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THE ROLE OF LOAN SUPPLY SHOCKS IN PACIFIC ALLIANCE COUNTRIES: A TVP-VAR-SV APPROACH

Carlos Guevara y
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Abstract

This paper analyzes the effect of loan supply shocks on the real economic activity of Pacific Alliance countries. The econometric approach is a Time-Varying Parameter VAR with Stochastic Volatility (TVP-VAR-SV), which is identified by sign restrictions. Results of a trace test, t-tests and the Kolmogorov-Smirnov test reveal the existence of significant changes in the distribution of parameters over time, which supports the use of time-varying parameters. The results indicate that loan supply shocks have an important impact on real economic activity in all Pacific Alliance countries: about 1% in Colombia, Mexico, and Peru, and about 0.5% in Chile. Moreover, loan supply shocks have a considerable role in driving business cycle fluctuations, not only in crisis periods, but also in stability periods. Their contribution to GDP growth is higher than that of aggregate supply shocks and as high as that of aggregate demand and monetary policy shocks. The evolution of the impact of loan supply shocks on real economic activity shows evidence of cross-country heterogeneity, reflecting different financial structures among Pacific Alliance countries. Furthermore, by assessing the effects on different measures of economic activity, it is estimated that loan supply shocks have a higher impact on domestic demand, while the impact is similar when the model is estimated for non-primary activities. Finally, the sensitivity analysis indicates that the results of the model are robust to different priors specifications, to different measures of external variables, and to multiple sets of sign restrictions. Moreover, by applying an agnostic identification, the results indicate that even letting the response of GDP unrestricted, its response to loan supply shocks remains positive and significant. With this multiple specification, the impact of loan supply shocks on GDP growth ranges between 0.8% and 1.2% in Peru and Colombia, and between 0.5% and 0.8% in Chile. These results are close to the baseline estimation and show robustness. Regarding Mexico, it is estimated that the impact of loan supply shocks varies between 0.8%-3.5%.

JEL Classification: C32, E32, E51.

Keywords: Loan supply shocks, Time-Varying Parameter VAR with Stochastic Volatility, Sign Restrictions, Variance Decomposition, Historical Decomposition, Business Cycles, Pacific Alliance bloc, Chile, Colombia, Mexico, Peru.

Resumen

Este documento analiza el efecto de los choques en la oferta de créditos sobre la actividad económica real de los países de la Alianza del Pacífico. El enfoque econométrico es un VAR con parámetros cambiantes en el tiempo con volatilidad estocástica (TVP-VAR-SV), que se identifica mediante restricciones de signos. Los resultados de un estadístico de traza, t-tests y la prueba de Kolmogorov-Smirnov revelan la existencia de cambios significativos en la distribución de los parámetros a lo largo del tiempo, lo que respalda el uso de parámetros variantes en el tiempo. Los resultados indican que los choques en la oferta de créditos tienen un impacto importante en la actividad económica real en todos los países de la Alianza del Pacífico: alrededor del 1% en Colombia, México y Perú, y alrededor del 0.5% en Chile. Además, los choques de la oferta de créditos tienen un papel considerable en la conducción de las fluctuaciones del ciclo económico, no solo en períodos de crisis, sino también en períodos de estabilidad. Su contribución al crecimiento del PIB es mayor que la de los choques de oferta agregada y tan alta como la de la demanda agregada y los choques de la política monetaria. La evolución del impacto de los choques en la oferta de créditos sobre la actividad económica real muestra evidencia de heterogeneidad entre países, lo que refleja diferentes estructuras financieras entre los países de la Alianza del Pacífico. Además, al evaluar los efectos en diferentes medidas de la actividad económica, se estima que los choques de la oferta crediticia tienen un mayor impacto en la demanda interna, mientras que el impacto es similar cuando se estima el modelo para las actividades no primarias. Finalmente, el análisis de sensibilidad indica que los resultados del modelo son robustos para diferentes especificaciones previas, para diferentes medidas de variables externas y para múltiples conjuntos de restricciones de signos. Además, al aplicar una identificación agnóstica, los resultados indican que aun dejando libre la respuesta del PIB, su respuesta a los choques del suministro de créditos sigue siendo positiva y significativa. Con esta especificación múltiple, el impacto de los choques en la oferta de créditos sobre el crecimiento del PBI oscila entre 0.8% y 1.2% en Perú y Colombia, y entre 0.5% y 0.8% en Chile. Estos resultados están cerca de la estimación de referencia y muestran robustez. Con respecto a México, se estima que el impacto de los choques en la oferta de créditos varía entre 0.8% -3.5%.

JEL Classification: C32, E32, E51.

Keywords: Choques de Crédito, Modelo VAR con Parámetros Cambiantes en el Tiempo y Volatilidad Estocástica, Restricciones de Signo, Descomposición de Varianza, Descomposición Histórica, Ciclos Económicos, Bloque de la Alianza del Pacífico, Chile, Colombia, Mexico, Peru.

The Role of Credit Supply Shocks in Pacific Alliance Countries: A TVP-VAR-SV Approach[1]

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1 Introduction

Macroeconomic literature has focused mostly on credit markets as a propagation channel for shocks. In this context, financial intermediaries have a passive role in the economy, implying that they only transmit macroeconomic shocks originating in other sectors, such as aggregate demand shocks or monetary policy shocks. However, the recent financial crisis highlighted the importance of credit markets not only as a transmission mechanism, but also as a source of shocks that may drive business cycle fluctuations.

Recent work on both the theoretical and empirical fronts emphasizes the role of financial intermediaries as a source of shocks defined as loan supply shocks. In the field of theoretical research, Goodfriend and McCallum (2007), Gerali et al. (2010), and Jermann and Quadrini (2012) assess the role of loan supply shocks on economic activity by introducing banks explicitly in DSGE models; and suggest that such shocks have real effects. On the other hand, empirical literature, by applying sign restrictions to identify credit supply shocks (Bean et al., 2010; De Nicoló and Lucchetta, 2011; Busch et al., 2010, Helbling et al., 2011; Hristov et al., 2012), or by employing survey methodologies (Bassett, et al., 2014), show that loan supply shocks have significant effects on real economic activity.

Nevertheless, this literature focuses on countries where banking operations have stabilized after a period of accelerated development, and capital markets have taken on a greater role as a source of funds. In this context, loan supply shocks may account partially for the impact from financial markets, but may not be the main contributor. For this reason, in order to shed light about the importance of shocks arising from the financial sector, this research assesses the effects of loan supply shocks in economies where the banking sector is the main source of funds. In particular, the countries under study are Chile, Colombia, Mexico, and Peru; i.e., the members of the Pacific Alliance (PA) bloc. Unlike other economies, there is no previous literature analyzing the effects of loan supply shocks in PA countries. Furthermore, in order to provide a richer quantitative analysis of the real effect of loan supply shocks, this research assesses its impact on two different measures of economic activity, domestic demand and non-primary GDP, with an aim to shed light about the different ways a shock can affect a country's macroeconomic structure.

[1]This paper is drawn from Carlos Guevara's Thesis at the Department of Economics of the Pontificia Universidad Católica del Perú (PUCP). We thank the useful comments by Professor Paul Castillo (Central Reserve Bank of Peru, BCRP, and PUCP) and participants in the 4th Annual Congress of the Peruvian Economic Association (APE, Lima, August 11-12, 2017). Any remaining errors are our responsibility.

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In the countries under study, the banking sector has expanded considerably, which may suggest that the dynamics between the banking system and real economic activity may not remain constant over time, as documented by Barnett and Thomas (2014) for other cases. Along these lines, the model proposed in this research is a time-varying parameter VAR with stochastic volatility (TVP-VAR-SV) similar to the specification suggested by Bijsterbosch and Falagiarda (2015) and Gambetti and Musso (2017). The use of time-varying parameters in the model allows to estimate the time-varying dynamics between variables while, according to Nakajima (2011), the introduction of stochastic volatility is expected to improve the estimation of the model. In order to identify the loan supply shocks, sign restrictions are employed. In this regard, Paustian (2007) argues that it is required to identify as many shocks as possible to identify a particular shock. Thus, four kinds of shocks are identified: aggregate demand (AD) shocks, aggregate supply (AS) shocks, monetary policy (MP) shocks, and loan supply (LS) shocks. In this baseline specification, an expansive LS shock generates a negative response in loan rates and a positive response in credit volume, as well as a positive response in both GDP growth and inflation. The model is estimated using Bayesian techniques, which is suitable for the high dimensionality of the parameter space and for the non-linearities of the model; see Bijsterbosch and Falagiarda (2015).

In order to assess the presence of time-varying parameters in the model, three tests are performed: the trace test, the Kolmogorov-Smirnov test, and the t-test. The results reveal the existence of significant changes in the distribution of parameters across time for all countries. In the case of the trace test, the 16%, 50% and 84% percentiles are greater than trace, indicating that the coefficients are subject to multiple shocks, causing them not to remain constant. On the other hand, the Kolmogorov-Smirnov test and the t-test indicate that the distributions of most of the coefficients change across the analyzed periods in all countries.

Results from the baseline model indicate that LS shocks have a significant effect on real economic activity in all PA countries. In particular, the effect is estimated to be higher in Colombia, Mexico, and Peru than in Chile, which may be explained by the differences across PA countries' financial structures. By including the magnitude of the shocks in the analysis through variance decomposition, LS shocks appear to account for a large share of the variance decomposition of GDP growth in all countries, about 16% of the total share, larger than AS shocks and as large as AD shocks. Moreover, the analysis of historical decomposition shows that LS shocks appear to be an important factor driving the slowdown periods of GDP growth in all PA countries. In particular, during the Russian and Asian crises of the late 1990s, LS shocks, associated with the sudden stop of external capital flows triggered by enhanced global risk, diminished GDP growth by about -0.67 percentage points in Chile, Colombia, and Peru. In contrast, in Mexico the first negative shocks occurred after 2000, implying that the effect is slow to materialize in this economy.

Regarding the evolution of the effect of LS shocks, the t-test and the Wilcoxon Rank Sum test are performed to assess whether the impact has changed over time. Therefore, it is estimated that the distribution of the impulse response function shows significant differences across the analyzed periods, thus showing evidence that the impulse response does not remain constant. Moreover, the results show that the power of LS shocks to affect GDP growth has evolved in a heterogeneous way among PA countries. In Colombia and Peru, the impact in recent periods is estimated to be higher than in the 1990s, while in Mexico and Chile the impact has increased considerably, although at a certain point it started to decline to levels close to those at the beginning of the sample.

In order to assess the robustness of the results, three sensitivity analyses are performed: different prior specifications, different measures of external variables, and multiple sets of sign restrictions. In most specifications the results do not differ much from baseline, indicating that the analysis is robust. Moreover, an important result is obtained in the analysis of different sets of sign restrictions. As can be observed in the baseline model, the response of real economic activity to LS shocks is restricted to be positive. This may cause the true effect not to be captured. For that reason, by taking a different approach from the previous empirical literature, the response of GDP growth to LS shocks is not restricted and the estimated response might be interpreted as the genuine response. This idea follows the agnostic identification proposed by Uhlig (2005). The results indicate that, even in this agnostic identification, the response of real economic activity remains positive and significant.

The paper is structured as follows. Section 2 provides a comprehensive review of the literature, both theoretical and empirical. Section 3 lays out the econometric model, explains the statistical methodology for estimating the parameters, provides a brief description of the data, and discusses the identification scheme. Section 4 presents and discusses the results of the model. Section 5 discusses the robustness of the results and explains some limitations of the model. Sections 6 provides the conclusions. An Appendix contains detailed information about the data and sources.

2 Literature Review

The initial approach to the study of credit markets focuses on financial intermediaries as a propagation mechanism of disturbances generated in other markets. This was emphasized first by Fisher (1933) in his debt-deflation theory, where the author argues that a generalized decrease in prices increases the value of banking credit and, as a result, agents stop consuming to pay their debts, so aggregate demand decreases more than due to the initial shock.

Fisher's analysis is complemented by Roosa (1951), who proposes a different mechanism whereby credit markets propagate monetary policy (the availability doctrine). In this context, monetary policy affects bank funds directly rather than indirectly through interest rates. This is called the lending channel of the availability doctrine. Although it is a supply-side theory, it does not describe how the banks offer credit and ignores the role of demand. In this respect, the credit view or credit channel literature argues that both the interest rate channel and the bank lending channel operate together; see Bernanke and Gertler (1995). Moreover, this literature proposes a second channel, known as the balance sheet channel, where a restrictive monetary policy decreases asset prices, thereby contracting the value of borrowers' collateral and deteriorating their creditworthiness. In this vein, credit markets have the role of amplifying the impact of monetary policy.[4]

[4] More recently, Borio and Zhu (2008) and Adrian and Shin (2009) complemented the analysis of credit markets and monetary policy by proposing a different propagation mechanism called *risk-taking channel* monetary policy not only affects the quantity but also the quality of credit.

An assumption of the literature discussed is that financial markets are complete. However, as Bernanke (1983) emphasizes, financial markets are incomplete because intermediation has transaction and information costs. Following this approach, Kiyotaki and Moore (1997), by modeling incomplete contracts, propose a different mechanism through which the financial sector propagates shocks. In this theory, small technology or income shocks generate large cycles due to changes in collateral value and credit constraints. In the same line, Bernanke et al. (1999) introduce an external finance premium, called the financial accelerator, which depends inversely on the wealth of borrowers. The authors argue that, in economic booms, agency costs fall because borrowers are more likely to pay their debts while the reverse happens in recessions. In this approach, credit markets work as a propagation mechanism that amplifies economic cycles. Nevertheless, Carlstrom and Fuerst (2001) propose that agency costs do not have an amplification role, but rather dampen the initial response of output to the shock.

The literature cited above considers that credit markets are a propagation channel, so there is no role for credit markets in driving business cycle fluctuations. Indeed, Cochrane (1994) and Bernanke and Gertler (1995) argue that credit is not a driving force of economic fluctuations, except in financial crises. However, Goodfriend and McCallum (2007) criticize this position because models do not explicitly include a banking sector. For that reason, they introduce the banking sector in DSGE models and formulate explicit shocks originated in the supply side of credit markets. In particular, they propose two types of financial shocks: (i) a banking productivity shock or a loan productivity shock; and (ii) an effective collateral shock or a financial distress shock. From this specification, the authors find that the cost of adjustment in bank production generates a banking attenuating effect that works in the opposite direction of the financial accelerator mentioned by Bernanke et al. (1999); and detect that financial shocks are major drivers of macroeconomic variables.

One important assumption in Goodfriend and McCallum (2007) is that financial frictions[5] are located on the supply side of credit markets. In this respect, Christiano et al. (2010) propose a model where frictions are located on the demand side of credit; i.e., entrepreneurs. They propose, among other disturbances, three shocks, one related to the demand side and the other two related to the supply side: (i) a financial wealth shock (shocks on financial frictions related to entrepreneurs), (ii) banking sector technology shocks; and (iii) shocks associated with the relative value of excess reserves (both associated with banks). The results from this specification is that the inclusion of banks has little effect on most of the variables. Moreover, the authors find that the shock on financial friction is most relevant than the financial shocks related to financial intermediaries.[6]

However, the analysis by Christiano et al. (2010) assumes perfect competition in credit markets. Gerali et al. (2010) criticize this assumption and formulate a model with an imperfectly competitive banking sector and financial frictions on the demand side. In their approach, banks have market power and offer different rates for deposits and loans. The main findings are that banks have

[5] Brunnermeier, Eisenbach, and Sannikov (2012) present a comprehensive literature review on financial frictions.

[6] Arend (2010) presents an analysis of this novel literature on credit markets. The author points out that to capture the importance of credit market shocks, financial frictions must be located inside the financial intermediaries sector; i.e., on the supply side of credit markets. However, subsequent literature proposes that the importance of credit markets as source of disturbances could stem from financial frictions on both the supply or demand sides.

two roles in the economy: (i) as a shield for economic agents against interest rate fluctuations, which creates an attenuating effect as in Goodfriend and McCallum (2007); and (ii) as a source of volatility that affects business cycle fluctuations.[7]

On the other hand, Jermann and Quadrini (2012) develop a representative firm model in which investment is financed using both debt and equity. In their model, if the firm chooses to default, lenders can recover only a fraction of their net worth, and shocks on the fraction the lender can recover severely alter firms' borrowing limits. The authors find that these shocks arising from the lending sector are an important driver of business cycles. Moreover, Khan and Thomas (2013) find that, in absence of any real shock on the economy, a credit shock originated in the financial system produces a recession which can be not only large but also persistent.

In general, as documented by Claessens et al. (2017), there is a theoretical consensus that credit markets have a dual role in macroeconomics: as a propagation mechanism of shocks originated in other markets and as a source of shocks driving business cycle fluctuations. Moreover, these shocks arising from the financial sector could have an important contribution to macroeconomic variables. In particular, these financial disturbances that are essentially credit supply shocks are the main interest of this research. The definition may vary according to researchers' assumptions. In this research, credit supply shocks are defined along the same lines as Hafstead and Smith (2012); i.e., as a negative shock on the cost of bank intermediation.[8] Specifically, a negative shock on bank intermediation costs can be understood as a decrease in the costs incurred by banks to provide credit to their clients.

Regarding the empirical literature, the evidence from early research on LS shocks supports both a high importance and a low relevance of such disturbances for real economic activity. For instance, Stock and Watson (1989), Friedman and Kuttner (1992), and Kashyap et al. (1994) find that proxies of credit conditions have a predictive power for real economic activity. However, Ramey (1993) estimates a multivariate error correction model and detects that credit variables such as credit velocity and the loan-to-securities ratio has a minimal contribution to output. In fact, Bernanke and Gertler (1995) argue that identifying output or credit movements due to a shift in credit demand or supply is particularly difficult. On the one hand, credit volume could increase because households and firms may demand more for consumption or investment, respectively. On the other hand, banks may be willing to offer more credit because of positive economic conditions. Thus, it is not possible to assess the role of LS shocks on economic activity because there is an important identification problem. Furthermore, Bernanke and Gertler (1995) argue that LS shocks can play a role only during economic crises and their contribution to real activity during stability periods may be very small.[9]

[7] These results are discussed in detail in Viziniuc (2015).

[8] The closest definition to the one adopted in this research is proposed by Gerali et al. (2010), who define the shocks arising from the banking sector as shocks on loan rates, on the loan-to-value ratio, and on bank capital. For their part, Christiano et al. (2010) define credit supply shocks as bank funding technology shocks and as bank reserve demand shocks. Moreover, Cúrdia and Woodford (2010) characterize loan supply shocks as bank resource cost shocks and bank loss rate shocks. Another definition is proposed by Gertler and Karadi (2011), who argue that credit supply shocks can be understood as shocks on bank capital quality and shocks on banks net worth.

