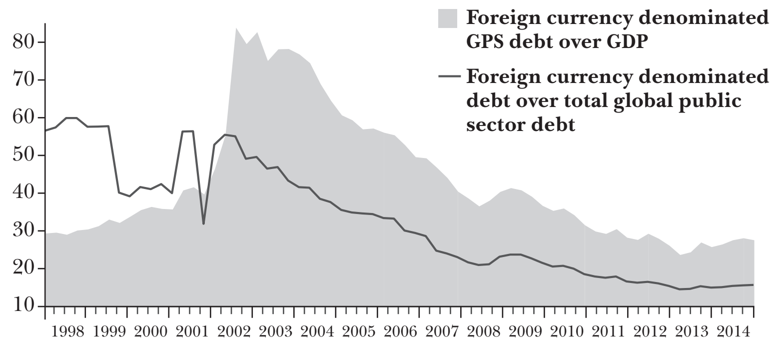


Source: BCU and author's calculations.

Figure 4

URUGUAY: PUBLIC SECTOR DOLLARIZATION

(as percentage of total bank credit)



Source: BCU and author's calculations.

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).[3]

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

[3] See Licandro et al. (2014).

[4] During the 2002 crises, more than 80% of total public debt was denominated in foreign currency; in 2002Q2-2002Q3, 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.

Under those circumstances, a tighter monetary policy decided by the Federal Reserve 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.[5] 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.[6] 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%).[7] 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.[8] Favaro and Sapelli (1989) 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 (1995) calibrates the importance of Argentina during two exchange-rate-based stabilization programs attempted in Uruguay (October 1978 and December

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5 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.

6 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.

7 See Lluberas and Odriozola (2014) and Lluberas and Saldain (2015).

8 Sosa (2010) presents a detailed review of the related literature.

1990, respectively) through an intertemporal optimization model with both tradable and regional goods. 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 (2001) 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 % 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 US 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 US 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 US 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 Noya 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 VAR. 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,[9] 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}:

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

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):

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

2 $$X_{it} = a_{1i} f_{1t} + a_{2i} f_{2t} + \ldots + a_{ri} f_{rt} = \boldsymbol{A}\boldsymbol{f}_t.$$

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).[10] Although factors do not need to have an economic meaning and their main purpose is to summarize the information content of the observed variables, 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 $$f_t = D_1 f_{t-1} + D_2 f_{t-2} + \ldots + D_p f_{t-p} + \varepsilon_t,$$

4 $$\varepsilon_t = Ru_t,$$

where R is an $r \times q$ matrix and $u_t = \left(u_{1t}\ u_{2t} \ldots u_{qt}\right)$ 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 1 to 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 $b_i(L) = a_i\left(I - D_1 L - \ldots - D_p L^p\right)^{-1} R$.

The dynamic factors u_t and $b_i(L)$ are assumed to be structural macroeconomic shocks and impulse-response functions, respectively.[11]

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.

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10 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.

11 They are called dynamic factor models.

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

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 relation 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 $(M \times 1)$ vector of observable variables and F_t is the $(k \times 1)$ 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 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 $$X_t = \Lambda^f F_t + \Lambda^O O_t + e_t,$$

where F_t is a $(k \times 1)$ vector of common factors,[12] Λ^f is a $(N \times k)$ matrix of factor loadings, Λ^O is $(N \times M)$, 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,

[12] 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.

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

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 *communualities*[13] are taken from the squared multiple correlations (SMC). 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.[14]

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

[13] *Communualities* are the common portion of the variance of the variable. See EViews 9 Reference Manual.

[14] See Fukawa (2010).

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 $\hat{F}_t$. 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 VAR. To conserve degrees of freedom, standard VAR 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 VAR 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, 2001). In fact, Bernanke and Boivin (2001) 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.

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 and Giannoni (2008), 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 covariance), 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 Federal Reserve'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.[15] 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 Federal Reserve 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 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.[16] All of them are expressed in real terms and in log levels (except ratios and interest

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

[16] Although the literature advises handling a larger number of time series, data availability was binding in this study.

rates) and whenever necessary, series are transformed in order to leave them stationary.[17] The data span the period from 1995Q2 to 2014Q4.[18] 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)*[19] 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 Federal Reserve 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*):

9
$$O_t = \sum_{i=1}^{p} A_i O_{t-i} + u_t^O,$$

where $O_t = \left(FFR_t,, T10_t, rer_t, UBI_t, i_{pt}, p_{ht}, y_t, pb_t\right)$. The information criteria select three lags for the VAR model, which satisfies the stability

[17] 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.

[18] China GDP is available only since 1995Q2.

[19] This will be the ordering that will be used afterwards when performing impulse-response analysis.

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).

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:

10 $$\begin{pmatrix} O_t^* \\ F_t \\ O_t \end{pmatrix} = \begin{bmatrix} \phi_{11}(L) & \phi_{12}(L) & \Phi_{13}(L) \\ \phi_{21}(L) & \phi_{22}(L) & \Phi_{23}(L) \\ \Phi_{31}(L) & \Phi_{32}(L) & \Phi_{33}(L) \end{bmatrix} \begin{pmatrix} O_{t-1}^* \\ F_{t-1} \\ O_{t-1} \end{pmatrix} + \begin{pmatrix} u_t^{O^*} \\ u_t^F \\ u_t^O \end{pmatrix},$$

where $O_t^* = (FFR_t, T10_t)$, $O_t = (rer_t, UBI_t, i_{pt}, p_{ht}, y_t, pb_t)$ and $F_t = (F_{1t}, F_{2t}, F_{3t})$ 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

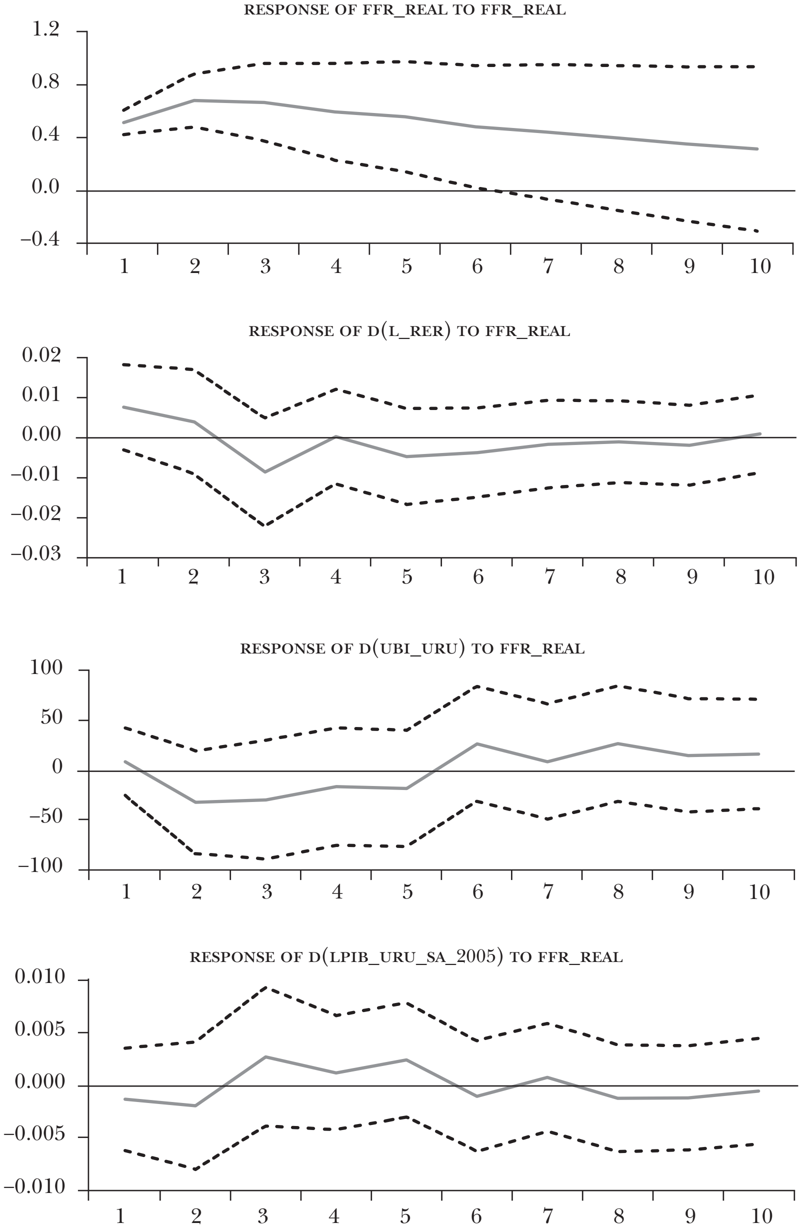
I estimate the model applying a two-step procedure. In the first step, the unobserved factors and their corresponding loadings are estimated by maximum likelihood. In the second step, I substitute the estimated factors into a VAR specification and estimate the FAVAR model by OLS.

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[20] remain. The final data set has a Kaiser's MSA

[20] 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

Figure 5

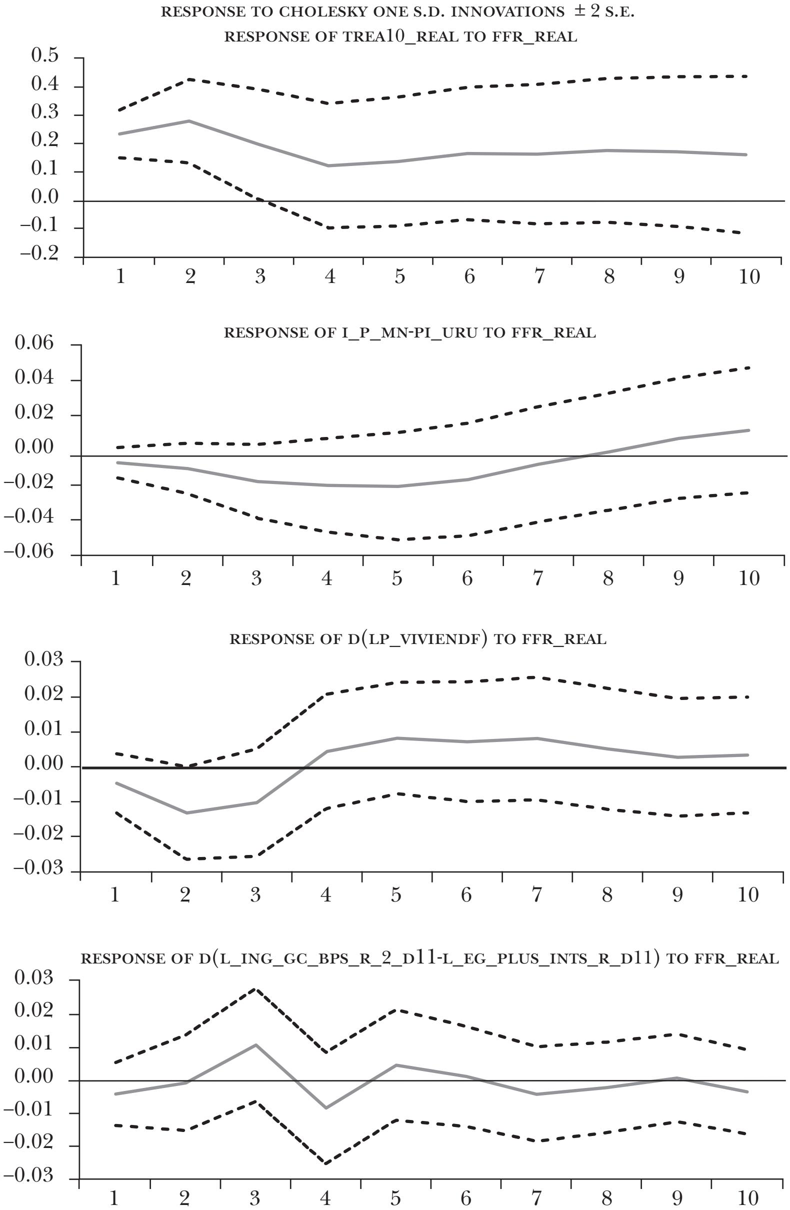
IMPULSE-RESPONSE FUNCTIONS, BASELINE VAR
(5,000 MONTE CARLO REPLICATIONS)