[9] One strand of empirical literature assesses the identification problem by using micro data. Lown et al. (2000) use information of bankers surveyed to build an index that can be assumed as a measure of loan supply. They introduce

Another strand of empirical literature uses sign restriction methodologies as proposed by Faust (1998), Canova and De Nicoló (2002), and Uhlig (2005) to isolate LS shocks. Bean et al. (2010) and De Nicoló and Lucchetta (2011) propose that credit supply shocks can be isolated from demand shocks by restricting supply shocks to affect credit volume and loan rates in different directions. In their econometric approach, Bean et al. (2010) estimate Bayesian VAR models for the U.S. and the UK, and detect that both credit supply and credit demand shocks explain credit growth as much as aggregate supply and demand shocks. On the other hand, De Nicoló and Lucchetta (2011) use a frequentist approach to estimate a factor-augmented VAR for G-7 countries, and find that loan demand shocks account for most of the movement of credit growth and, in some countries, for the movement of GDP growth.

Nevertheless, Meeks (2012) criticizes previous literature and argues that restrictions must be imposed only on pure financial variables. In this way, the author uses a VAR model and identifies the model by imposing restrictions only on spreads and default rates and assuming an agnostic position on the response of GDP. He finds that credit supply shocks have a lesser impact on economic activity in stable times, but are highly important during economic crises, which confirms the stance of Bernanke and Gertler (1995). In a similar line, Helbling et al. (2011) argue that the response of other variables needs to be restricted to identify LS shocks. In this regard, instead of imposing restrictions only on credit volume and loan rates, they also impose productivity to increase and default rates to diminish. They document that credit market shocks have a considerable impact on output, but the effects on other variables are not significant.

The cited literature proposes that the sign restriction approach can isolate shocks. However, the response of variables to an LS shock may be the same as for an MP shock or an AS shock. In this regard, Hristov et al. (2012) criticize previous identification schemes and propose that the response of monetary policy should go in the opposite direction of the response of the lending rate when LS shocks hit the economy. Based on this approach, they estimate a panel VAR for Euro Area countries and find that a considerable share of the decline of GDP growth (about 0.6 percentage points) and credit growth (around 1.9 percentage points) is related to LS shocks, and they show that the Euro Area has an important degree of financial heterogeneity.

A common feature of previous literature is that sign restrictions are imposed at the time of impact. Nevertheless, the impact of financial shocks may take some time to affect economic activity. Taking into consideration this idea, Barnett and Thomas (2014) propose an identification based

the index in a reduced model and detect that changes in credit standards, defined as a company's requirements to establish customer creditworthiness, are highly correlated with commercial bank lending and GDP. However, their analysis relies on reduced-form models. For instance, Lown and Morgan (2006) estimate a recursive SVAR that includes the credit standards index and confirm the results of Lown et al. (2000). Moreover, they detect that credit standards are significant in predicting real GDP and inventory investment in the trade sector. More recently, Bassett et al. (2014) provided similar evidence using this approach. For other studies in this literature, see Del Giovane et al. (2011) and Darracq Paries and De Santis (2015). The micro data-based methodology discussed above assumes that bank surveys capture exogenous changes in bank activity. However, bankers' response may be influenced by credit demand conditions. Moreover, the construction of the index is subject to the criteria of the researcher, so different specifications may lead to different results. In this regard, although this literature attempts to overcome the problem, demand conditions are not fully isolated. As a result, a possibility is to use nonlinear models. However, under this approach, a researcher models the relevance of credit through credit market states and there is not an explicit LS shock. See Balke (2000), and Calza and Sousa (2006).

on both zero and sign restrictions. In particular, they impose GDP growth not to react contemporaneously to LS shocks. The estimation of their model shows that an adverse LS shock drives GDP growth and inflation in opposite directions in the UK. Along the same lines, Halvorsena and Jacobsen (2014) implement different identification sets by mixing zeroes and sign restrictions. Using data from Norway and the UK, the authors show that the importance of LS shocks in business cycle fluctuations is robust under multiple identification schemes.

Moreover, Barnett and Thomas (2014) suggest the possibility that the impact of LS shocks has not remained constant over time because banking sectors have expanded considerably. For this reason, they estimate rolling-window regressions and find that the impact of LS shocks has increased over time and that its effect has become more persistent. These results suggest that coefficients in models are time-varying. Following this idea, Bijsterbosch and Falagiarda (2015) use a TVP-VAR-SV, introduced by Cogley and Sargent (2005) and Primiceri (2005), to capture the changing effects over time in Euro Area countries. They follow previous literature and identify the model by sign restrictions based on the theoretical model of Gerali et al. (2010). The findings suggest that, besides the important role of LS shocks in driving economic fluctuations, the effect of these shocks has increased strongly after the financial crisis. Moreover, the authors document that after the 2008 crisis, homogeneous countries began to show a heterogeneous behavior. In a similar fashion, Gambetti and Musso (2017) estimate a TVP-VAR-SV to study credit supply shocks on three important economic areas: the UK, the U.S., and the Euro Area. The authors detect significant time variation in parameters and estimate that LS shocks play an important role in driving GDP growth, inflation, and credit growth, particularly during economic crises. For example, the authors estimate that the contribution of these shocks explains almost 20% of the decline in GDP growth in the recent crisis for the Euro Area and the U.S.

An important feature of the literature discussed is that it focuses on countries where banking operations have stabilized after a period of accelerated development, and capital markets have taken on a greater role as a source of funds. In this context, LS shocks may account partially for the effect of financial markets, but may not be the main contributor. For this reason, this research attempts to show evidence from economies where banking sectors are the main source of funds. In particular, the countries under study are Chile, Colombia, Mexico, and Peru; i.e., the members of the PA bloc. Unlike other countries,[10] there is no empirical literature assessing the effects of LS shocks on real economic activity in PA countries. Moreover, in order to provide a richer quantitative analysis of the real effect of LS shocks, this research assesses their impact on two different measures of economic activity, domestic demand and non-primary GDP, which sheds light on the ways a shock can affect a country's macroeconomic structure.

[10] Abildgren (2012) for Denmark; Deryugina, et al. (2015) for Russia; Duchi and Elbourne (2016) for Netherlands; Halvorsen and Jacobsen (2014) for Norway; Houssa et al. (2013) for South Africa; Mwabutwa et al. (2013) for Malawi; Kabashi and Suleva (2016) for Macedonia; Hosszú (2018) for Hungary; Pereira and da Silva Fonseca (2012) for Brazil; Bäurle and Scheufele (2016) for Switzerland.

3 Empirical Methodology

3.1 The Empirical Model

The empirical approach follows the model proposed by Primiceri (2005), which is a TVP-VAR-SV model. On one hand, the inclusion of time-varying coefficients attempts to capture the evolution of macroeconomic dynamics. On the other hand, multivariate stochastic volatility allows to capture shocks heteroskedasticity, which improves estimates according to Nakajima (2011). Consider the reduced-form VAR:

$$y_t = B_{0,t} + \sum_{i=1}^{p} B_{i,t} y_{t-i} + u_t, \tag{1}$$

where y_t is an $n \times 1$ vector of endogenous variables, $t = 1, 2 \ldots, T$, $B_{0,t}$ is an $n \times 1$ vector of time-varying intercepts, $B_{i,t}$ is an $n \times n$ matrix of time-varying coefficients, and u_t is the heteroskedastic innovation, such that $E(u_t) = 0$ and $E(u_t u_t') = \Sigma_t$, where $[\Sigma]_{ij} \neq 0$ for each $i \neq j$. The variance-covariance matrix Σ_t is factorized by triangular decomposition $\Sigma_t = A_t^{-1} H_t H_t' A_t^{-1\prime}$, where A_t is an $n \times n$ lower triangular matrix that associates variance of structural innovation with variance of the model in its reduced form; i.e. contemporaneous coefficients:

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{21,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{n1,t} & \cdots & \alpha_{n(n-1),t} & 1 \end{bmatrix}, \tag{2}$$

and H_t is an $n \times n$ diagonal matrix that contains the standard deviations of the structural errors:

$$H_t = \begin{bmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{n,t} \end{bmatrix}. \tag{3}$$

In order to obtain a tractable model, the VAR is transformed into a simultaneous equation model. Let $Z_t' = [1, y_{t-1}', \ldots, y_{t-p}']$ be a row vector of exogenous variables and $B_t = [B_{0,t}, B_{1,t}, \ldots B_{p,t}]$ a matrix of time-varying coefficients. Then, the elements of B_t are stacked such that $\beta_t = vec(B_t')$, where vec is the column stacking operator. Thus, equation (1) can be written as:

$$y_t = [I_n \otimes Z_t']\beta_t + A_t^{-1} H_t \epsilon_t, \tag{4}$$

where the operator$\otimes$ is the Kronecker product and $u_t = A_t^{-1} H_t \epsilon_t$, where the term ϵ_t is the structural shock, such that $E(\epsilon_t \epsilon_t') = 0$ for each $i \neq j$.

In order to establish the dynamics of the model, it is required to collect the components of H_t and A_t. In this way, the $i < j$ elements of A_t are compiled in a vector $\alpha_t = [\alpha_{21,t}, \alpha_{31,t}, \ldots, \alpha_{n(n-1),t}]'$ and the diagonal elements of H_t in a vector $\sigma_t = [\sigma_{1,t}, \sigma_{2,t}, \ldots, \sigma_{n,t}]'$. Then, by proposing a law of motion for β_t, α_t and σ_t, the dynamics of the model can be expressed as:

$$\beta_t = \beta_{t-1} + \eta_t, \tag{5}$$

$$\alpha_t = \alpha_{t-1} + \psi_t, \tag{6}$$

$$\ln \sigma_t = \ln \sigma_{t-1} + \varphi_t, \tag{7}$$

where $\eta_t \sim N(0, \Sigma_\beta)$, $\psi_t \sim N(0, \Sigma_\alpha)$ and $\varphi_t \sim N(0, \Sigma_\sigma)$ and matrices of innovations Σ_β, Σ_α, and Σ_σ are diagonal.

Note that β_t and α_t are modeled as random walks, while σ_t is a geometric random walk process. These assumptions have important implications. First, the model specification allows to capture both transitory and permanent shifts in the parameters, which is desirable for the purposes of this research. However, the variance of parameters depends on time; thus, it increases arbitrarily as the sample increases. Second, by assuming a random walk for the law of movements of the parameters, the underlying shift in coefficients can be captured. Nevertheless, spurious movements and implausible coefficient behavior may be estimated, given that the model allows parameters to move freely. Regarding the first negative implication, Primiceri (2005) shows through simulations that results are similar in both specifications, whether random walks or autoregressive processes. Regarding the second case, the movement of parameters can be controlled by the prior tightness of the covariance matrix of innovations. Thus, by choosing suitable prior tightness, the model can be estimated appropriately. However, different set of priors might lead to different models. So, as marked by Nakajima (2011), a prior sensitivity analysis would be necessary in order to assess robustness of the results. For this reason, in the last part of the paper, a sensitivity analysis of priors is presented.

There are four sources of shocks in the model: structural shocks ϵ_t, disturbances associated with the time-varying parameters η_t, innovations from contemporaneous coefficients ψ_t, and shocks from stochastic volatility φ_t. These innovations are collected in a vector V such that:

$$V = Var \begin{bmatrix} \epsilon_t \\ \eta_t \\ \psi_t \\ \varphi_t \end{bmatrix} = \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_\alpha & 0 \\ 0 & 0 & 0 & \Sigma_\sigma \end{bmatrix}, \tag{8}$$

where it is assumed that all shocks in the model are orthogonal; i.e., V is a diagonal matrix and Nakajima (2011) shows that the results are not sensitive to this assumption.

In order to study the dynamics of the model through impulse response functions (IRFs), equation (1) is converted into its moving average representation:

$$y_t = \mu_t + \Psi_t(L)u_t, \tag{9}$$

where μ_t is the time-varying mean of y_t and $\Psi_t(L) = \sum_{j=1}^{\infty} \Psi_{j,t}L^j$ is the time-varying multiplier of the Wold decomposition. The IRFs are determined by $\Psi_t(L)$, but the targets are structural IRFs defined by $\Psi_t(L)A_t^{-1}H_t$. To achieve this objective, sign restrictions are used. The implementation of sign restrictions need an orthogonal matrix R such that $RR' = R'R = I_n$. By including the identity matrix in the decomposition of $\Sigma_t = A_t^{-1} H_t I_n H_t' A_t^{-1\prime}$ and by replacing I_n, the result is $\Sigma_t = A_t^{-1} H_t R R' H_t' A_t^{-1\prime}$. Thus, the innovation of the reduced form is such that $\epsilon_t = A_t^{-1} H_t R u_t$. Note that the expression of ϵ_t has changed. However, since matrix R is orthogonal, the decomposition of Σ_t is not altered. Moreover, $A_t^{-1} H_t H_t' R$ is not necessarily a triangular matrix, and therefore the IRFs are $IRF = \mathbf{\Psi}_t(L) A_t^{-1} H_t R$. Nevertheless, matrix R is not unique. For that reason, many draws are simulated for each possible value of R.

3.2 Estimation

Given the context of a high number of parameters, high dimensionality of the parameter space, and non-linearity (Primiceri, 2005; Koop and Korobilis, 2010; Bijsterbosch and Falagiarda, 2015), we use a Bayesian approach to estimate the model.[11] The parameters to be estimated are β_t, α_t, $\ln \sigma_t$, Σ_β, Σ_α, and Σ_σ. The following priors are assumed for these parameters: $\beta_0 \sim N(\hat{\beta}, \hat{V}_\beta)$, $\alpha_0 \sim N(\hat{\alpha}, \hat{V}_\alpha)$, $\ln \sigma_0 \sim N(\ln \hat{\sigma}_0, I_n)$, $\Sigma_\beta \sim W(s_1 k_1 \hat{V}_\beta, s_1)$, $\Sigma_\alpha \sim W(s_2 k_2 \hat{V}_\alpha, s_2)$, $\Sigma_\sigma \sim W(s_3 k_3 I_n, s_3)$ where $N(a, b)$ represent the Normal distribution with mean a and variance b, and $W(R, h)$ represent the Wishart distribution with scale matrix R and h degrees of freedom. The priors are calibrated with the estimation of $\hat{\beta}$, $\hat{\alpha}$, $\hat{V}_\beta$, $\hat{V}_\alpha$ and $\ln \hat{\sigma}_0$ by OLS. The values s_1, s_2 and s_3 are the degrees of freedom of each prior , and are set equal to the corresponding number of rows of $\Sigma_\beta, \Sigma_\alpha$ and Σ_σ, respectively. The parameters k_1, k_2 and k_3 control the tightness of the priors. In the context of TVP-VAR-SV, these parameters represent the prior beliefs of time variation. In particular, k_1, k_2 and k_3 are set to 0.0005, 0.05, and 0.5, respectively, which are similar to the priors used by Gambetti and Musso (2017). These parameters are modified in the sensitivity section.

Regarding lag order p, there are no selection criteria in the context of TVP-VAR-SV. Thus, to approximate the lag order, a plain VAR is estimated with the same variables and selection criteria are then calculated. In general, the results are the following: the AIC, HQ, and SIC criteria choose $p = 8$, $p = 2$, and $p = 1$, respectively. In order to avoid overparameterization, the Schwarz criterion is selected, thus $p = 1$.

Finally, the simulation is performed for 10,000 Gibbs iterations, discarding the first 5,000 and collecting one of every 5 iterations from the remaining 5,000. Thus, 1,000 draws are collected. The first sampling of the priors is estimated by ordinary least squares.

3.3 Data

The variables analyzed are six ($n = 6$): real GDP annual growth, annual inflation, loan volume annual growth, the loan rate, the short-term interest rate, and Standard & Poor's General Stock Commodity Index (SPGSCI) annual growth. The definitions and sources of variables associated with each country, as well as the methodology to construct each series, is detailed in the Appendix. The selected sample period for the analysis is restricted to availability of the loan rate. This causes the span of data to vary among the countries under study. In particular, data for Chile, Colombia, Mexico, and Peru are available for the periods 1990Q1-2017Q1, 1994Q1-2017Q1, 1995Q3-2017Q1,

[11] For the detailed process of the estimation, see the online Appendix of Galí and Gambetti (2015).

and 1993Q2-2017Q1, respectively. Series in levels are presented in Figure 1, while series in annual growth terms are presented in Figure 2.

Real GDP levels show a positive trend in all countries. However, during the late 1990s an interruption in the positive evolution of GDP is observed. A similar scenario is detected during the period 2007-2008. While analyzing the annual growth rates, it is observed that during those periods growth rates fell moderately, with a larger decline in 2007-2008. Such periods of contraction of economic activity in all PA countries are associated with international economic crises, specifically the Asian-Russian crisis and the global financial crisis. From this evidence, it is observed that the countries are synchronized during their crisis stages, but the severity of crises varies across countries.

For the first part of the sample, inflation shows a declining behavior in all countries, reflecting the corrective measures implemented in response to the high-inflation periods experienced in the past. Then, inflation stabilizes around 3% in Chile and Peru, around 4% in Colombia, and around 4.5% in Mexico. As in the case of GDP growth, during the 2008 crisis inflation declined moderately.

In the first part of the sample, credit showed high growth rates, explained by the financial liberalization policies that allowed access to external funding and resulted in an expanding banking system. In subsequent periods, the explosive growth rate normalized. In the late 1990s, as a result of the Asian-Russian crisis and associated sudden stop episodes, credit compressed in all countries, but with less severity in Chile. In the second part of the sample, credit recovered and entered into a more stable stage than in the first half of the sample.

For all countries, the loan rate shows a marked negative trend, from levels between 20%-45% to close to 10%. Moreover, it is observed that the volatility of lending rates decreases as the sample progresses, which could be the result of banking expansion and improved macroeconomic stability.

As in the case of the loan rate, the short-term interest rate in all countries shows its highest values in the first part of the sample. It is also observed that in such periods the interest rates register high levels of volatility compared to the second half of the sample. This result is consistent with the adoption of inflation targeting by all PA central banks. During the last part of the sample, which is associated with a more stable macroeconomic behavior, the short-term interest rates range at around 3.5% in Chile and Peru, and around 6.5% in Colombia and Mexico.

Finally, as PA countries are low- and middle-income economies, they are subject to external shocks, as documented by Castillo and Salas (2010) and Rodríguez et al. (2018). In this regard, the external conditions are introduced into the model by the SPGSCI (Standard & Poor's Goldman Sachs Commodity Index), which represents the general level of commodity prices and world economic activity. The series does not show a clear trend over the first half of the sample. However, in the late 1990s, moderate negative growth rates are observed, which could reflect the negative consequences on world activity of the Asian and Russian crises. In the following periods, as China registered growth rates above 8% and boosted global demand for commodities, the SPGSCI started to show a positive trend. Nevertheless, this trend was interrupted by the 2008 crisis, where it records a strong fall. Since the crisis, it does not show a clear trend.

3.4 The Identification Scheme

This paper is focused on loan supply shocks which are identified by sign restrictions. However, as Paustian (2007) argues, it is necessary to identify as many shocks as possible to identify a particular shock. Thus, four kinds of shocks are identified: aggregate demand (AD) shocks, aggregate supply (AS) shocks, monetary policy (MP) shocks, and a credit supply (LS) shocks.