Source: FRED and own calculations for US interest rates. FRED for exchange rate and stock prices.

Figure 5 (cont.)

IMPULSE-RESPONSE FUNCTIONS, BASELINE VAR
(5,000 MONTE CARLO REPLICATIONS)



Source: FRED and own calculations for US interest rates. FRED for exchange rate and stock prices.

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[21] in order to have a balanced panel of time series.

Velicer's MAP method has retained three factors, labeled *F1*, *F2* and *F3*. 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 USA, 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.[22]

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 responses when a specific unanticipated[23] 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

the 0.80s are *meritorious*; values in the 0.70s are *middling*; values the 0.60s are *mediocre*, values in the 0.50s are *miserable*, and all others are *unacceptable* (Kaiser and Rice, 1974).

21 It spans from 1980Q1 to 2014Q4, originally.

22 Recall, again, that some authors do not give factors an economic interpretation, rather a statistical one.

23 US monetary policy normalization can be regarded as *unanticipated* because its precise timing of occurrence is unknown.

linkages between them:

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

where $\times$ stands for freely estimated parameters.

In the *non-recursive scheme*, the restrictions imposed[24] 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 $N \times 3$ block of the matrix Λ^f, which is assumed to be block diagonal. Here, I impose zero restrictions on some of

[24] 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.

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 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).

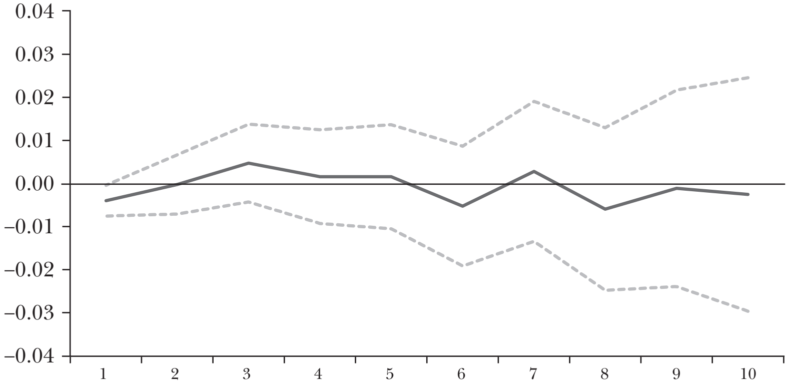
Under the recursive shock identification scheme, an increase of one standard deviation of FFR (2.3 or 230 basis points) reduces quarterly output growth by 0.40% on impact but as confidence intervals grow rather fast as time goes by, forecasts are not credible[25] (see Fig-

[25] 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

Figure 6

FAVAR: IMPULSE-RESPONSE FUNCTION FOR D(Y)

(10, 000 Monte Carlo replications)



Source: BCU and author's calculations.

ures 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 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[26].

There seems to be four channels through which a one-time rise in FFR affects real output in Uruguay. These 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.

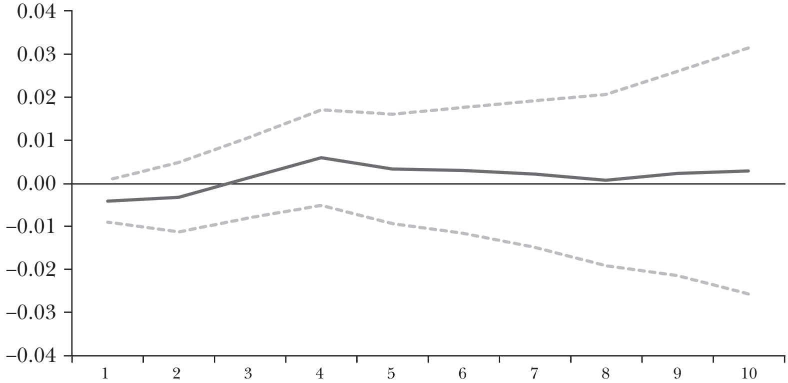
interval crosses the horizontal axis, however, the forecast can either be positive or negative with the same probability and therefore the estimate does not add any useful information. That is why I employ the expression "credible forecasts".

[26] The results are available upon request.

Figure 7

FAVAR: IMPULSE-RESPONSE FUNCTION FOR F1

(10,000 Monte Carlo replications)



Source: BCU and author's calculations.

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.