An AD shock is generated by transitory shocks, such as an unexpected increase in consumption, investment or fiscal spending; and by permanent shocks, such a preferences shock. Theoretical literature agrees that these kinds of shocks drive GDP growth and inflation in the same direction. However, the impact on credit markets does not seem to be clear. For example, a positive consumption shock increases credit demand; thus, the loan volume increases, but agents requiring to raise their consumption withdraw their bank deposits, so bank funds decrease and the loan volume cannot expand, or can even decrease. In this regard, the loan volume is not restricted, similarly to the scheme proposed in Hristov et al. (2012). On the other hand, in the context of an AD shock, central banks react by raising the interest rate to avoid inflationary pressures in line with the monetary policy rule, in turn boosting the loan rate due to the link between interest rates and the monetary policy rate. Thus, the short-term interest rate and the loan rate are restricted to be positive.

AS shocks are generated by technology shocks and cost shocks, such as an oil price shock or wage shocks. In this case, GDP and inflation move in opposite directions. Regarding credit markets, a negative AS shock that pushes up costs may decrease investment and the loan volume. However, firms may attempt to fund their higher costs through loans, which may increase credit volume. Moreover, as GDP is falling and inflation is rising, there is no clear central bank response, so the effect on the short-term interest rate is unclear, as well as the response of the loan rate. Because of these unclear effects, the responses of credit volume, the short-term interest rate, and the loan rate are unrestricted.

An MP shock is an unexpected intervention of the monetary authority through the short-term interest rate. A positive MP shock rises the short-term interest rate, decreases GDP and reduces inflation. The effect on the loan volume is ambiguous. On the one hand, as a result of the high opportunity cost of money, agents prefer to save; thus bank funds increase, which means that credit to the private sector could rise. On the other hand, the higher interest rates makes borrowing more expensive, so agents demand less credit. In the model proposed by Gerali et al. (2009) and Atta-Mensah and Dib (2008), the loan volume responds negatively to a positive MP shock, while in the model proposed by Christiano et al. (2010) the sign is unclear. As the response of the loan volume in credit markets seems unclear, the response of the loan rate may also be uncertain. In this context, both variables are unrestricted.

LS shocks are associated with a bank intermediation cost shock, a bank capital shock or a bank technology shock; see Christiano et. al. (2010), Gerali et al. (2010), Hafstead and Smith (2012). For instance, a positive LS shock increases the availability of credit for the private sector, thereby pushing up the loan volume beyond the market equilibrium and creating an oversupply. This excess of funds in the market pushes down the loan rate. Thus, an LS shock drives the loan volume and the loan rate in opposite directions. Since these restrictions are not sufficient to differentiate LS shocks from other disturbances (LS shocks orthogonal to other shocks), other variables are restricted, as suggested by Hristov et al. (2012). In particular, the responses of GDP and inflation are restricted. In this regard, given that credit becomes inexpensive, firms increase their investment and households demand more for consumption, thus GDP increases. At the same time, as economic activity expands, firms expect higher prices; thus, they increase their current prices. Regarding this issue, in theoretical literature there is no consensus about the response of inflation to an LS shock. However, most of the literature supports that the response of inflation is positive, as detailed by Gambetti and Musso (2017); thus, the response of inflation is restricted to be positive. On the contrary, the response of the short-term interest rate is unrestricted. This specification is proposed because, in a similar way as in the case of AS shocks, LS shocks are difficult to observe by the central bank. Therefore, leaving the short-term interest rate unrestricted may be appropriate.

Table 1 summarizes the sign restrictions used to identify each shock in the model. It should be noted that while there are six variables, only four shocks are identified. Conceptually, the remaining shocks, which are not identified, are loan demand shocks and external shocks, the latter related to the SPGSCI. In this respect, first, the loan demand shock is not identified because of lack of theoretical evidence describing its potential effects. Second, although there is evidence of the effects of external shocks, the literature does not assess the role of these shocks when the banking sector is included in the model. Following the argument of Gambetti and Musso (2017), although these shocks are not identified, they may act as a buffer and capture the effect of omitted variables. Finally, regarding the response of the SPGSCI to identified shocks, it is unrestricted in all cases because PA countries are considered small economies and cannot influence the global economy.

In order to identify the proposed shocks, sign restrictions are only imposed at the time of impact. In case of estimation, those draws that satisfy the proposed sign restrictions are collected from the orthogonal R matrices generated, and all the others cases are discarded. From the pool of draws, the result of interest is the median of the impulse response functions (IRFs) and the 16% and 84% percentiles for the standard deviations that represent the 5% significance level; see Sims and Zha (1999).

4 Results

Before discussing the results of the model, three tests are performed to assess the presence of time-varying parameters in the model. As in Bijsterbosch and Falagiarda (2015), the trace test, the Kolmogorov-Smirnov test, and the t-test are performed. In the first case, the trace test reports whether the prior of the variance-covariance matrix associated with the movement law of the parameters is smaller than the posterior. According to Cogley and Sargent (2005), if the trace is lower than the percentiles, there is evidence that the coefficients are subject to multiple shocks, so they do not remain constant. In the second case, the Kolmogorov-Smirnov test indicates whether two different vectors have the same continuous distribution. In the third case, the t-test determines if the mean of two random samples belongs to the same normal distribution. The tests are performed for elements of matrices B, H and A resulting from the estimation of the model for each country.

The results are presented in Table 2. The analysis is performed for two different periods in two cases, the beginning of the sample against the middle of the sample (symbolized by 1-2), then the middle of the sample against the end of the sample (symbolized by 2-3). In general, the tests reveal the existence of time variation in the parameters estimated for each country. In the case of the trace test, it is estimated that the trace value is lower than the 16%, 50%, and 84% percentiles, indicating that coefficients are subject to multiple shocks that made them not to remain constant over the time. On the other hand, results from the Kolmogorov-Smirnov test indicate that most of the estimated parameters of B, H and A present significant differences across their distributions when comparing the samples in the two cases, which indicates that parameters evolve over time. Moreover, results from the t-test suggest that the difference in mean between the samples of most of the coefficients is significant, which confirms the previous results. Thus, the evidence suggests that the model specification, a TVP-VAR-SV, is appropriate for the analyzed data.

4.1 Stochastic Volatility

The results for stochastic volatility are presented in Figure 3. The blue lines correspond to the median of the distribution, while the upper and lower red lines represent the confidence intervals corresponding to the 84th and 16th percentiles, respectively. The evidence suggests that volatility does not remain constant; instead, it appears to evolve over time. In the case of GDP growth, Chile, Colombia, and Peru show similar patterns. At the end of the 1990s, output volatility reached its highest values, ranging between 5%-10% for Peru and Chile, and between 3%-4% for Colombia. This behavior can be associated with the consolidation of liberalization reforms in these countries and the impact of the Russian-Asian crisis. In particular, the latter became important, as a result of the reforms that opened trade and liberalized the financial sector. Moreover, it is observed that volatility in Peru's GDP is higher than in other PA countries, which can be explained by El Niño Phenomenon, which also affected this economy in 1997. After these episodes, volatility shows a negative trend, interrupted partially by the volatility increase generated during the global financial crisis of 2008. However, the increase in volatility during the financial crisis was lower than during the late-1990s crisis in Chile, Colombia, and Peru. While these countries' high volatility episodes are located in the late 1990s, Mexico's higher volatility period is at the beginning of the sample, with the *Tequila* crisis; and in 2009, in the wake of the global financial crisis. Unlike other PA countries, Mexico's trade is more integrated with the U.S., which could explain the greater impact of 2008 crisis on its economy.

In contrast with the results for GDP growth, the stochastic volatility of inflation is estimated to be smaller in magnitude in all of PA countries. Moreover, the evolution of inflation volatility appears to be similar for Chile and Peru. In these countries, inflation volatility registers its highest values on the first part of the sample and drops over the following periods. This can be explained by the high inflation periods in these countries during the 1980s (3,000% and 150% in Peru and Chile, respectively) and the subsequent policy measures to control it. Later, these countries adopted an inflation targeting scheme, which contributed to controlling inflation and reducing its volatility.

Inflation volatility in Colombia shows a different pattern. At the beginning of the sample, volatility is relatively small, but with a marked positive trend. In 1999 it reached its highest values over the whole sample; then the trend turned negative with the adoption of inflation targeting and the elimination of exchange rate controls. Similarly, stochastic volatility in Mexico shows a positive trend at the beginning of the sample, which can be explained by the subsequent effects of the *Tequila* crisis. Then, volatility declined as the economy became more stable in macroeconomic terms.

Regarding the stochastic volatility of loan volume growth, it appears to show a heterogeneous behavior across countries. However, some similarities can be detected. In particular, Peru and Chile register periods of high credit volatility between 1997 and 2003. This unstable period responds to a number factors. During the reform period, free entry of capitals was permitted and regulation of the banking sector decreased, which made the financial sector more linked to the world. Thus, when the Asian-Russian crisis erupted, capital flows to these countries stopped, causing banks to lose funds, and credit became more volatile. In Colombia, credit volatility increases heavily since 2001 and reaches a peak of 137% in 2003. During this period there were many banking mergers and acquisitions, and consequently the competition for funds and the risk taken by banks increased, which can explain the rising volatility. In contrast, credit volatility in Mexico shows a growing trend over the first part of the sample. This is consistent with the banking crisis in Mexico caused by risky lending practices after the privatization of public banks. Later this effect began to decline.

Loan rate volatility shows a more uniform behavior across PA countries, with higher values at certain parts of the sample and a marked downward trend in the second part of the sample. At the beginning, loan rate volatility reaches its highest levels, ranging between 6%-12% in Colombia, Peru and Chile, and between 10%-25% in Mexico, which is consistent with the high volatility of inflation during the same periods. In particular, as inflation rates were very high in 1993-1995, banks attempted to set a higher loan rate to avoid negative real interest rates, which can explain the behavior at the beginning of the sample. In the following years, together with a decrease in inflation volatility, loan rate volatility also decreased. In 2004-2017, stochastic volatility ranges between 0.1%-1% in all cases. This stable pattern responds to the stability of inflation and the short-term interest rate, which can be linked to monetary policy rules implemented in PA countries.

Regarding the stochastic volatility of the short-term interest rate, the estimation suggests that the volatility path has an instability period, placed at the beginning of the sample, and a more stable phase over the last decade. Regarding Mexico, short-term rate volatility registers high values at the beginning of the sample, corresponding to the banking crisis of 1994. In contrast, the highest volatility period in Colombia, Peru, and Chile was the late 1990s. Moreover, as a result of the late-1990s crises, Chile, Colombia, and Mexico suffered sudden stops, which caused their crawling band systems to collapse. Thereafter, short-term interest rate volatility turns small and remains stable. This pattern is consistent with the adoption of an inflation targeting scheme by all PA countries. In particular, Chile and Colombia adopted the inflation targeting scheme in 1999, and Mexico and Peru implemented it in 2001 and 2002, respectively.

The stochastic volatility of the SPGSCI is much higher for the other variables. This may result from the fact that the external variable captures much of the volatility of the model. Regarding its evolution over time, it is observed that the crisis period in the late 1990s represents a smaller increase in volatility compared with the effect of the 2008 financial crisis. In that period, SPGSCI stochastic volatility reached its highest value in all the sample. In this respect, it is observed that GDP growth fluctuations were more drastic in the recent crisis than in the Asian-Russian crisis. For example, during the recent financial crisis, GDP growth was 4.2% in 2007 and fell drastically to -1.7% in 2009, while during the Asian-Russian crisis world GDP growth remained between 2.5% and 4%, reflecting less uncertainty than during the 2008 crisis.

A common feature of estimated volatility in all countries is that it started to decline at the beginning of 2000 and remained relatively stable during the last decade, which shows evidence of great moderation in PA countries. In particular, volatility of GDP growth, inflation, and interest rates appears to decline despite the 2008 financial crisis. These results can be partially explained by the implementation of fiscal rules and inflation targeting schemes in these countries, as documented by Garcés (2016) and Castillo et al. (2016).

4.2 The Impact of Loan Supply Shocks on Real Economic Activity

In the context of time-varying parameters, the shocks may generate multiple non-uniform trajectories in the variables, which make analysis diffuse.[12] For this reason, the effects of LS shocks are normalized with respect to the loan rate. In particular, the median response of the loan rate is set to be -0.5% at the time of impact over the whole sample for all the countries. The responses of the remaining variables are weighted according to this restriction. This allows to compare the effects of LS shocks across periods.

4.2.1 The Average Loan Supply Shock

The mean IRF of an LS shock is reported in Figure 4.[13] Some key differences and similarities arise when assessing the effects of LS shocks across PA countries. In all cases, the effect of a positive LS shock on real economic activity is strong but short-lived, although the magnitude of the effect varies across countries. Particularly, on average, in Colombia, Mexico, and Peru an expansionary credit supply shock boosts GDP growth by about 1%, while the effect in Chile is much smaller, around 0.5%. These results can be explained by the different financial structures of these countries. On the one hand, the banking system has an important participation in lending activity of Colombia, Mexico, and Peru, with banks taking a share of around 90% of total credit to the private sector. On the other hand, Chile has a more developed capital market than other PA countries. For instance, market capitalization as a percentage of GDP is about 98% in Chile, while in the remaining countries it ranges between 30%-40%. This suggests that firms in Chile can

[12] For instance, the LS shock that reduced the loan rate by -1% in 1999 may generate a smaller effect on other variables than the LS shock that decreased the loan rate by -5% in 2007.

[13] The results for IRFs are the median, the 84th and the 16th percentiles. Given that the model has time-varying parameters, the results are obtained for each quarter over the whole sample. Thus, formally speaking, the mean IRF is the average of the median IRF corresponding to all periods in the entire sample.

substitute bank loans, so the banking system plays a more critical role in Colombia, Mexico, and Peru than in Chile.

Regarding inflation, the impact of the positive credit supply appears to be heterogeneous across countries. In particular, results from Mexico and Peru indicate a short-lasting impact, up to two quarters following the shock. In contrast, it is observed that in Chile the shock lasts one quarter, which can be explained by the more dynamic financial markets in this economy. Moreover, the response of inflation in Colombia is estimated to be more persistent than in the other countries. In this case, as the loan rate increases rapidly after falling by 50 basis points, firms face higher credit prices, which translates into higher prices up to one and a half years following the shock.

In the case of credit market variables, the effect of an expansionary LS shock is more persistent on credit volume growth than on GDP growth. The effect on the credit volume tends to last more than three quarters in all countries. These results show that while in the medium run credit markets expand after the shock, real economic activity does not. In this respect, the increased credit can be obtained by firms or households; but the fact that real economic activity is not expanding implies that credit is only expanding for households, which play a less important role than credit to firms in driving GDP according to Beck et al. (2012). Regarding the loan rate, their trajectory following the LS shock appears to have broad uncertainty bands and an increasing behavior in all PA countries. This result may be explained by the moderate degree of credit market concentration in these countries, which makes the trajectory of the loan rate diffuse. For instance, Martin et al. (2011) report a Herfindahl-Hirschman Index of 1052, 1168, 2145 for Colombia, Chile, and Peru, respectively, in 2009, while Rodríguez (2012) reports an index of 1404 for Mexico in 2010. Additionally, the response of the short-term interest rate appears to be non-significant at the moment of impact in all cases. A possible explanation is that LS shocks are not completely visible to the central bank. Thus, the reaction to the monetary authority is not clear. A second explanation is that these economies register high interest rate spreads, ranging on average between 4%-8% in Colombia, Mexico, and Chile, and 15% in Peru, which may cause the response of the short-term interest rate to be diffuse following the LS shock.

In order to understand the quantitative importance of an LS shock, the forecast error variance decomposition (FEVD) is estimated. The mean of the 50% percentiles of variance decompositions in each moment of time are presented in Figure 5 for GDP growth, inflation, loan volume growth, and the loan rate for horizons 0, 4, 8, 12, 16 and 20.[14] The results suggest that the multiple identified shocks play a similar role among PA countries. In particular, LS shocks appear to account for a large share of the variance decomposition of GDP growth in all countries, about 16% of the total share in all horizons of time, higher than that of AS shocks and as high as that of AD shocks. Moreover, among the identified shocks, MP shocks seem to explain the largest share of GDP volatility, whose contribution ranges between 15% and 19% in all cases. On average, all shocks contribute about 56% of total GDP variance. The remaining share corresponds to external shocks, which play an important role in these countries according to Castillo and Salas (2010), Rodríguez et al. (2018), and to other non-identified shocks. In the case of inflation, AS shocks have small effects on inflation

[14] The variance decomposition of the remaining variables and the remaining horizons are available upon request.

volatility at the time of impact. However, in the following periods, its effect increases in all PA countries. Regarding loan volume growth, both LS shocks and MP shocks appear to be the most important factors explaining loan volume growth variance, with both sharing about 36% of total variance, while AD and AS shocks appear to have a less critical role. On the other hand, the variance decomposition of the loan rate indicates that AD and AS shocks are the main sources of volatility in that variable, sharing about 38% of total variance.

Both IRFs and FEDV show that LS shocks have an important effect on real economic activity in PA countries. However, this analysis does not permit to evaluate the role of LS shocks over business cycles. In order to assess the quantitative importance of LS shocks over business cycle fluctuations, historical decomposition is performed. The contributions of LS, MP, AD, and AS shocks to GDP growth, inflation, loan volume growth, and the loan rate are presented in Figure 6. Two important results arise from the estimations. First, LS shocks are an important factor driving the slowdown periods of GDP growth in all PA countries. In particular, during the late-1990s crisis, LS shocks diminished GDP growth by about -0.67 percentage points in Chile, Colombia, and Peru due to the sudden stop of external capital flows triggered by increased global risk during the Russian and Asian crises. Mexico, instead, did not face major negative shocks like other countries during the late 1990s, but the negative effects of LS shocks hit the economy with a lag after 2000. In the recent 2008 crisis, LS disturbances accounted for a significant reduction of GDP growth in most countries. Chile, Mexico, and Peru registered the highest negative impacts, with credit shocks reducing GDP growth by about -1.19 percentage points, while the contribution was lower in Colombia, with shocks reducing GDP growth by -0.36 percentage points. This heterogeneous behavior during the 2008 financial crisis can be explained by the different degrees of dependence of PA countries' financial systems on foreign currencies. For instance, Chile, Mexico, and Peru have higher foreign currency liabilities/total liabilities and foreign currency loans/total loans ratios than Colombia. Therefore, Chile, Mexico, and Peru were more vulnerable to the sudden stop episodes caused by the financial crisis than Colombia. The second important result is that LS shocks have a considerable role in driving business cycle fluctuations, not only in crisis episodes, but also in stability periods. After the late-1990s turbulence and before the financial crisis, LS shocks accounted for a considerable share of GDP growth in all countries. By taking the absolute value of the contribution (in order to focus on the magnitude rather than the sign), it is estimated that the average contribution of LS shocks to GDP growth is about 0.23 percentage points in 2002-2006, larger than the contribution of AS shocks (0.14 percentage points) and similar to the contribution of AD shocks (0.26 percentage points).