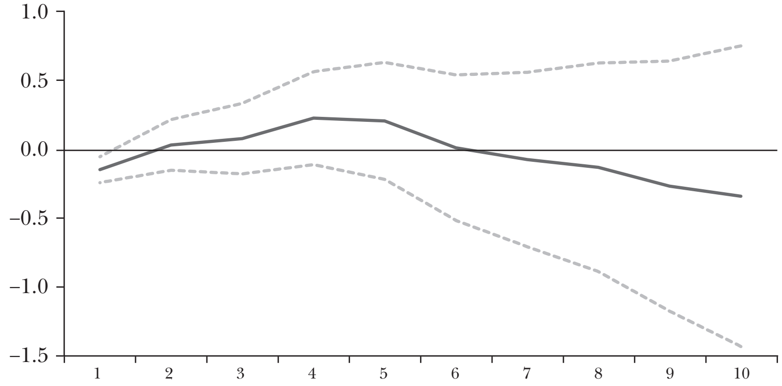
Then, the demand channel appears. Developed countries' output declines, responding to the FFR rise and the decline in commodity prices. This can be seen in Figure 8, where factor F2 significantly drops on impact. The effect coming from the so-called region is not so clear. In essence, in Figure 9 no 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 linkages to the United[27]) and oil price. Foreign monetary policy transmission is usually done through changes in asset prices and capital flows. A tightening in foreign monetary

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

Figure 8

FAVAR: IMPULSE-RESPONSE FUNCTION FOR F2

(10,000 Monte Carlo replications)

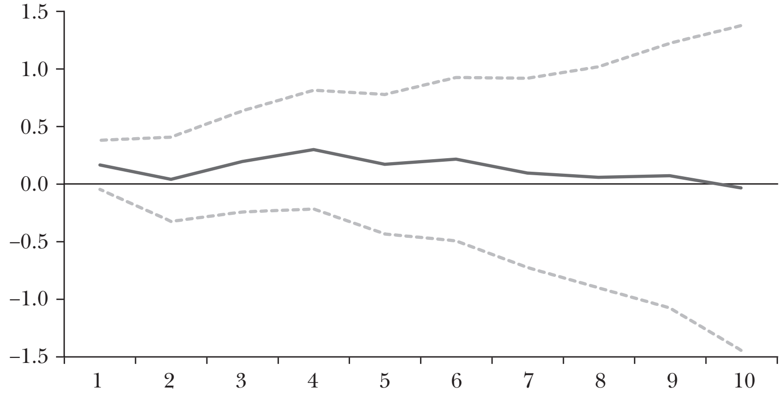


Source: BCU and author's calculations.

Figure 9

FAVAR: IMPULSE-RESPONSE FUNCTION FOR F3

(10,000 Monte Carlo replications)

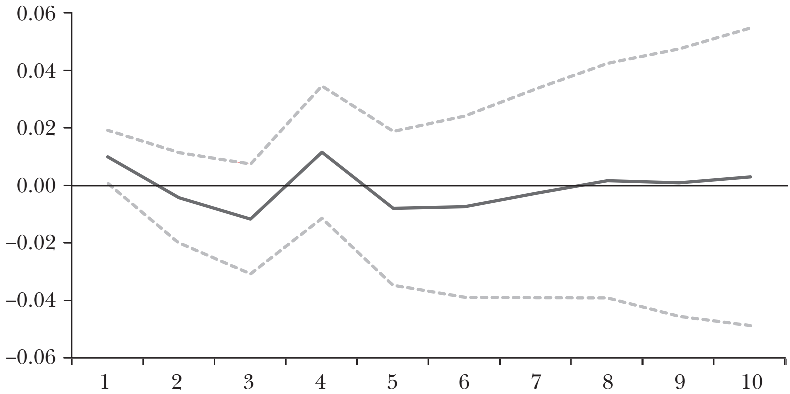


Source: BCU and author's calculations.

Figure 10

FAVAR: IRF FOR D(RER)

(10,000 Monte Carlo replications)

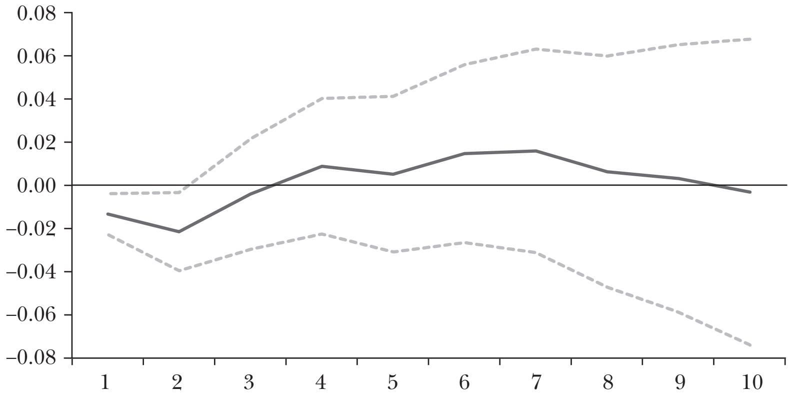


Source: BCU and author's calculations.

Figure 11

FAVAR: IRF FOR D(P_HOUSE)

(10,000 Monte Carlo replications)

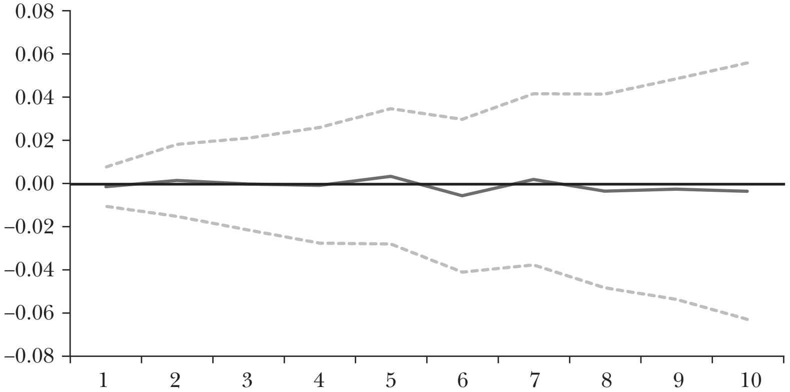


Source: BCU and author's calculations.

Figure 12

FAVAR: IRF FOR D(PB)

(10,000 Monte Carlo replications)



Source: BCU and author's calculations.