Regarding to inflation, it is estimated that LS shocks drive inflation as much as other shocks, but its quantitative importance is heterogeneous among countries. In the case of Chile and Peru, AS shocks are the main driver of inflation fluctuations, as expected, and LS shocks contribute to the evolution of inflation as much as AD and MP shocks. In Colombia, LS shocks are estimated to be the main driver of inflation fluctuations at the beginning of the sample, which can be explained by a high increase in the loan rate, in turn translating into higher prices during that period. In subsequent years, LS shocks produced prolonged and large decreases in inflation, because LS shocks made credit inexpensive and caused prices to decrease. In Mexico, most of the increase in inflation in the late 1990s is due to AD shocks and LS shocks. In the following periods, it is estimated that the reductions in inflation below average respond mostly to LS shocks. Particularly, during this period, the loan rate decreased and the loan volume increased over extended periods; thus, the cost to firms diminished and prices decreased for many periods.

The results also suggest that LS shocks have been an important factor driving credit volume growth. These shocks appear to have had a large negative contribution to loan volume growth in the period following the Russian and Asian crises, which lingered for several years up to 2005. A common feature among PA countries is that the net incurrence of liabilities to non-residents decreased during the above mentioned period, implying that local financial institutions faced financing restrictions in that period, which might explain the prolonged negative effect. Particularly, in Peru the prolonged negative effect is explained by the fact that this economy is more dependent on foreign funds than the other countries. In the following periods, these economies faced favorable economic outcomes that allowed credit volume to expand. However, in 2009, when the financial crisis hit them, the contribution of LS shocks turned negative, accounting for a decline of about -1.5 percentage points in loan volume growth in all countries. This result is associated with the previously mentioned sudden stops that these countries faced during the financial crisis. Nevertheless, the sudden-stop episodes were brief and the LS shocks turned positive in the following quarters in all countries, although Chile registers negative values in the last part of the sample. The fact that the negative contribution of LS shocks coincides with sudden capital flow stops is consistent with Lane and McQuade (2014), who provide empirical evidence of the close link between capital flows and local credit growth for several advanced and emerging economies.

In the case of the loan rate, it is estimated that the importance of LS shocks for driving loan rate fluctuations varies between periods and countries. During the first half of the sample for all countries, LS shocks are estimated to account for a large part of the movements of the loan rate, as much as the contribution of shocks that arose from the real sector. In the case of Colombia and Peru, the contribution of LS shocks diminished and loan rate fluctuations are mainly driven by AS and AD shocks. Mexico shows small deviations from the mean, but most of these deviations are due to LS and MP shocks. On the other hand, all shocks are estimated to contribute similarly to loan rate fluctuations in Chile.

4.2.2 The Impact of Loan Supply Shocks over Time

In order to investigate how the effects of LS shocks have evolved over time, an analysis of the evolution of the IRF at the time of impact is performed and the results are reported in Table 3 and Figure 7. Table 3 shows results obtained using the t-test, which compares the means, and the Wilcoxon rank sum test, which compares the median. Specifically, the tests are estimated on the distributions of IRF at the time of impact for two different periods in two cases: 1996Q4 against 2006Q1 and 2006Q1 against 2017Q1 for all the countries. Both t-test and Wilcoxon rank sum test indicate that in most cases the effect of LS shocks at the time of impact has significantly changed across the periods evaluated.

The figure 7 shows that the power of LS shocks to affect GDP growth has evolved in a heterogeneous way among PA countries. In the case of Chile, the effect of LS shocks has increased from the beginning of the sample until late 2009. This behavior may be explained by the expansion of the banking sector in this country. For instance, the ratio of banking credit to GDP in Chile was about 42.1% in 1990 and increased to 80.8% in 2016. However, from 2009 onwards, the effect of LS shocks declines to levels close to those at the beginning of the sample, which may be explained by stock market development in this country. As a result, funding sources expanded and the participation of the banking system in lending activities decreased.

In Colombia, the effect of LS shocks on GDP rose during the first half of the sample. This behavior can be explained by financial structure changes in Colombia, evolving from specialized banking to a mixed banking system where banks are allowed to offer multiple services to the private sector. In this context, banks' direct investment as percentage of their total assets increases, in turn raising the importance of banks in real activity. However, in the periods following 2005, the effect of LS shocks decreases slightly and then remains stable around 0.9%. Particularly, after 2005, banks' direct investment decreases and portfolio investment rises, which can explain the consequent evolution of the impact of the shock.

Regarding Mexico, the impact of LS shocks on real economic activity shows a gradually increasing behavior from 1996 to 2011. This progressive increase can be explained by the reprivatization of financial entities implemented after 1994 as an effort to reconstruct the banking system. Nevertheless, from 2012 onwards, the effect of LS shocks decreases. A possible explanation is that agents in Mexico employ multiple sources of credit in addition to commercial banks. Particularly in Mexico, 79.5% of enterprises (on average in 2011-2017) reported to be financed by credit from suppliers, while 36.1% also reported to be financed by the banking sector, which could indicate that the participation of suppliers in real economic activity is as important as that of the banking system.

In Peru, the impact of LS shocks shows an increasing pattern during the first part of the sample. During this period, the country experienced a financial liberalization process that resulted in an increase in capital inflows for banking activities. As a consequence, banking expansion translated into an increase in the impact of LS shocks on real economic activity. However, after 2000, the effect began to decline as a result of the Asian and Russian crises, which caused a severe sudden stop in the economy. The result from this event is that 15 financial institutions went bankrupt between 1998 and 2001. Later, in the periods following 2006, the banking sector recovered and the effect of LS shocks increased to a range around 0.94%.

4.2.3 Different Specifications of Economic Activity

LS shocks may exhibit different effects depending on the measure of real economic activity. For instance, the impact of LS shocks could be greater on non-primary activities than on primary activities, since non-primary activities, such as trade and services, are mainly financed by banks. Moreover, the effect may be stronger on domestic demand than on total GDP, as domestic demand excludes the foreign component.

In order to assess these quantitative differences in economic activity, the model is re-estimated for non-primary activities and for domestic demand. Regarding the analysis of non-primary GDP, the activities considered as non-primary GDP are manufacturing, electricity, water supply, construction, trade, and services. The components of domestic demand are private consumption, private investment, government consumption, and government investment. The results of both cases are presented in Figure 8. The estimation indicates that the effect of LS shocks over non-primary activities is quantitatively and qualitatively similar to the case of total GDP for all countries. The explanation for this result may be associated with the share of non-primary activities over total GDP (about 80% in all PA countries), which means that both specifications are closely related.

On the other hand, the effect on domestic demand is stronger that the effect on total GDP in all cases, although the magnitude varies across countries. In Chile and Peru, the impact of LS shocks over the economic activity increased by 0.45 percentage points, compared with around 0.15 percentage points in Mexico and Colombia. These remarkable differences can be explained by the structure of the trade balance in PA countries. In general, the trade balance has an important weight in the GDP of these countries, and exports are an important income source. However, their exports have different structures, which can explain the differences. Regarding the first group, exports are mainly based on mining commodities, with capital markets as the main financing source. Thus, by excluding the trade balance and focusing only on domestic demand, enterprises financed by sources other than the banking system are excluded; thus, the impact of credit supply shocks increases considerably. In the second group, exports are not as concentrated on mineral commodities as in the previous cases. As a result, by excluding the trade balance from the analysis, the effect of firms financed by other sources different from financial intermediaries is partially isolated. Therefore, focusing the analysis only on domestic demand for Colombia and Mexico produces an increase in the impact of LS shocks but not as high as in the case of Chile and Peru.

4.3 Remaining Shocks

Average non-normalized IRFs of AD, AS, and MP shocks are presented in Figure 9, Figure 10, and Figure 11, respectively. On average, an AD shock boosts GDP growth by about 0.2 percentage points in all countries. A similar situation is observed in the response of inflation at the time of impact. In the case of the interest rate, its response to the AD shock is estimated to be higher in Chile and Peru. This result indicates that central banks in these countries have a more restrictive behavior towards inflation, which might be explained by the fact that these countries faced hyperinflation periods and, as a consequence, adopted a hawkish-oriented behavior. On the other hand, results of AS shocks show a similar quantitative effect over all variables, but with broad confidence bands. Moreover, it is estimated that the response of the short-term interest rate is quantitatively close to zero, suggesting that central banks do not react to AS shocks. This result is explained by the fact that AS shocks have a small effect on GDP growth and inflation. In addition, the result can also be explained by the fact that AS shocks are more difficult to be observed by the central bank. Finally, the effect of MP shocks on GDP growth and inflation, at the time of impact, is similar among countries. However, after the time of impact, the impulse response function is different among countries: MP shocks are more persistent in Colombia and Chile than in Peru and Mexico.

5 Sensitivity and Limitations

In order to assess the robustness of the previous results, modifications are introduced in the baseline estimation. First, the model is estimated using different priors specifications. The model is then estimated replacing the SPGSCI by the terms of trade (ToT) of each country. Finally, different sets of sign restrictions are implemented.[15]

Regarding the first sensitivity analysis aimed at evaluating if results are determined by data rather than imposed by the priors specification, two priors sets are used. In the baseline model, the priors set is $k_1 = 0.0005$, $k_2 = 0.05$, and $k_3 = 0.5$. The second specification consists of a priors set similar to Primiceri (2005), which are more flexible: $k_1 = 0.0001$, $k_2 = 0.01$, and $k_3 = 0.01$. The third specification is based on a more restrictive set such that $k_1 = 0.001$, $k_2 = 0.1$, and $k_3 = 0.1$.[16] The results from both specifications are reported in Figure 12. The estimation of stochastic volatility, average impulse response, and evolution of impulse response under the new specifications indicates that the results for Mexico and Peru are qualitatively and quantitatively similar to the baseline model. In the case of Colombia and Chile, the results show some minor quantitative changes, but no major changes emerge while analyzing the trends of results. This suggests that the main results are robust to the different priors specifications.

In the second sensitivity analysis, as the baseline model includes the SPGSCI, some idiosyncratic features of each country associated with external conditions are not captured. For this reason, the index is replaced by the ToT of each country. For Peru and Mexico, the comparison is made with the full sample, while for Chile and Colombia the sample is reduced because the ToT of these countries are not available for the sample of the baseline model. The estimation with the new variable is presented in Figure 13. The results indicate that stochastic volatility functions are quite similar in Chile, Mexico and Peru, while it differs for Colombia, but by a small magnitude. A similar situation is observed in the case of the average impulse response. The only major difference appears in the evolution of the impulse response function for Peru, where it is estimated to be higher in recent periods than the baseline model. In general, results do not differ much from the baseline specification that includes the SPGSCI.

The third sensitivity analysis consist of estimating the model using multiple sets of sign restrictions for LS shocks. In particular, two additional sets of sign restrictions are used. The first set corresponds to the theoretical model by Cúrdia and Woodford (2010) and Gertler and Karadi (2011). In these models, LS shocks have a positive effect on the short-term interest rate and have

[15] The results of the sensitivity analysis are only presented in terms of stochastic volatility, average impulse response, and the evolution of the impulse response function at the time of impact. Moreover, the estimation is only presented for the case of GDP growth. The results for historical decomposition and variance forecast error decomposition, as well as for inflation, the short-term interest rate, credit volume growth, the loan rate, and SPGSCI growth are available upon request.

[16] In the case of Mexico, it is not possible to estimate the last priors specification; thus, the set $k_1 = 0.003$, $k_2 = 0.1$, and $k_3 = 0.1$ is used, which is closely related to the original case and also captures the objective of estimating the model with lower priors.

the same effects on the remaining variables. The second set is based on the model by Gerali et al. (2010) and Atta-Mensah and Dib (2008), who find that LS shocks drive GDP and inflation in opposite directions and that the response of the short-term interest rate is negative. The results are presented in Figure 14. In the case of Colombia and Peru, the estimated results are similar to the baseline model. In contrast, for Mexico the results vary quantitatively across the different specifications, but qualitatively they look close to the main model. In the case of Chile, the results from some of the sign restriction sets differ substantially for the first half of the sample, but thereafter the results tend to resemble the main model.

As can be observed in the baseline model, the response of real economic activity to LS shocks is restricted to be positive. This may cause the true effect on real economic activity not to be captured. For that reason, by taking a different approach from the previous empirical literature, the response of GDP growth to LS shocks is not restricted. As a result of this identification, the estimated response might be interpreted as the genuine response. This idea follows the agnostic identification proposed by Uhlig (2005). The estimation is also presented in Figure 14. The results indicate that even in this agnostic identification, where GDP growth is unrestricted, the response of real economic activity remains positive and significant in all PA countries, which reinforces the idea that LS shocks are an important factor boosting GDP growth.

The sensitivity analysis indicates that the baseline results are robust against multiple specifications. However, some limitations arise in this research. First, the credit variable used is total credit, including both foreign and local currencies, which were only available at the current exchange rate for most countries. In this regards, credit at current exchange rates is used in all cases for comparison purposes. In this case, it is plausible that LS shock movements may be influenced by the exchange rate. Nevertheless, by using total credit at constant exchange rates for Peru, which is the only one country where this variable is available, the results indicate that no major changes arise. Second, PA countries are characterized as middle-income economies; thus, most capital goods are imported, and for this reason credit in foreign currency is important for economic activity. In this paper, an aggregate credit variable that includes both currencies is used and a disaggregated analysis of credit in local and foreign currencies is not performed. Third, the variables used in the estimation are in annual growth terms, except for the short-term interest rate; thus, the long-run relationships and cointegration are not assessed. Fourth, the analysis is performed only for unexpected shocks.

6 Conclusions

This research assesses the impact of LS shocks over real economic activity in PA members. The analyzed countries are characterized by an expanding banking system, which implies that the dynamics between the real sector and the financial system has not remained constant. In this context, the proposed model is a TVP-VAR-SV, which can be suitable for the analyzed countries. In order to assess the relevance of the time-varying parameters and stochastic volatility in the model, some tests are performed on the distribution of the parameters for different periods of the sample. The tests performed are the trace test, the Kolmogorov-Smirnov test, and the t-test. The results from the tests reveal the existence of significant time variation in the parameters of the models estimated for each country.

Results from the average impulse response function indicate that LS shocks have a considerable effect on real economic activity in all PA countries. Regarding the variance decomposition analysis, LS shocks appear to account for a large share of the variance decomposition of GDP growth in all cases, about 16% of the total share, which is larger than that of AS shocks and as large as that of AD shocks. Based on historical decomposition analysis, two important results arise. First, LS shocks are an important factor driving slowdown periods of GDP growth in all PA countries. In particular, during the late-1990s crises, LS shocks diminished GDP growth by about -0.67 percentage points in Chile, Colombia, and Peru, which is associated with the sudden stop of external capital flows triggered by increased global risk during the Russian and Asian crises. In contrast, in Mexico the negative effect materialized after 2000. Moreover, in the recent 2008 crisis, it is estimated that LS disturbances accounted for a significant reduction of GDP growth in most countries. Chile, Mexico, and Peru registered the highest negative impacts (about -1.19 percentage points), while the contribution was lower in Colombia (about -0.36 percentage points). The second important result is that loan supply shocks have a remarkable role in driving business cycle fluctuations, not only in crisis periods, but also in stability periods. For instance, in 2002-2006, it is estimated that the average contribution of LS shocks to GDP growth were about 0.23 percentage points, larger than the contribution of AS shocks and similar to the contribution of AD shocks.

Regarding the analysis of the evolution of LS shocks over time, the results indicate that the effect on real economic activity evolves over time. In order to assess if the impulse response function is different across time, the t-test and the Wilcoxon rank sum test are performed for certain periods. The results indicate that the distribution of the impulse response function shows significant differences across periods. However, the evolution of the impact is heterogeneous across countries. In Colombia and Peru the impact is estimated to be higher than in the 1990s, while in Mexico and Chile the impact increased considerably, but at certain point started to decline to levels close to the beginning of the sample.

In order to assess the robustness of the baseline results, three sensitivity analyses are applied. First, the model is estimated with higher and lower priors than the original set. Second, the SPGSCI is replaced by the ToT of each country. Third, the impulse response function is estimated with a different set of sign restrictions. In most specifications the results do not differ much from the baseline specification, suggesting that the main results are robust. Moreover, by applying an agnostic identification and making the response of GDP growth to be unrestricted, the impact of loan supply shocks remains positive and significant.

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Appendix

Data and Sources

The sample period for each country is chosen depending on the availability of loan rate data.

1 Chile

1.1 Real GDP

Two series at two different base years are spliced to build a long real GDP series. The first one is real GDP at 1986 prices, available from 1990Q1-2001Q3. The second one is real GDP at 2013 prices, available from 1996Q1-2017Q1. A retropolation splicing procedure is performed to obtain the real GDP series at 2013 prices from 1990Q1 to 2017Q1. Finally, the series is seasonally adjusted using Census X13.
Source: Central Bank of Chile.

1.2 Non-Primary Real GDP

The GDP series by economic activities at two different base years are spliced (retropolation method) and then added. The first set is real GDP by economic activity at 1986 prices. Agriculture; Fishing; Mining; Manufacturing; Electricity and Water Supply; Construction; Retail Trade and Restaurants; Transport and Communication; Financial Services; Housing Services; Personal Services; Public Administration and Defense are available for the period from 1990Q1-2001Q3. The second set is real GDP by economic activity at 2013 prices for the same activities, available for 1996Q1-2017Q1. The procedure is to splice each series separately and add them. The production of each activity does not include import tariffs or value added taxes. The non-primary GDP series is seasonally adjusted using Census X13.
Source: Central Bank of Chile.

1.3 Domestic Demand

Real GDP by expenditure components at 2013 prices is used. Two series are spliced in two different base years to build a long series of domestic demand. The first one is GDP at 1986 prices, available from 1990Q1-2001Q3 and the second one is GDP at 2013 prices, available from 1996Q1-2017Q1. Both are the sum of total consumption and investment in their respective base years. A retropolation splicing procedure is performed to obtain the series of real domestic demand at 2013 prices from 1990Q1-2017Q1. Finally, the series is seasonally adjusted using Census X13.
Source: Central Bank of Chile.

1.4 CPI

Two series at two different base years are spliced to build the CPI series. The first one is CPI (December 2008=100), available from 1990M1-2001M12; and the second one is general CPI (De-

cember 2013=100), available from 2001M12-2017M3. The quarterly CPI series is obtained as a three-month average.
Source: Central Bank of Chile.

1.5 Short-Term Interest Rate

The interbank interest rate series is extended backward using the deposit rate. The overnight interbank interest rate is available from 1996M1-2017M1. The quarterly series is obtained as a three-month geometric average. To expand the period of analysis, it is extended backward using the 30- to 90-day deposit rate, available for 1990M1-1995M4. The quarterly deposit rate series is calculated as a geometric three-month average. Then, it is spliced backward to the interbank interest rate. The analysis for 1990Q1-2017Q1 is thus carried out. The argument to make this exercise is that the deposit rate that banks pay to their costumers is closely related to interbank interest rate in both value and trend.
Source: Central Bank of Chile.