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).

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,[28] 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.

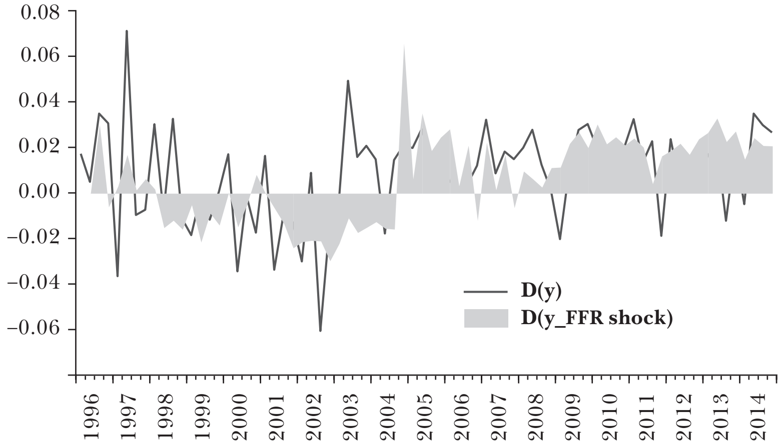
The effect of a US monetary policy change on Uruguayan fiscal accounts is ambiguous, because its primary balance could either be 0.76% better or 1.05% worse on impact. This situation is never solved and the final outcome is inconclusive.

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

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

Figure 13

THE HISTORICAL DECOMPOSITION OF THE URUGUAYAN OUTPUT



Source: BCU and author's calculations.

and imported goods purchases, which will increase the fiscal deficit and will also reduce domestic 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 IRF 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[29] (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.[30]

The historical decomposition of the Uruguayan output growth

[29] Recall that the impulse came from a rise in FFR.

[30] Recall that Choleski's ordering is: FFR, T10, F1, F2, F3, rer, UBI, i_p, , p_h, y, pb. Results are available upon request.

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.[31] When country-specific risk is treated as exogenous, an increase of one 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.

[31] 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 USA. 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).

I also applied block restrictions on the FAVAR equation[32] in order to prevent feedbacks from the observed domestic variables to the foreign interest rate and the unobserved factors blocks:

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

where $O_t = \left(rer_t, UBI_t, i_{pt}, p_{ht}, y_t, pb_t\right)$, $F_t = (F_{1t}, F_{2t}, F_{3t})$, 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 Figures A.1 and B.1 in Annex 2). However, when FFR_im is used as the Federal Reserve's monetary policy stance, the effects on domestic variables are relatively sharper.

5. CONCLUSION

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 20 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 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.[33] This approach is preferred to a traditional VAR because FAVAR models, being a mixture of factor

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

[33] Sample adjusted for lagged variables.

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 IRF 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 0.4% 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.

ANNEXES

Annex 1. Data

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__SA_R)
psoybean	Commodity Price of soybean in US dollars; deflated by US CPI and deseasonalized	International Monetary Fund	D(L_Psoybean__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__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

mnemonics	*Description*	*Source*	*Transformation*
FBKF_PUB	Public domestic investment over GDP ratio	Author's calculations on Banco Central del Uruguay data	L_FBKF_PUB
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)

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
Standard deviation	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