1.6 Credit to Private Sector

The series is total credit to the non-financial private sector, which is sum of credit to households and credit to firms, both at market prices. The series includes loans in both domestic and foreign currency. Furthermore, the total credit series covers only the banking sector, not shadow banking. All series are available for 1990Q1-2017Q1.
Source: Central Bank of Chile.

1.7 Loan Rate

The loan interest rate that banks charge their costumers is used. The series is obtained as a geometric average of loan rates at different periods. The 30- to 90-day loan rate, the 90-day to 1 year loan rate, the1- to 3-year loan rate, and the loan rate for terms longer than 3 years are used. The loan rate is thus available for 1990M1-2017M3. The quarterly series is calculated as a three-month geometric average.
Source: Central Bank of Chile.

1.8 External Factors

The external variables used are the S&P GSCI (Standard & Poor's Goldman Sachs Commodity Index) and the terms of trade (ToT). First, The S&P GSCI index used is a composite index reflecting general price movement levels and inflation in the world economy. The components and weights of the index are Energy (78.65%); Industrial Metals (6.12%); Precious Metals (1.81%); Agriculture (10.42%); and Livestock (3.01%). The index is available for the analysis period 1990Q1-2017Q1. Second, the ToT used is calculated as the ratio between export and import prices. Import and export price series at two different base years are spliced to obtain the series. The first are import and export indexes at 2013 prices, available from 2008Q1-2017Q1 and the second are import and export indexes at 2003 prices, available from 1996Q1-2011Q3. A retropolation splicing procedure

is performed for each series. The ratio is then calculated to obtain an analysis series from 1996Q1-2017Q1.
Source: Bloomberg and Central Bank of Chile.

2 Colombia

2.1 Real GDP

Two GDP series at different base years are spliced to obtain the complete GDP series. The first is GDP at 1994 prices, available from 1994Q1-2007Q4. The second is gross domestic product at 2005 prices, available from 2000Q1-2017Q1. A retropolation splicing procedure is performed to obtain the real GDP series at 2005 prices from 1994Q1-2017Q1. The data is already seasonally adjusted using X12 ARIMA.
Source: Departamento Administrativo Nacional de Estadística (DANE) of Colombia.

2.2 Non-Primary Real GDP

The GDP series by economic activity at two different base years are spliced (retropolation method) and then added. The first set is real GDP by economic activity at 1994 prices, available from 1990Q1-2001Q3. The second set is real GDP by economic activity at 2005 prices, available for 1996Q1-2017Q1. The procedure is to splice each series separately and add them. The production of each activity does not include import tariffs of value added taxes. Each series are already seasonally adjusted by DANE with the X12 ARIMA method.
Source: Banco de la República.

2.3 Domestic Demand

GDP series by expenditure components at different base years are used. The first set is a GDP series at 1994 prices for 1994Q1-2007Q4. The second set is a GDP series at 2005 prices for 2000Q1-2017Q1. A retropolation splicing procedure is performed to obtain the series from 1994Q1-2017Q1 at 2005 prices. All series are already seasonally adjusted by DANE with the X12 ARIMA method.
Source: Departamento Administrativo Nacional de Estadística (DANE) of Colombia.

2.4 CPI

The consumer price index (2008=100) is used. The period available is from 1990M1-2017M3. The quarterly series is calculated as a three-month average.
Source: Banco de la República.

2.5 Short-Term Interest Rate

The money market rate series is extended backward using the deposit rate. A money market rate series is available from 1995M3-2017M3. The quarterly series is obtained as a geometric three-month average. To series is extended backward using a 90-day deposit rate series available from 1994M1-1995M2. The quarterly deposit rate series is calculated as a three-month geometric average. Then

it is spliced backward to the money market rate to complete the period. This exercise is plausible, given that both series have common trends and values.
Source: International Monetary Fund and Banco de la República.

2.6 Credit to Private Sector

The series is total domestic credit to the non-financial private sector, which includes credit to households and credit to firms, both at market prices. The series includes both loans in domestic and foreign currencies. In the case of total credit, it covers only the banking sector, not shadow banking. The period available is 1994M1-2017M1. The quarterly series is calculated as a three-month average.
Source: Bank of International Settlements and Banco de la República.

2.7 Loan Rate

It is a weighted average of the rate charged by depository corporations on commercial, ordinary, short-term (Treasury), and long-term preferential loans. The weights are established according to loan amounts. The period available is 1994Q1-2017Q1. The quarterly series is calculated as a three-month geometric average.
Source: International Monetary Fund.

2.8 External Factors

Same as 1.8.
Source: Bloomberg and Banco de la República.

3 Mexico

3.1 Real GDP

The GDP at 2008 prices is used for the period from 1993Q3 to 2017Q1. The series is seasonally adjusted using Census X13.
Source: Instituto Nacional de Estadística y Geografía (INEGI).

3.2 Non-Primary Real GDP

The GDP series by economic activity at 2008 prices are added to obtain primary and non-primary GDP series for 1993Q3-2017Q1. The series of economic activities do not include value added taxes. The non-primary GDP series is seasonally adjusted using Census X13.
Source: Instituto Nacional de Estadística y Geografía (INEGI).

3.3 Domestic Demand

The GDP series by expenditure components at 2008 prices is used for 1993Q3-2017Q1. The series is seasonally adjusted using Census X13.
Source: Instituto Nacional de Estadística y Geografía (INEGI).

3.4 CPI

A national consumer price index (NCPI) is available (December 2008=100) for 1993M1-2017M3. The quarterly series is obtained as a three-month average.
Source: Instituto Nacional de Estadística y Geografía (INEGI).

3.5 Short-Term Interest Rate

The money market rate is used. It is calculated as the weighted average rate on loans between financial corporations. The rate is weighted by daily loan amounts. The period used is from 1993M3-2017M1 and the quarterly series are obtained as a three-month geometric average.
Source: International Monetary Fund.

3.6 Credit to Private Sector

The series is total credit to the non-financial private sector at market prices. The credit series includes loans in both domestic and foreign currency only for the banking sector, not shadow banking. The period available is from 1994M12-2017M1. The quarterly series is obtained as a three-month average. Since the credit series is not available prior to 1994Q4, it is extended backward using a banking credit series provided by the Bank of International Settlements for 1993Q3-1994Q3.
Source: Instituto Nacional de Estadística y Geografía (INEGI) and Bank of International Settlements.

3.7 Loan Rate

The loan rate is approximated with the loan rate on commercial papers to companies. The available period is 1993M9-2017M3. The quarterly series is calculated as a three-month geometric average.
Source: International Monetary Fund.

3.8 External Factors

Same as 1.8.

4 Peru

4.1 Real GDP

A GDP series at 2007 prices is used for the period from 1993Q2-2017Q1. The series is seasonally adjusted using Census X13.
Source: Banco Central de Reserva del Perú.

4.2 Non-Primary Real GDP

The GDP series by economic activity at 2007 prices are added for 1993Q2-2017Q1. The non-primary GDP series is seasonally adjusted using Census X13.
Source: Banco Central de Reserva del Perú.

4.3 Domestic Demand

The GDP series by expenditure components at 2007 prices is used for the period 1992Q2-2017Q1. The series is seasonally adjusted using Census X13.
Source: Banco Central de Reserva del Perú.

4.4 CPI

The consumer price index (2009=100) is used. The period used is 1992M4-2017M3. The quarterly series is obtained a three-month average.
Source: Banco Central de Reserva del Perú.

4.5 Short-Term Interest Rate

The average interbank interest rate and the interest rate of BCRP deposit certificates. The interbank interest rate series is available from 1995M11-2017M3. The quarterly series is obtained as a three-month geometric average. To expand the series, it its extended backward using the interest rate of BCRP deposit certificates available from 1992M4-1995M10. The quarterly series of interest rate of BCRP deposit certificates is calculated as a three-month geometric average. Then it is spliced backward to the average interbank interest rate. The argument to make this exercise is that the purpose of BCRP deposit certificates is to provide liquidity to the market; thus the interest rate of deposit certificates approximates the interbank interest rate.
Source: Banco Central de Reserva del Perú.

4.6 Credit to Private Sector

The series is total credit to the non-financial private sector at market prices. The credit series includes loans in both domestic and foreign currency. The credit series only covers the banking sector, not deposit companies or other types of financial intermediaries. The total credit series is available for 1992M4-2017M3 and the quarterly series is obtained as a three-month average.
Source: Banco Central de Reserva del Perú.

4.7 Loan Rate

The average loan rate that banks charge their costumers is used. It is calculated as the average of the interest rate for overdrafts on current accounts, credit cards, loans, and housing loans. It is available from 1992M2-2017M3. The quarterly series is calculated as a three-month geometric average.
Source: Banco Central de Reserva del Perú.

4.8 External Factors

Same as 1.8.
Source: Bloomberg and Banco Central de Reserva del Perú.

Table 1. Sign Restrictions

Structural Shocks	Responses of Variables					
	GDP Growth	Inflation	Loan Volume Growth	Loan Rate	Short-Term Rate	SPGSCI Growth
Aggregate Demand (AD)	+	+	NR	+	+	NR
Aggregate Supply (AS)	+	–	NR	NR	NR	NR
Monetary Policy (MP)	–	–	NR	NR	+	NR
Loan Supply (LS)	+	+	+	–	NR	NR

Notes: Sign restrictions are imposed on the impact; NR=Not Restricted.

Table 2. Testing Time Variation in Coefficients and Volatility

	Trace Test				Kolmogorov-Smirnov Test[a]						t-test[b]					
					B		H		A		B		H		A	
	Value	16%	50%	84%	1-2	2-3	1-2	2-3	1-2	2-3	1-2	2-3	1-2	2-3	1-2	2-3
Chile	0.36	6.1	12.2	27.5	41/42	39/42	6/6	6/6	15/15	14/15	39/42	37/42	6/6	5/6	14/15	15/15
Colombia	0.24	1.7	2.6	4.6	39/42	31/42	6/6	6/6	15/15	15/15	34/42	25/42	5/6	6/6	15/15	15/15
Mexico	0.27	1.9	2.9	5.0	39/42	35/42	6/6	6/6	14/15	15/15	38/42	34/42	6/6	6/6	13/15	14/15
Peru	0.17	1.4	2.3	3.8	41/42	32/42	6/6	6/6	13/15	15/15	38/42	30/42	6/6	6/6	13/15	14/15

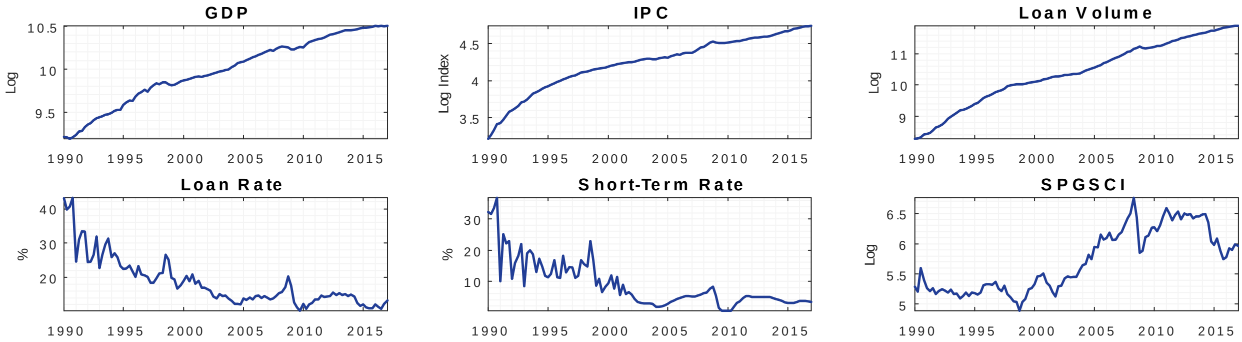
Notes: The matrix B contains the regression coefficients, the elements of H are the variance of innovations and A cointains the contemporaneously relations; [a] Kolmogorov-Smirnov test for two samples. It is performed for each elements of B, H and A. The numerator indicates the number of parameters that changed across the sub-samples according to the test at 0.05 level of significance. The denominator indicates the total number of parameters of each matrix; [b] t-test for two samples. It is performed for each elements of B, H and A. The numerator indicates the number of parameters that changed across the sub-samples according to the test at 0.05 level of significance while the denominator indicates the total number of parameters of each matrix.

Table 3. Evolution of the Effect of Loan Supply Shock

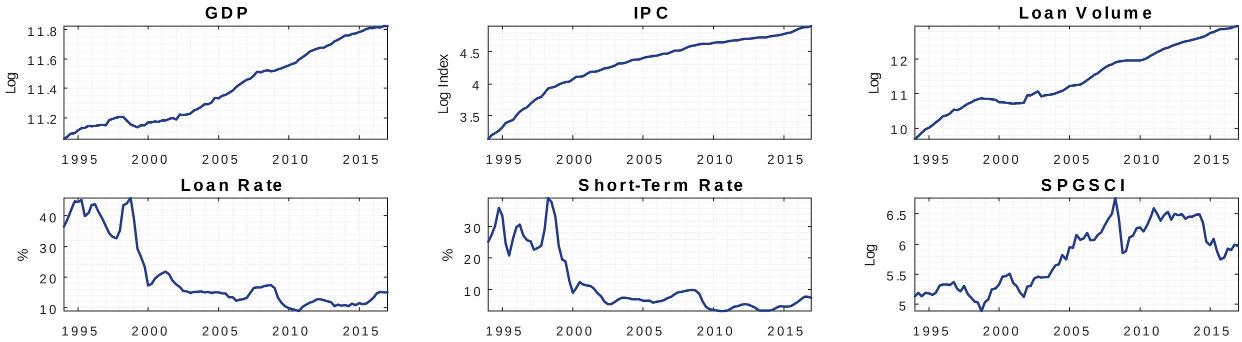
Country	t-tets										Wilcoxon Rank Sum Test									
	y		π		lv		lr		$stir$		y		π		lv		lr		$stir$	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Chile	$=$	$\neq^-$	$\neq^+$	$\neq^-$	$\neq^+$	$\neq^-$	$\neq^+$	$\neq^-$	$\neq^+$	$\neq^-$	$=$	$\neq^-$	$\neq^+$	$\neq^-$	$\neq^+$	$\neq^-$	$=$	$=$	$\neq^+$	$\neq^-$
Colombia	$\neq^+$	$=$	$\neq^+$	$\neq^+$	$\neq^+$	$=$	$\neq^-$	$=$	$\neq^+$	$=$	$\neq^+$	$=$	$\neq^+$	$\neq^+$	$\neq^+$	$=$	$=$	$=$	$\neq^+$	$\neq^-$
Mexico	$\neq^+$	$\neq^-$	$\neq^+$	$=$	$\neq^+$	$\neq^-$	$\neq^-$	$=$	$\neq^-$	$\neq^+$	$\neq^+$	$\neq^-$	$\neq^+$	$=$	$\neq^+$	$\neq^-$	$=$	$=$	$\neq^-$	$\neq^+$
Peru	$=$	$\neq^+$	$\neq^+$	$\neq^+$	$\neq^+$	$\neq^+$	$=$	$=$	$\neq^-$	$\neq^+$	$=$	$\neq^+$	$\neq^+$	$\neq^+$	$\neq^+$	$\neq^+$	$=$	$=$	$\neq^-$	$\neq^+$

Notes: The test are implemented to the 50% percentile of the impulse responses density at the time of impact $h = 1$. The variables y, π, lv, lr and $stir$ are the output growth, inflation, loan volume growth, loan rate and short-term interest rate, respectively. The effects on SPGSCI are omitted. The letters a and b represent the comparison between 1995Q2 vs 2006Q1, and 2006Q1 vs 2017Q1, respectively. Chosen dates are the same for all countries. The symbol $\neq$ means that the null hypothesis of two samples come from the same distribution is rejected, the positive superscripts $\neq^+$ indicates that the mean (t-tets) or median (Wilcoxon Rank Sum test) has increased significantly, while superscripts $\neq^-$ indicates the opposite. The symbol $=$ indicates that null hypthotesis is not rejected. The results are computed at the 0.05 significance level.

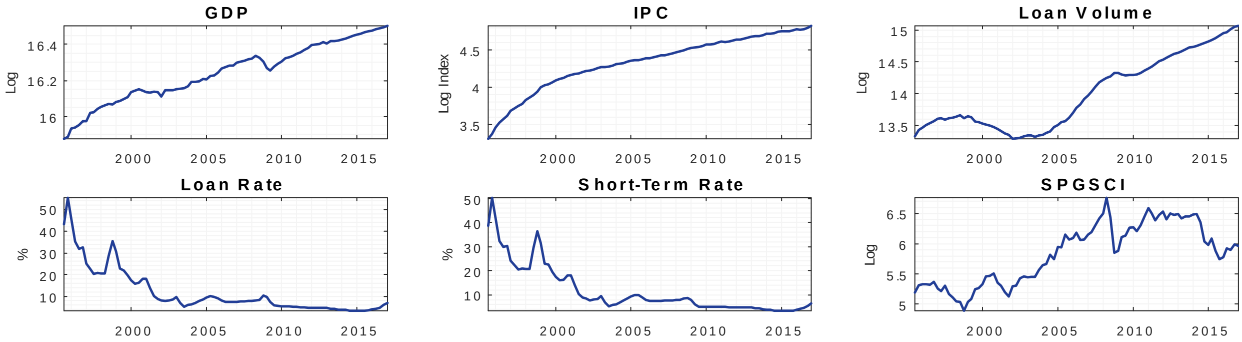
I. Chile



II. Colombia



III. Mexico



IV. Peru

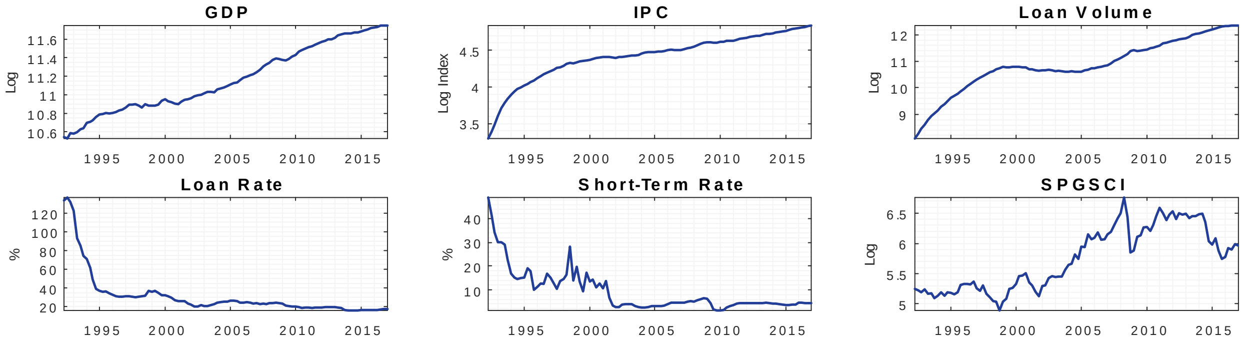
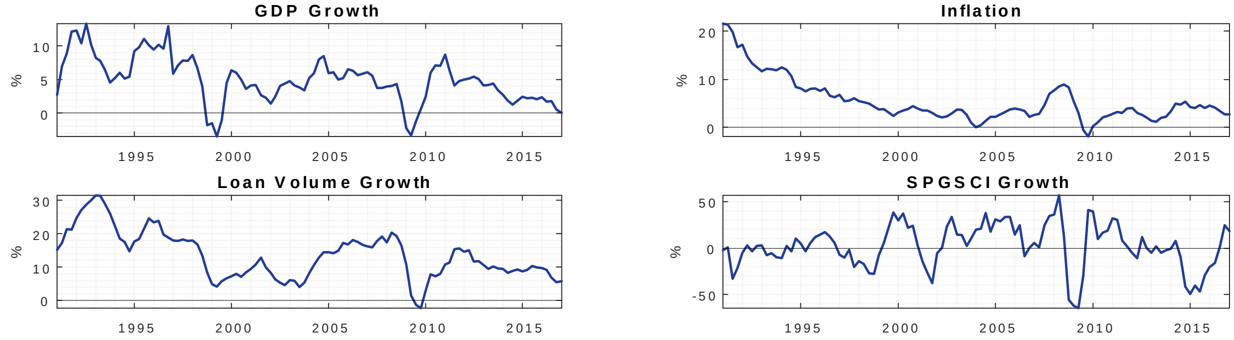
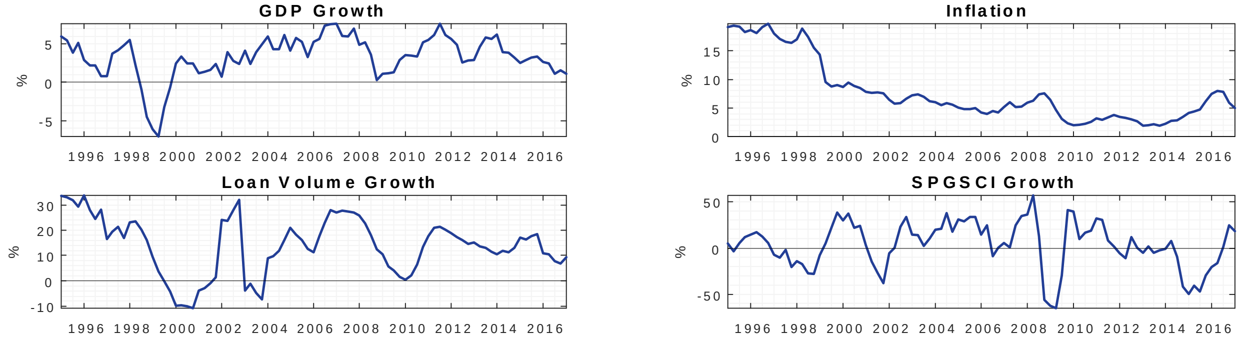


Figure 1. Series in Levels

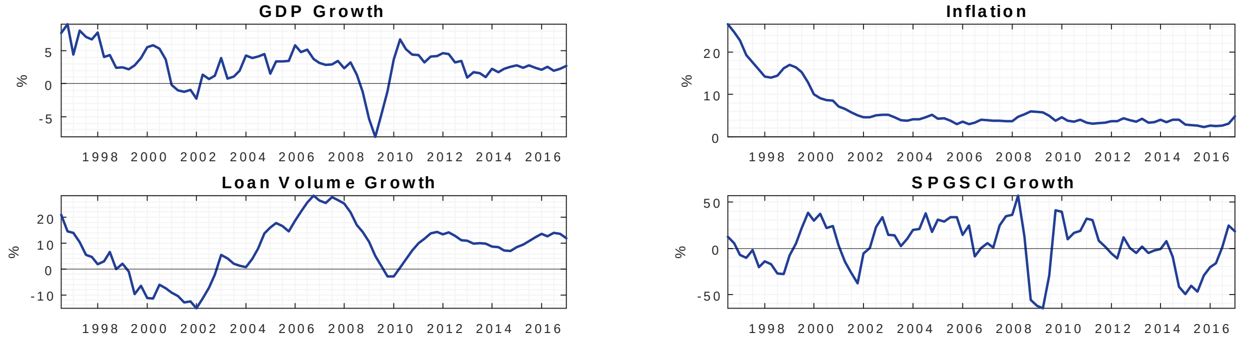
(a) Chile



(b) Colombia



(c) Mexico



(d) Peru

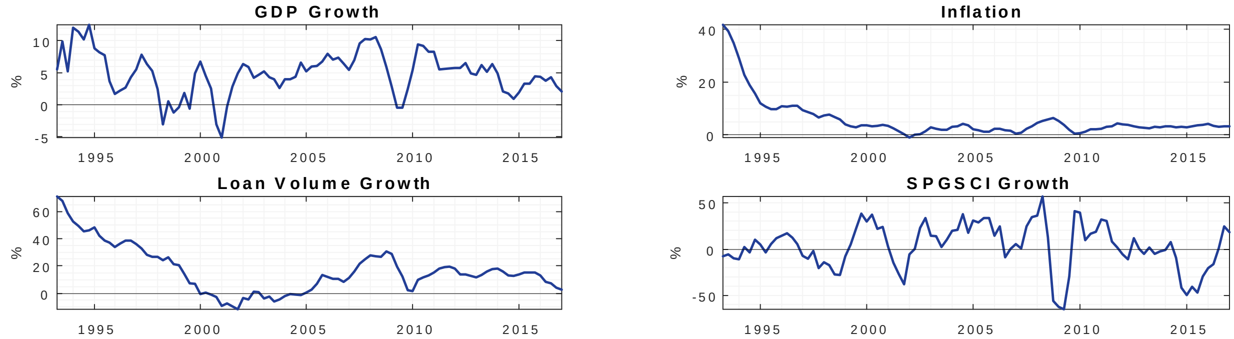
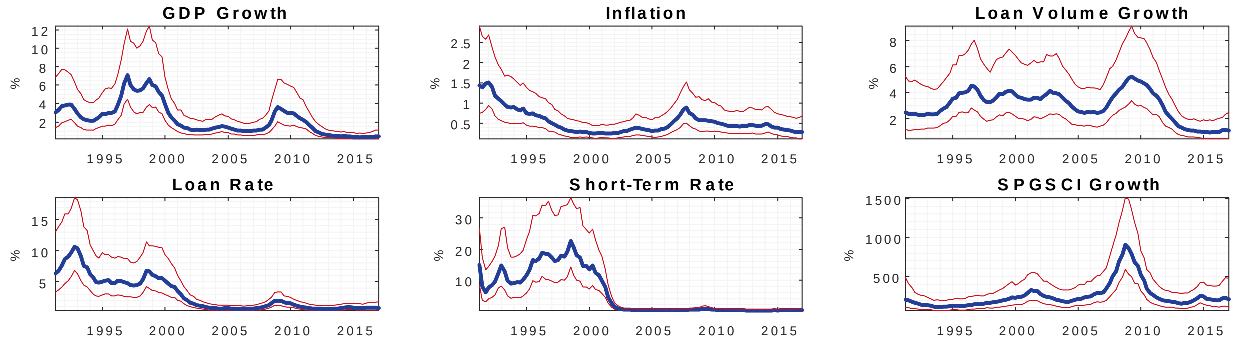
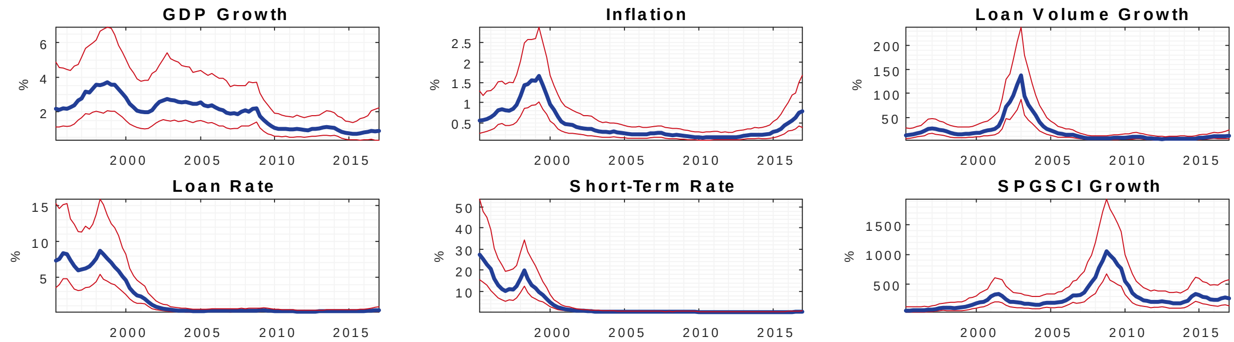


Figure 2. Series in Annual Growth Rates

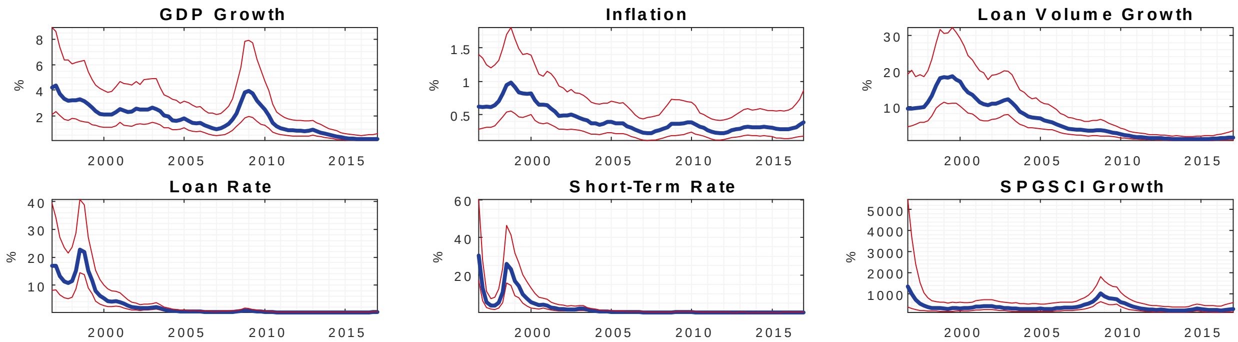
I. Chile



II. Colombia



III. Mexico



IV. Peru

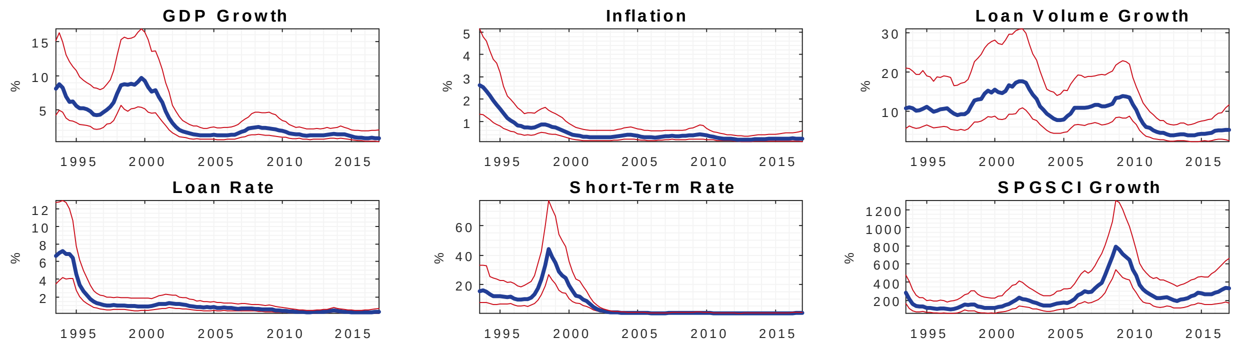


Figure 3. Stochastic Volatility. The Blue lines correspond to the Median of the Distribution while the Upper and Lower Red lines represent the Confidence Intervals that correspond to the 84th and 16th percentiles, respectively.

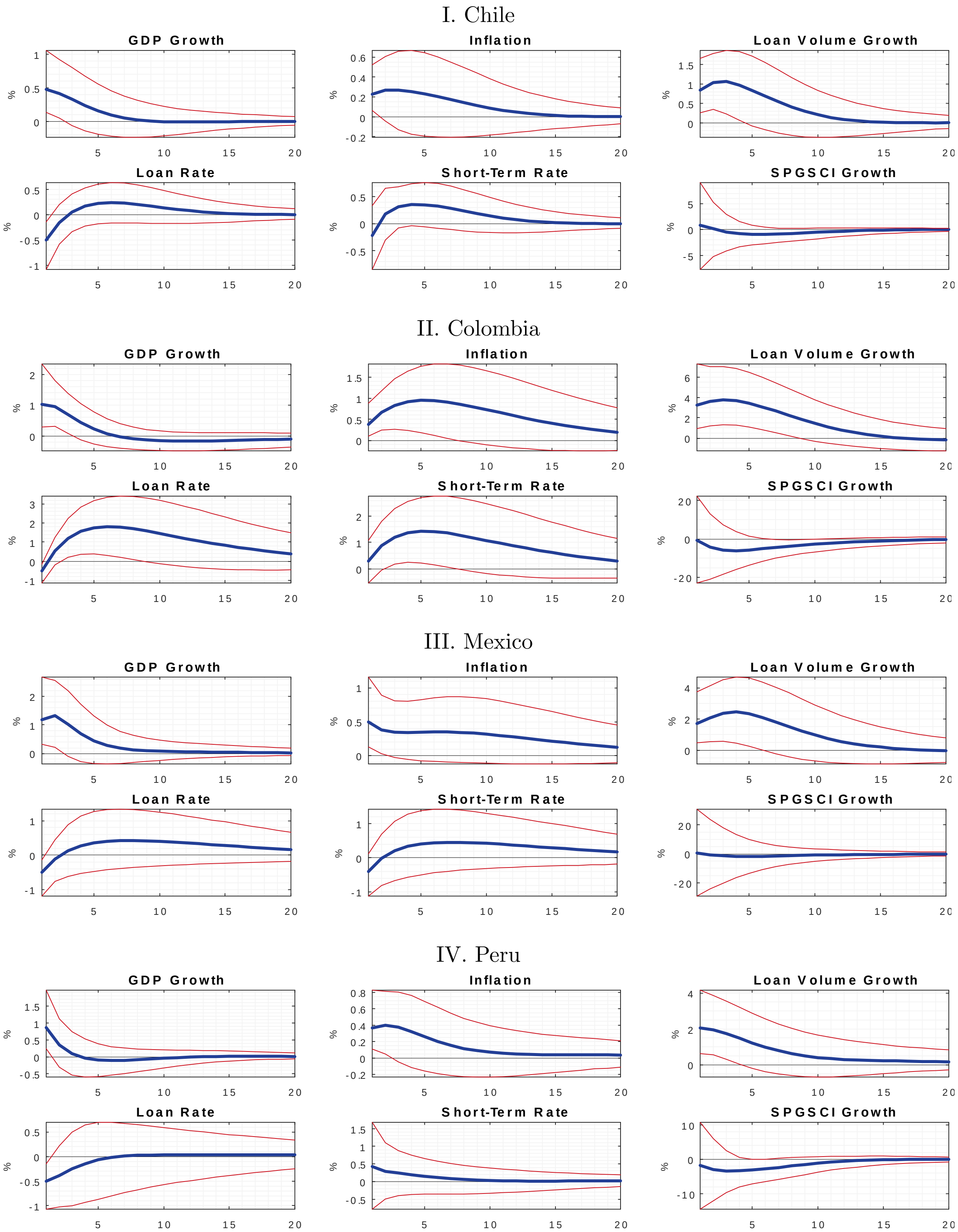
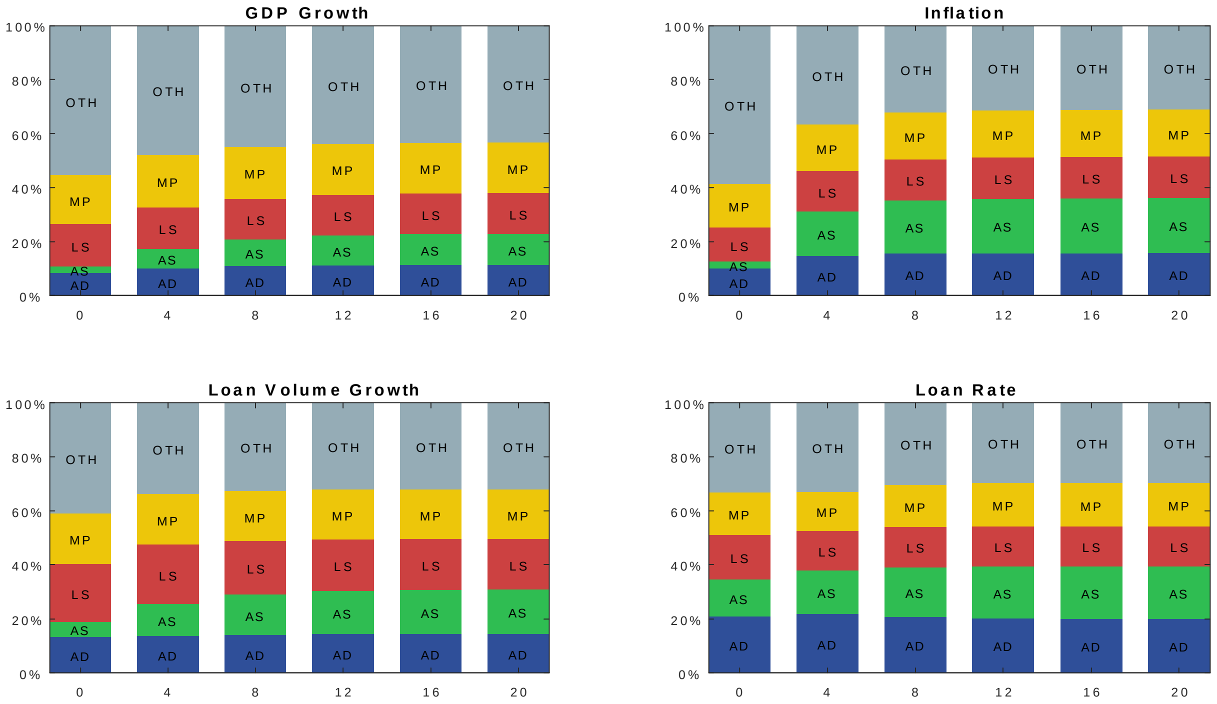


Figure 4. Average Impulse Response to a Loan Supply (LS) Shock. The Blue lines correspond to the average of the Median corresponding to every moment of time. The Upper and Lower Red LInes represent the Confidence Intervals that correspond to the 84th and 16th percentiles, respectively.