Annex 2. Figures

Figure A.1

IMPULSE-RESPONSE FUNCTIONS, FAVAR WITH BLOCK RESTRICTIONS

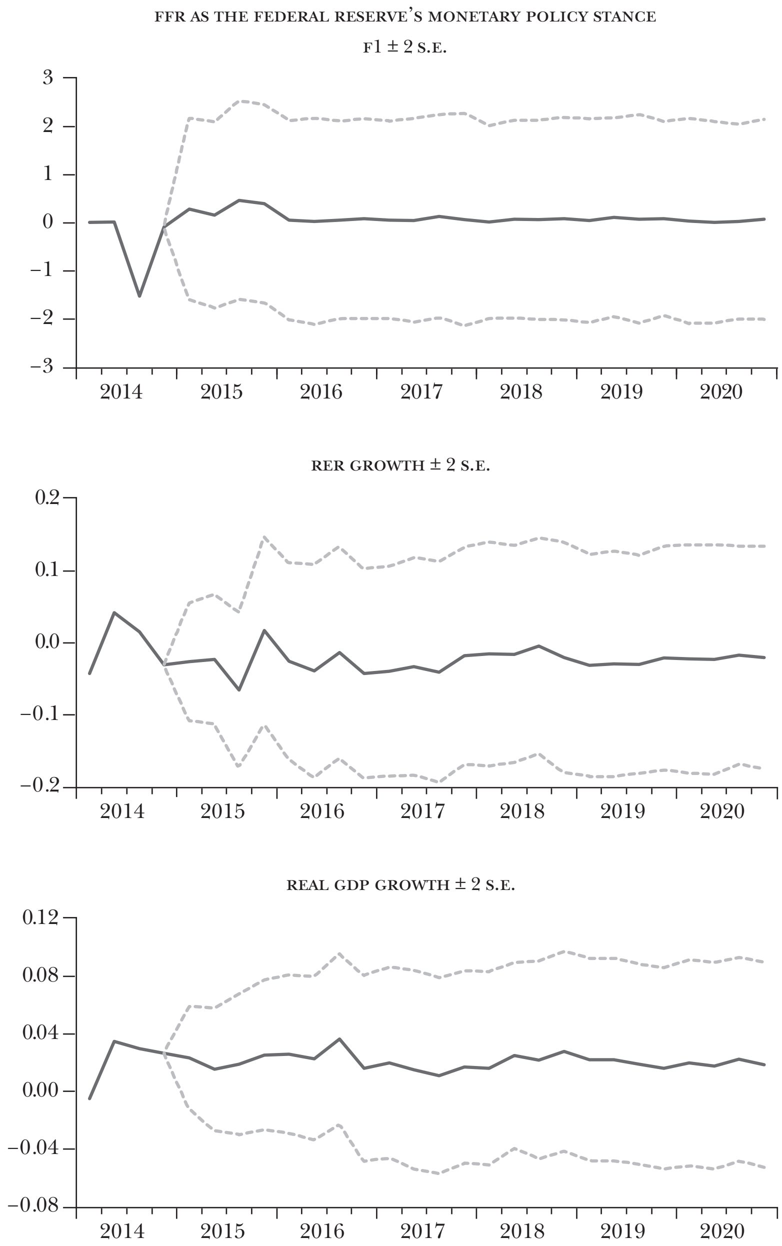
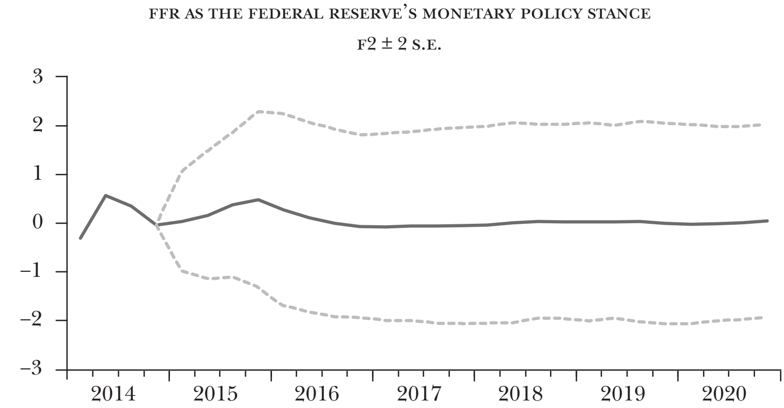
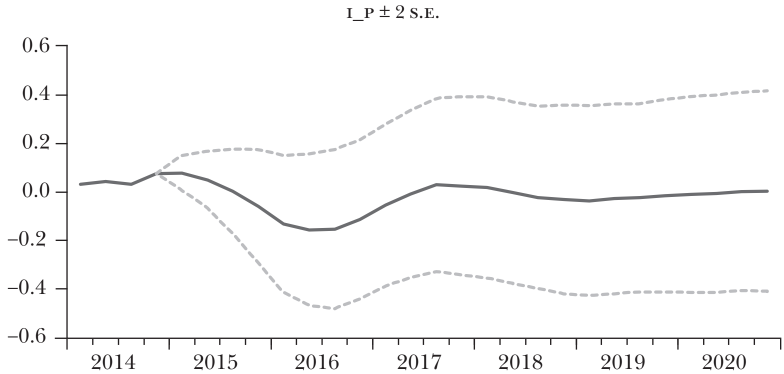


Figure A.1 (cont.)

IMPULSE-RESPONSE FUNCTIONS, FAVAR WITH BLOCK RESTRICTIONS





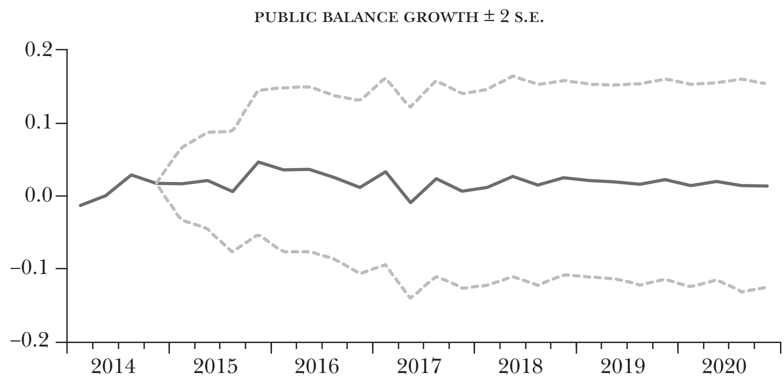
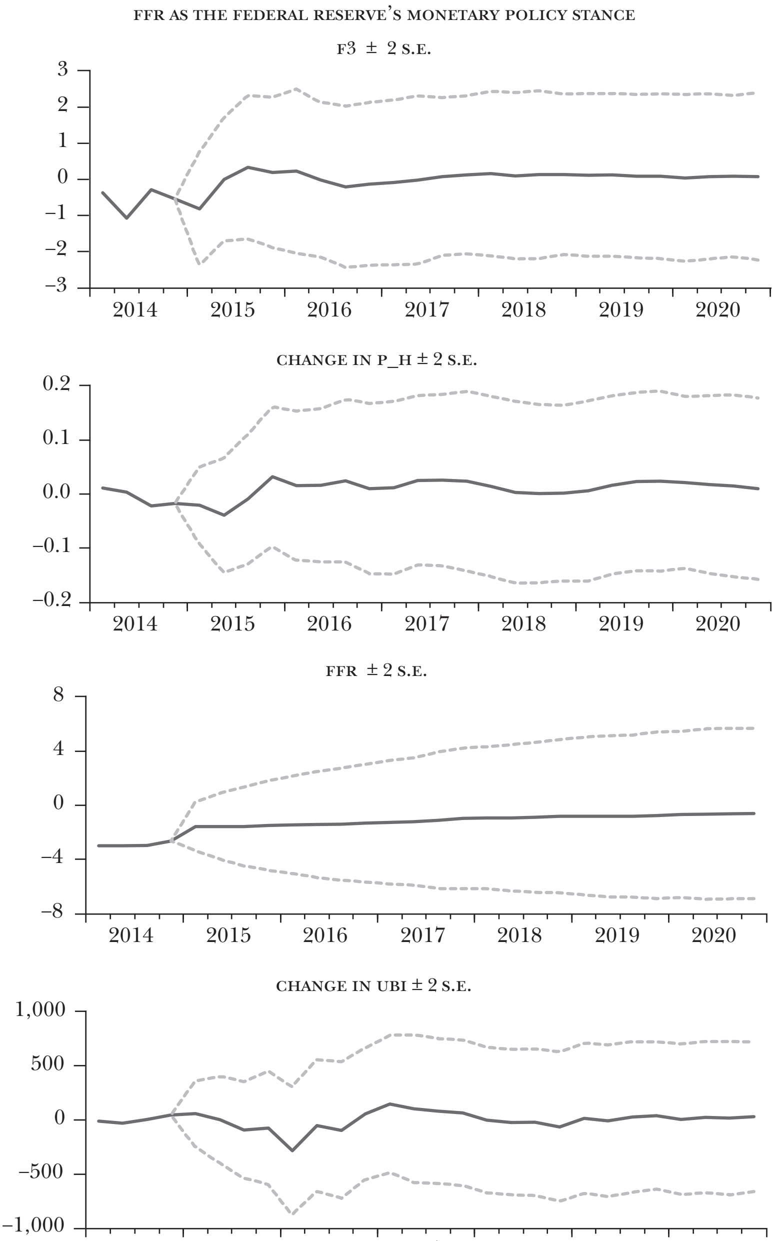