I. Chile



II. Colombia

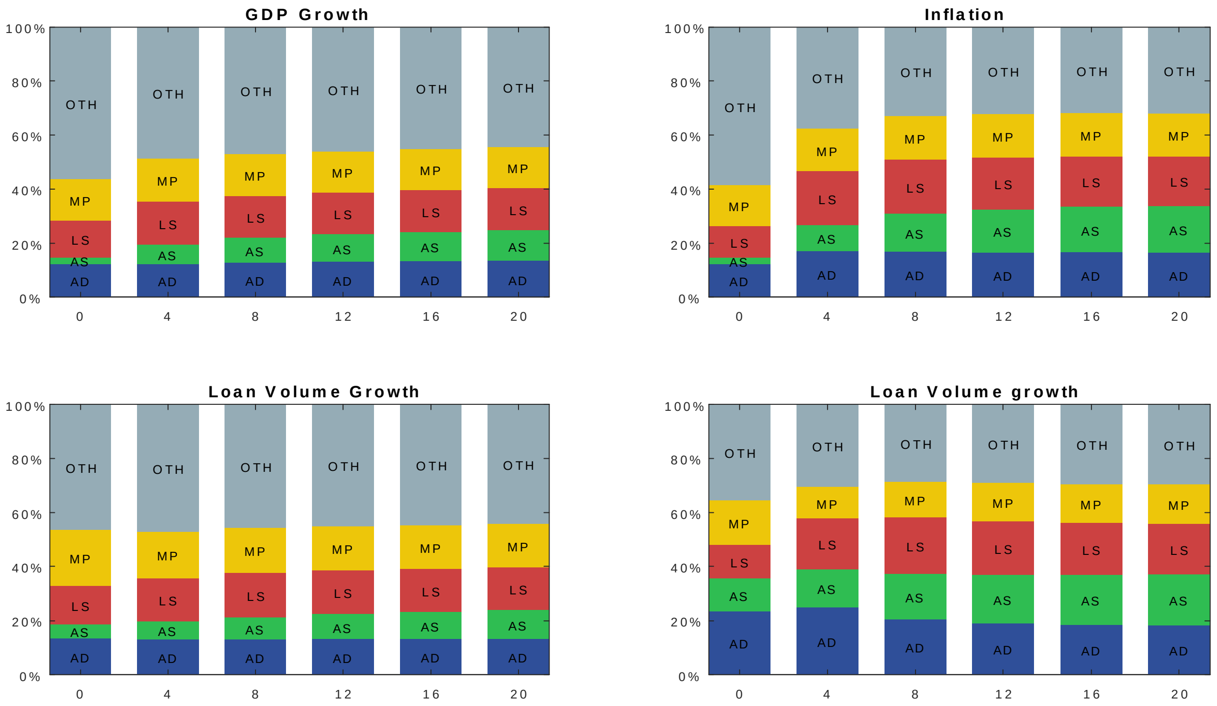
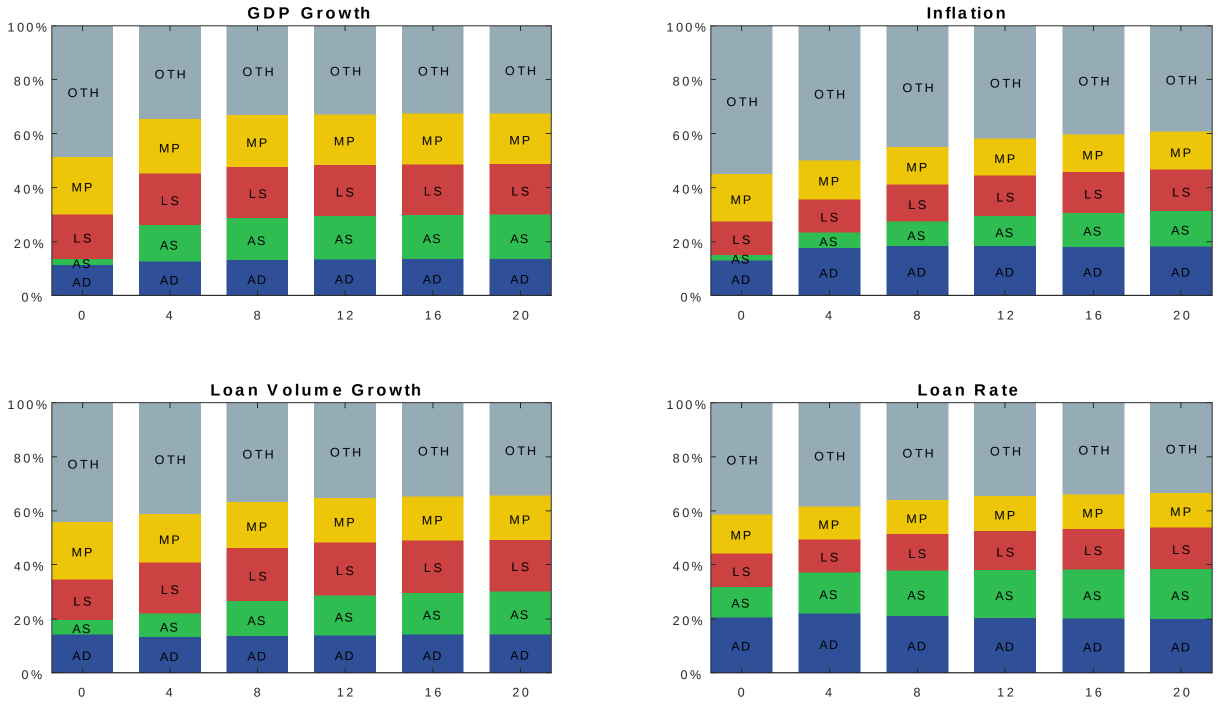


Figure 5. Forecast Error Variance Decomposition (FEVD). The results are the average of the median variance decomposition at every moment of time. The Blue color represents the contribution of AD shocks, the Green color represents contribution of AS shocks, the Red color means contribution of LS shocks, the Yellow color represents contribution of MP shocks and the Grey color represents the non identifed shocks.

III. Mexico



IV. Peru

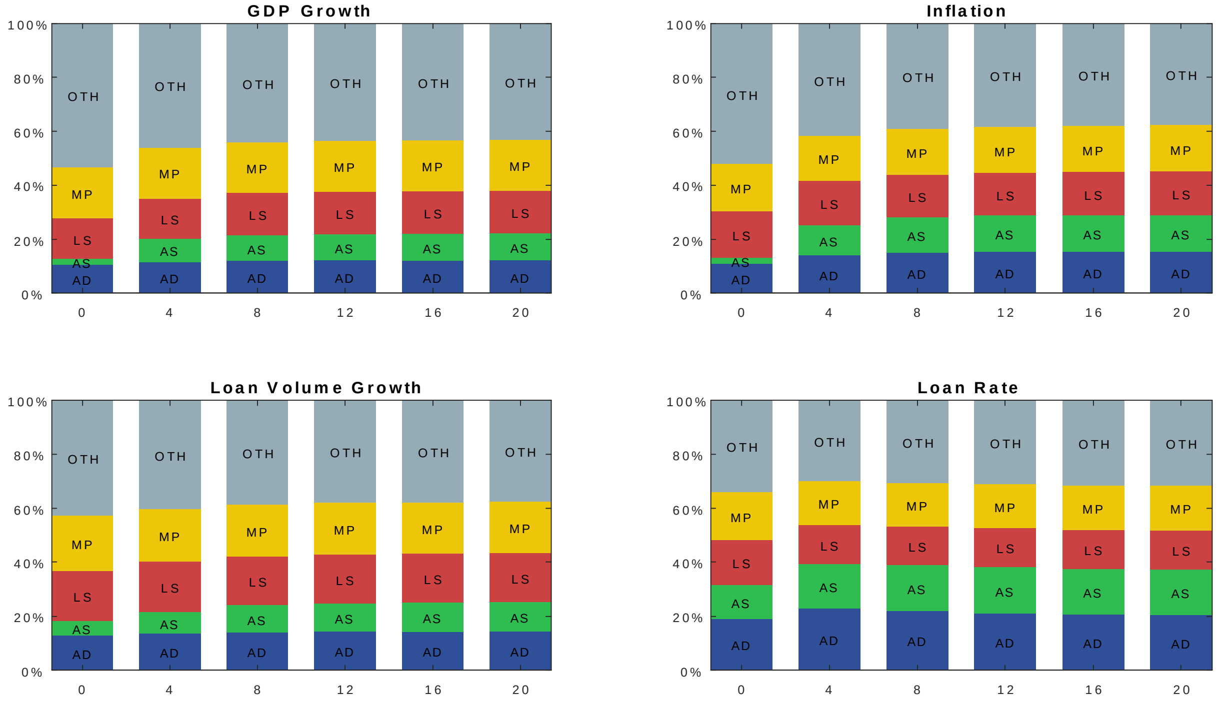
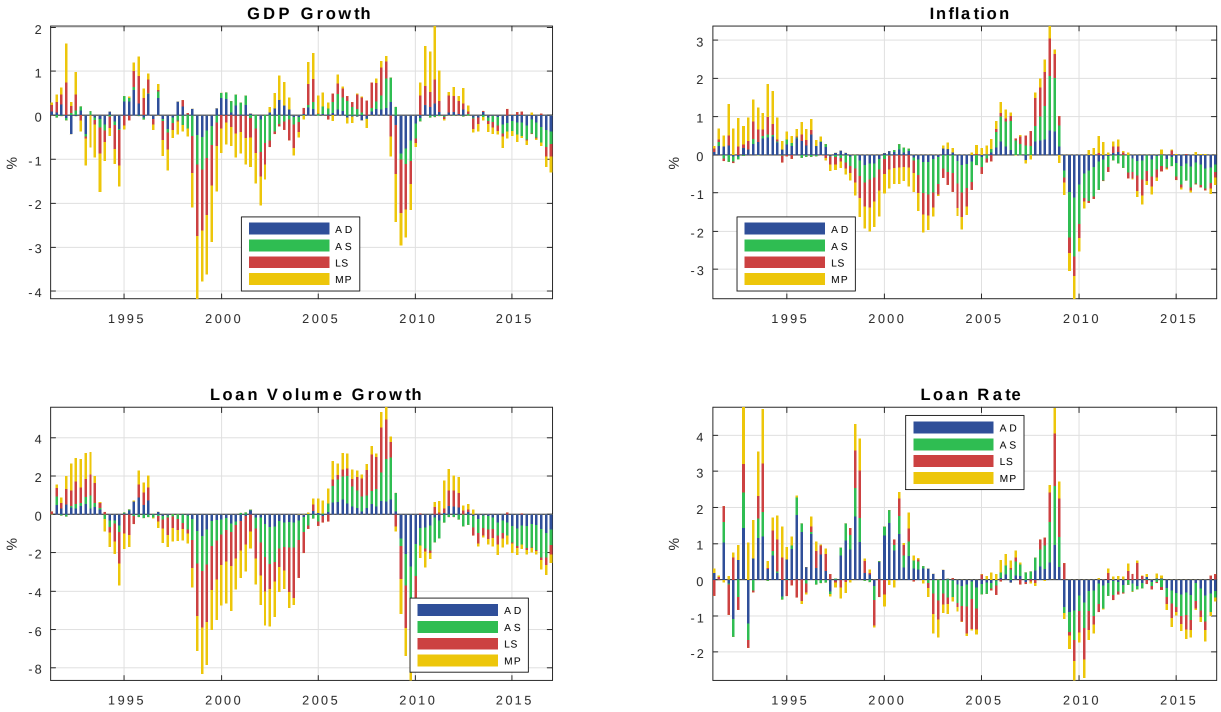


Figure 5 (continues). Forecast Error Variance Decomposition (FEVD). The results are the average of the median variance decomposition at every moment of time. The Blue color represent the contribution of AD shocks, the Green color represents contribution of AS shocks, the Red color means contribution of LS shocks, the Yellow color represents contribution of MP shocks, and the Grey color represents the non identifed shocks.

I. Chile



II. Colombia

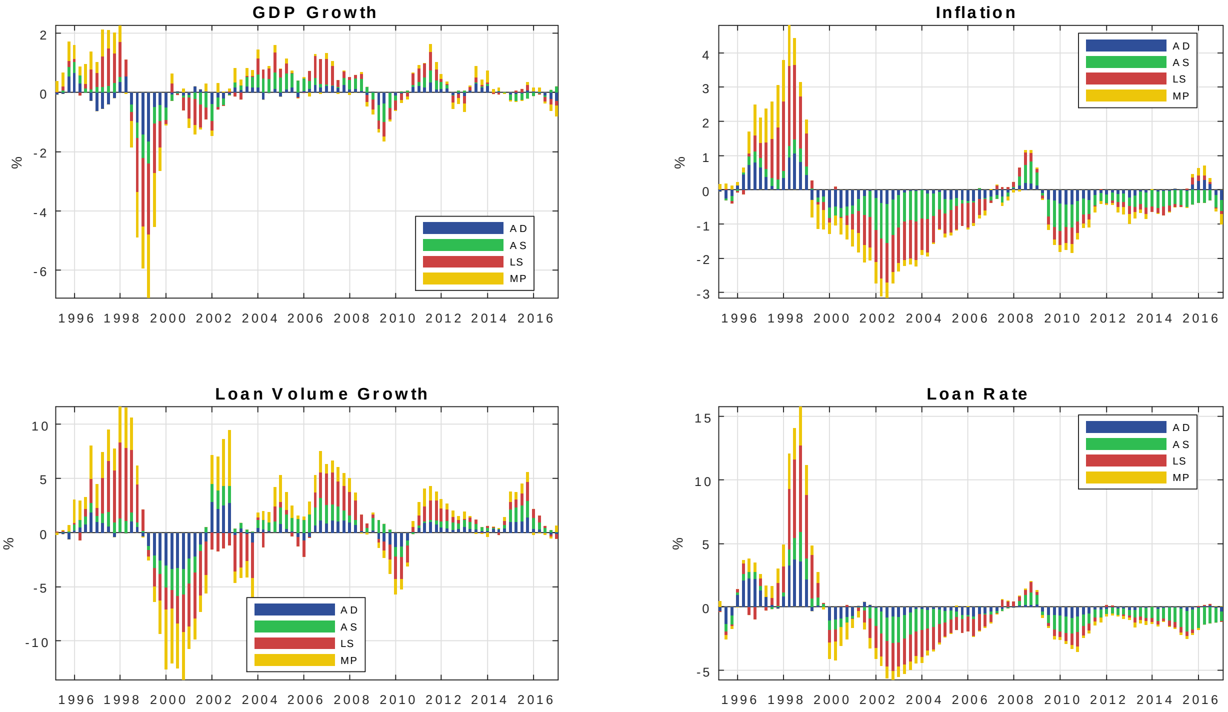
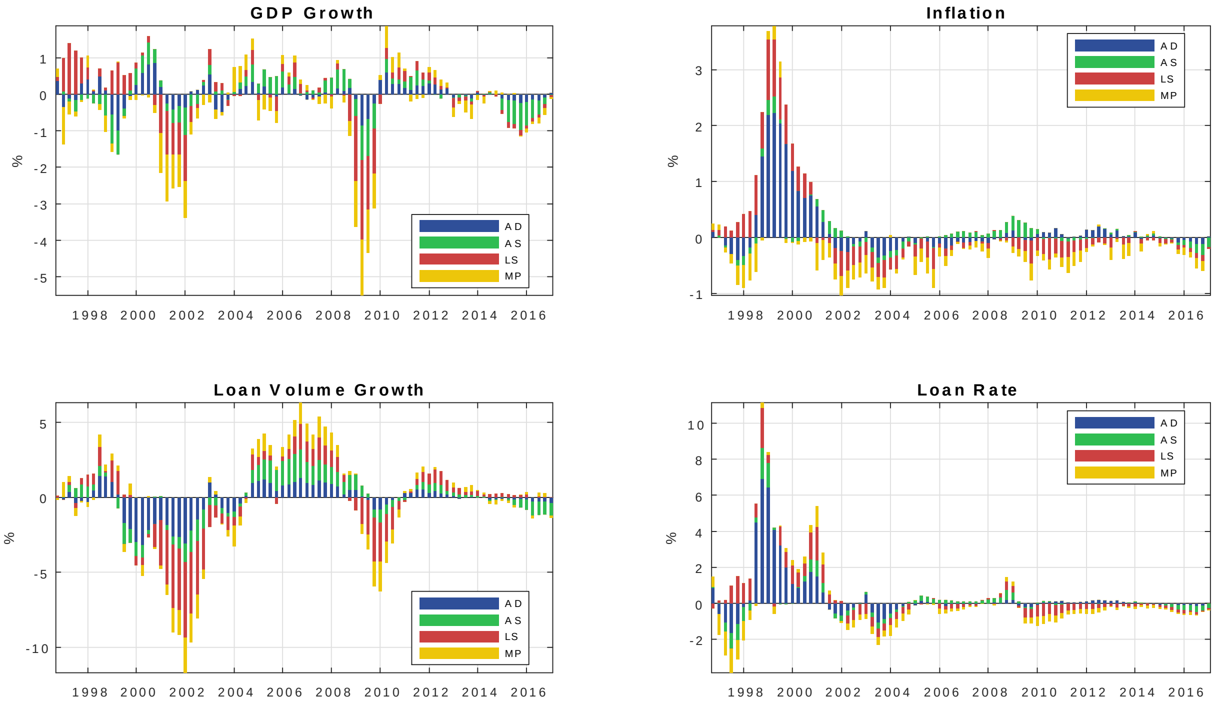


Figure 6. Historical Decomposition (HD). The HD is calculated using the estimated parameters for each specific time. The Blue color represents the contribution of AD shocks, the Green color represents contribution of AS shocks, the Red color means contribution of LS shocks, the Yellow color represents contribution of MP shocks, and the Grey color represents the non identifed shocks.