Figure A.1 (cont.)

IMPULSE-RESPONSE FUNCTIONS, FAVAR WITH BLOCK RESTRICTIONS



Source: FRED and own calculations for US interest rates. FRED for exchange rate and stock prices.

Figure B.1 (cont.)

IMPULSE-RESPONSE FUNCTIONS, FAVAR WITH BLOCK RESTRICTIONS

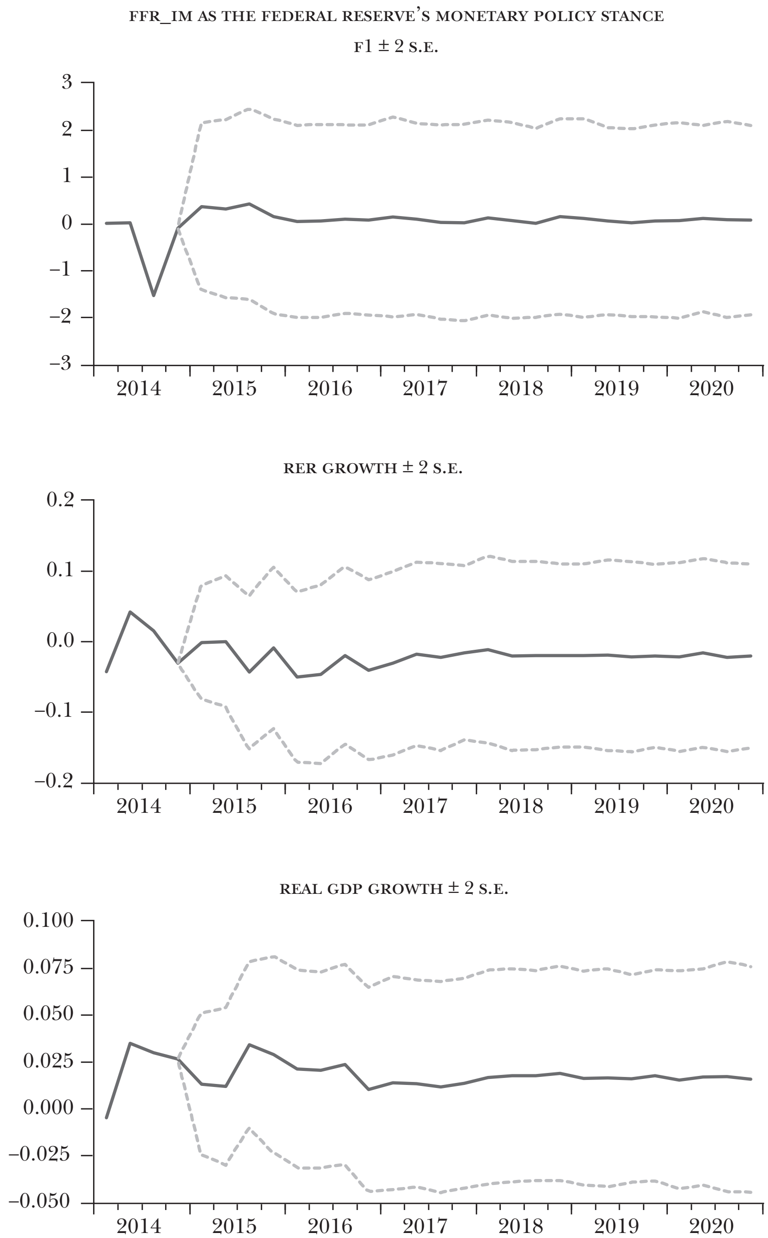


Figure B.1 (cont.)

IMPULSE-RESPONSE FUNCTIONS, FAVAR WITH BLOCK RESTRICTIONS

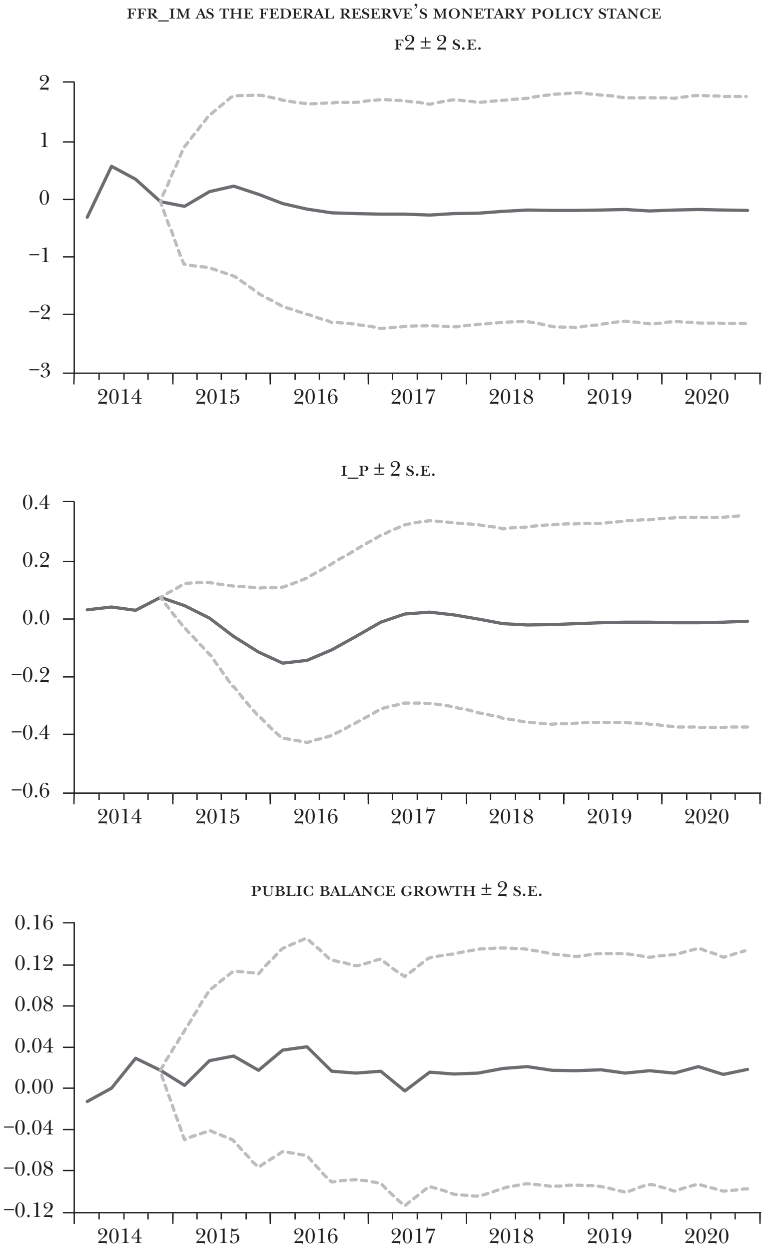
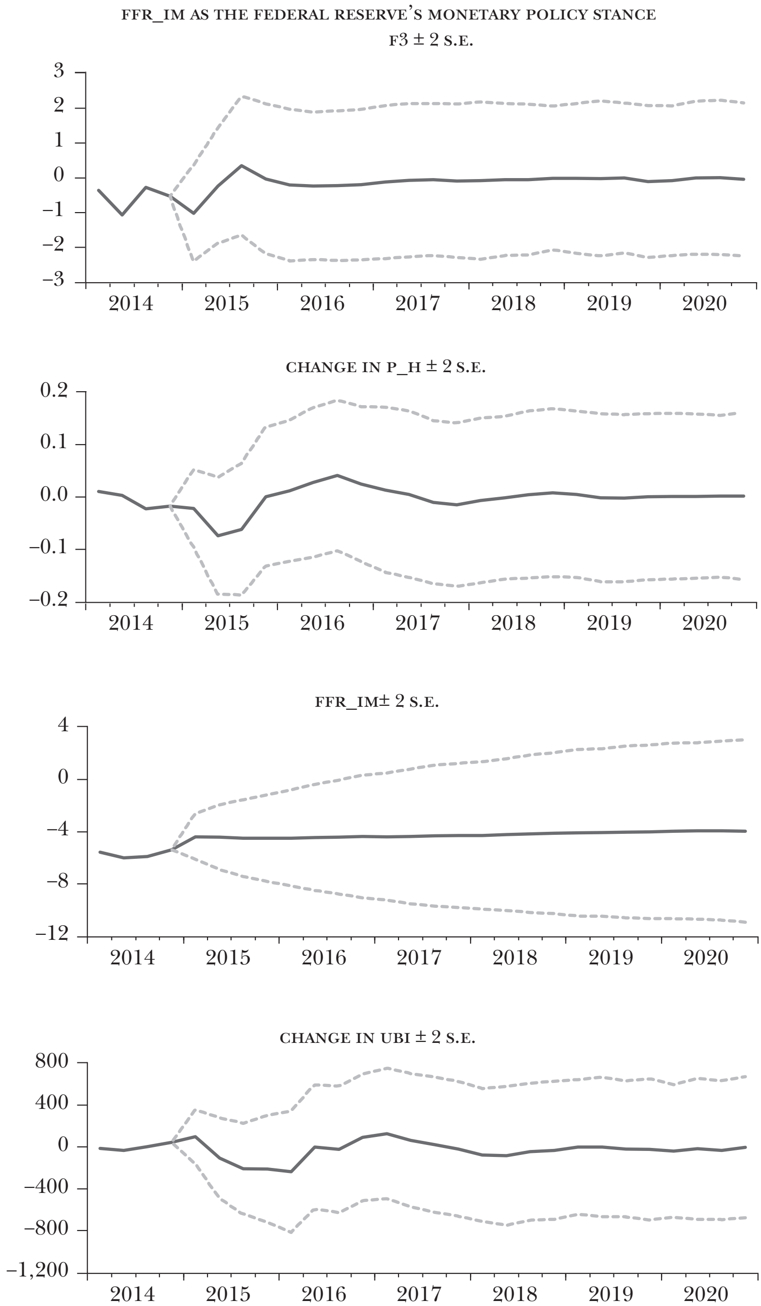


Figure B.1 (cont.)

IMPULSE-RESPONSE FUNCTIONS, FAVAR WITH BLOCK RESTRICTIONS



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