III. Mexico



IV. Peru

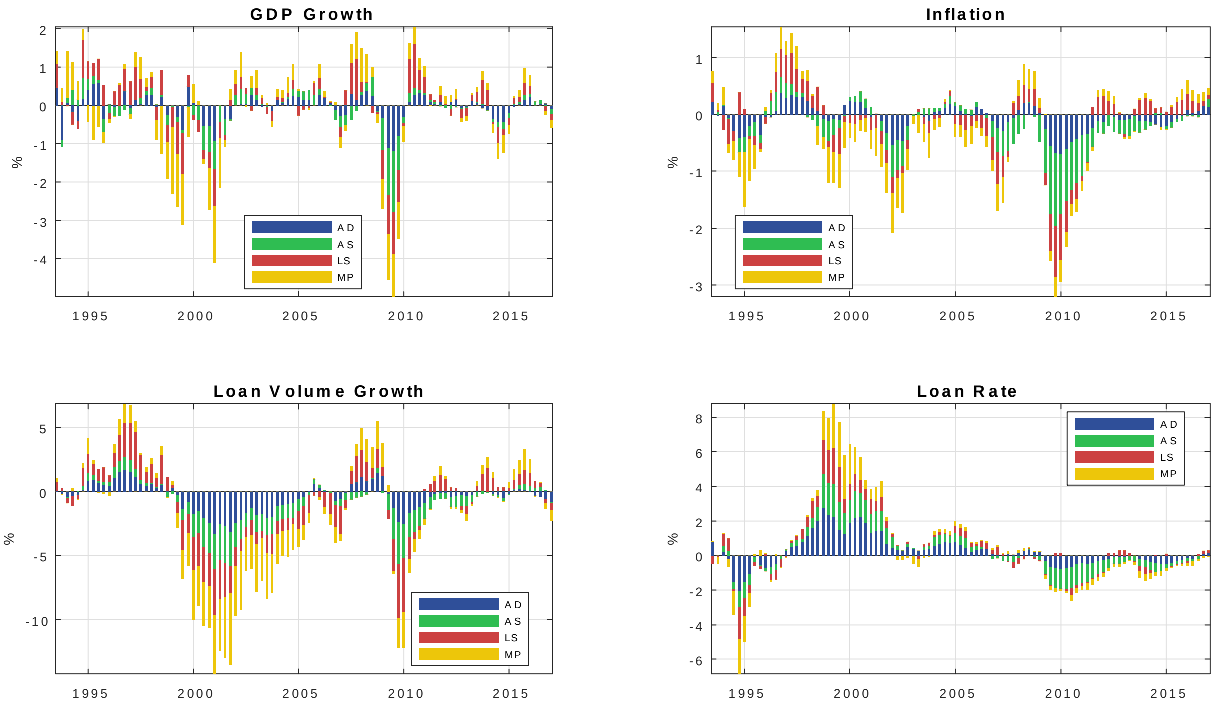
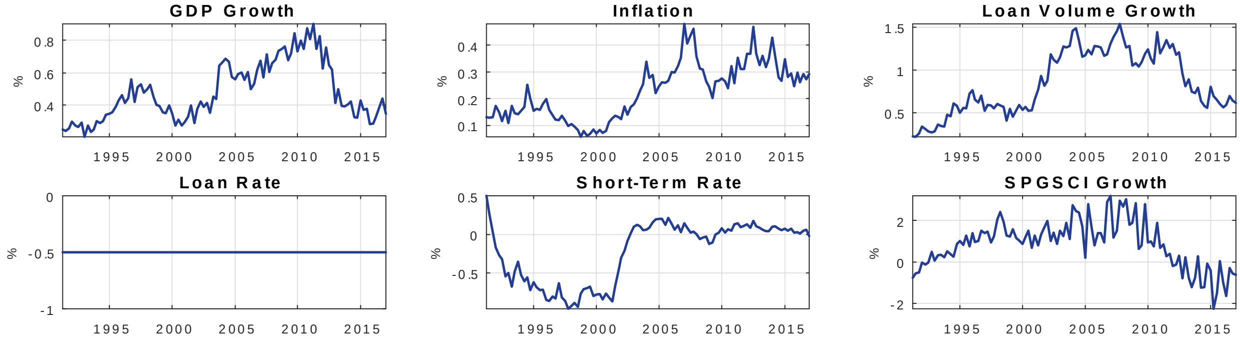
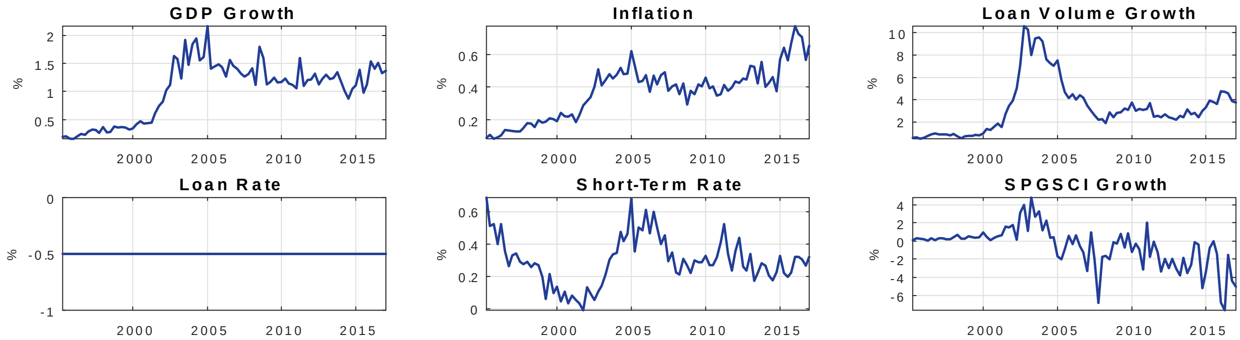


Figure 6 (continues). Historical Decomposition (HD). The HD is calculated using the estimated parameters for each specific time. The Blue color represents the contribution of AD shocks, the Green color represents contribution of AS shocks, the Red color means contribution of LS shocks, the Yellow color represents contribution of MP shocks, and the Grey color represents the non identifed shocks.

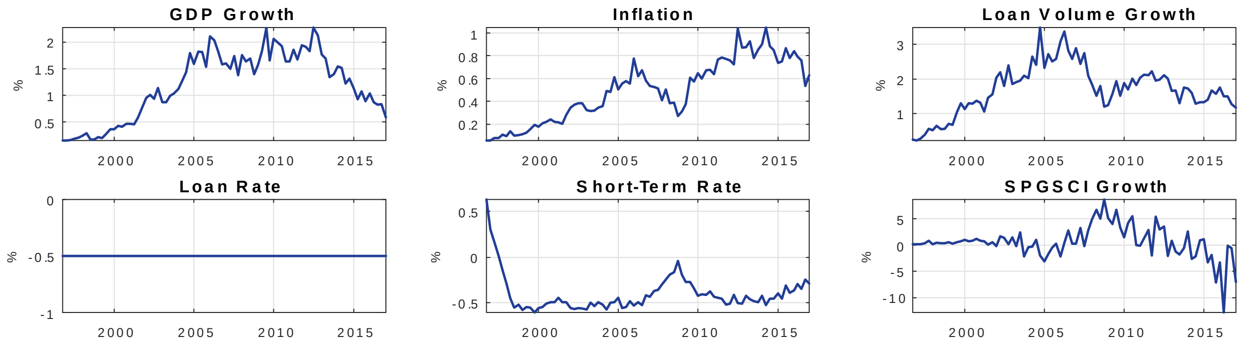
I. Chile



II. Colombia



III. Mexico



IV. Peru

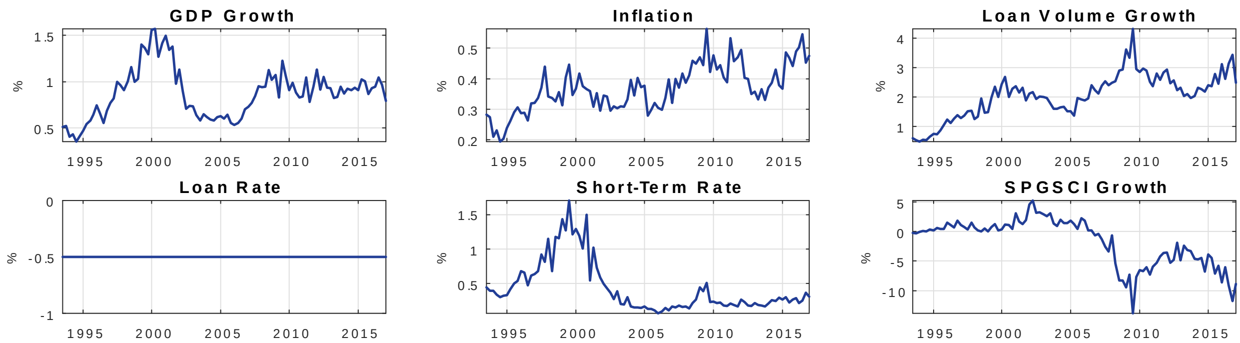
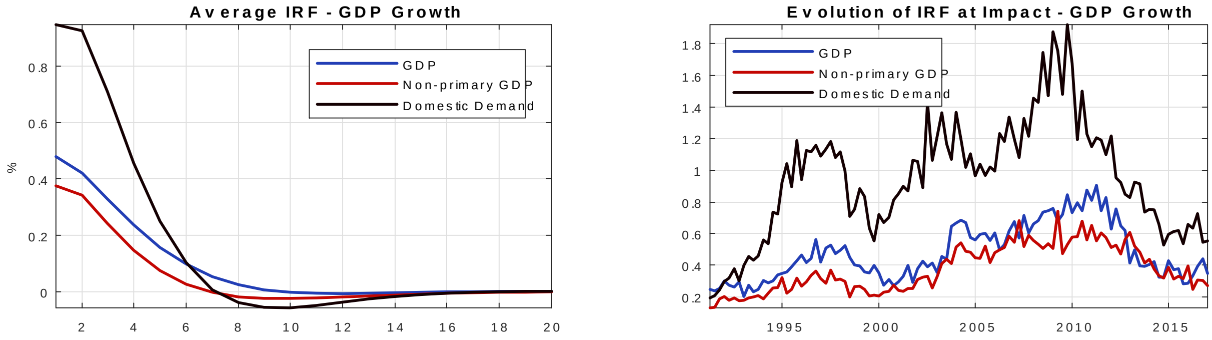
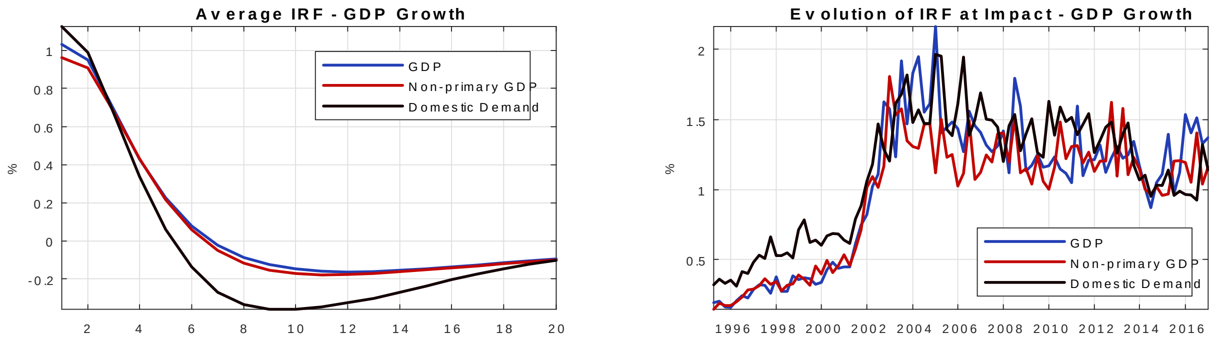


Figure 7. Evolution of Impulse Response to a LS Shock at the time of impact. The results are the evolution of the Median of distribution of the Impulse Responses at the time of impact. The Blue lines represent the Median.

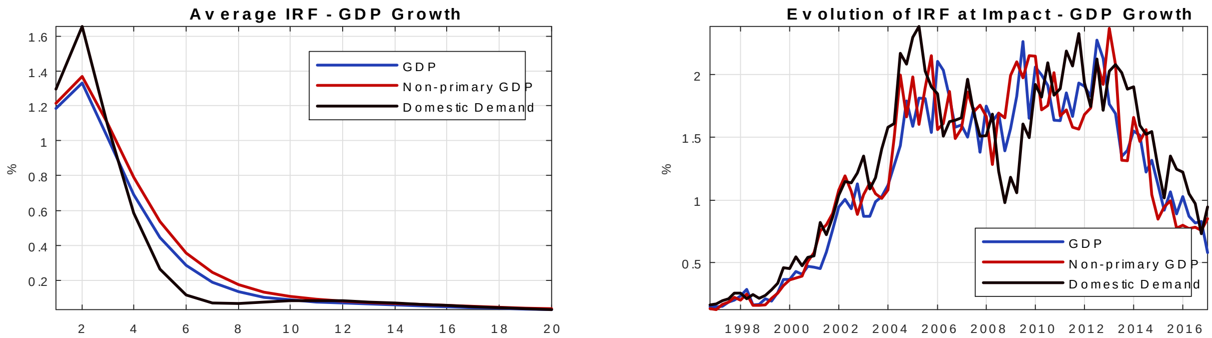
I. Chile



II. Colombia



III. Mexico



IV. Peru

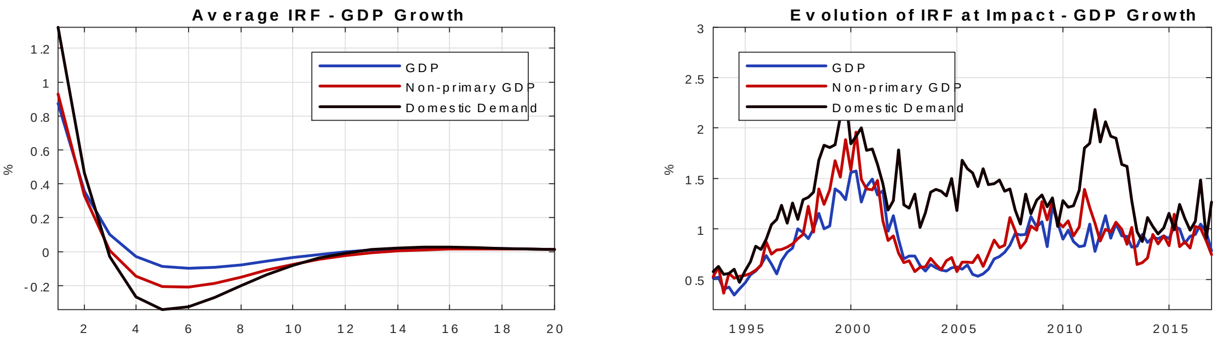
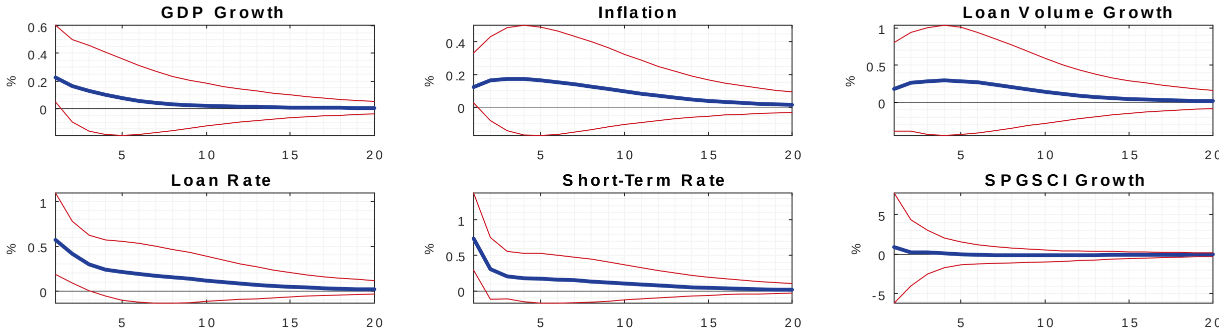
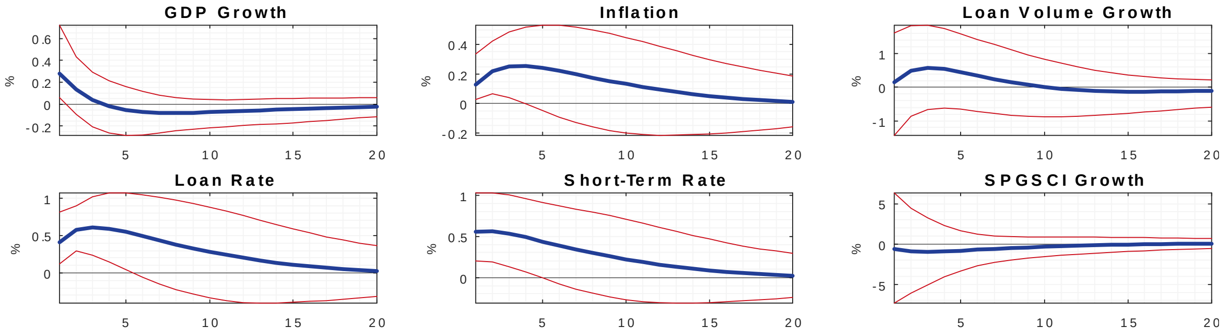


Figure 8. Loan Supply Shocks with different measures of economic activity. The Blue line represents the Median of the distribution using GDP (Baseline specification). The red line is the Median of the distribution using Non-Primary GDP. The Black line is the Median of the distribution using Domestic Demand.

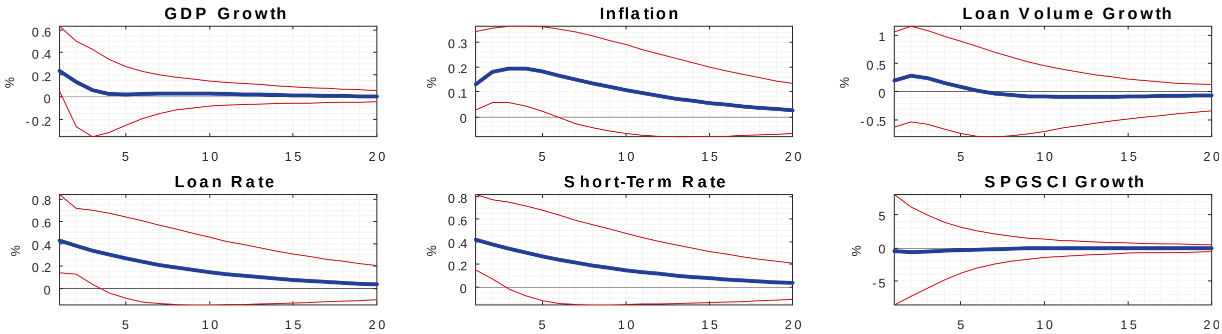
I. Chile



II. Colombia



III. Mexico



IV. Peru

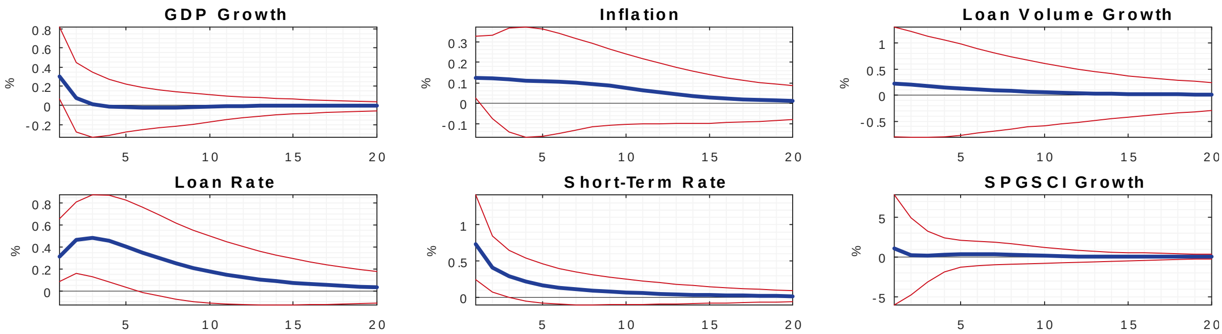


Figure 9. Average Impulse Response to an Aggregate Demand Shock. The blue lines corresponds to the average of median corresponding to every moment of time. The upper and lower red lines represents the confidence intervals that correspond to the 84th and 16th percentiles, respectively.

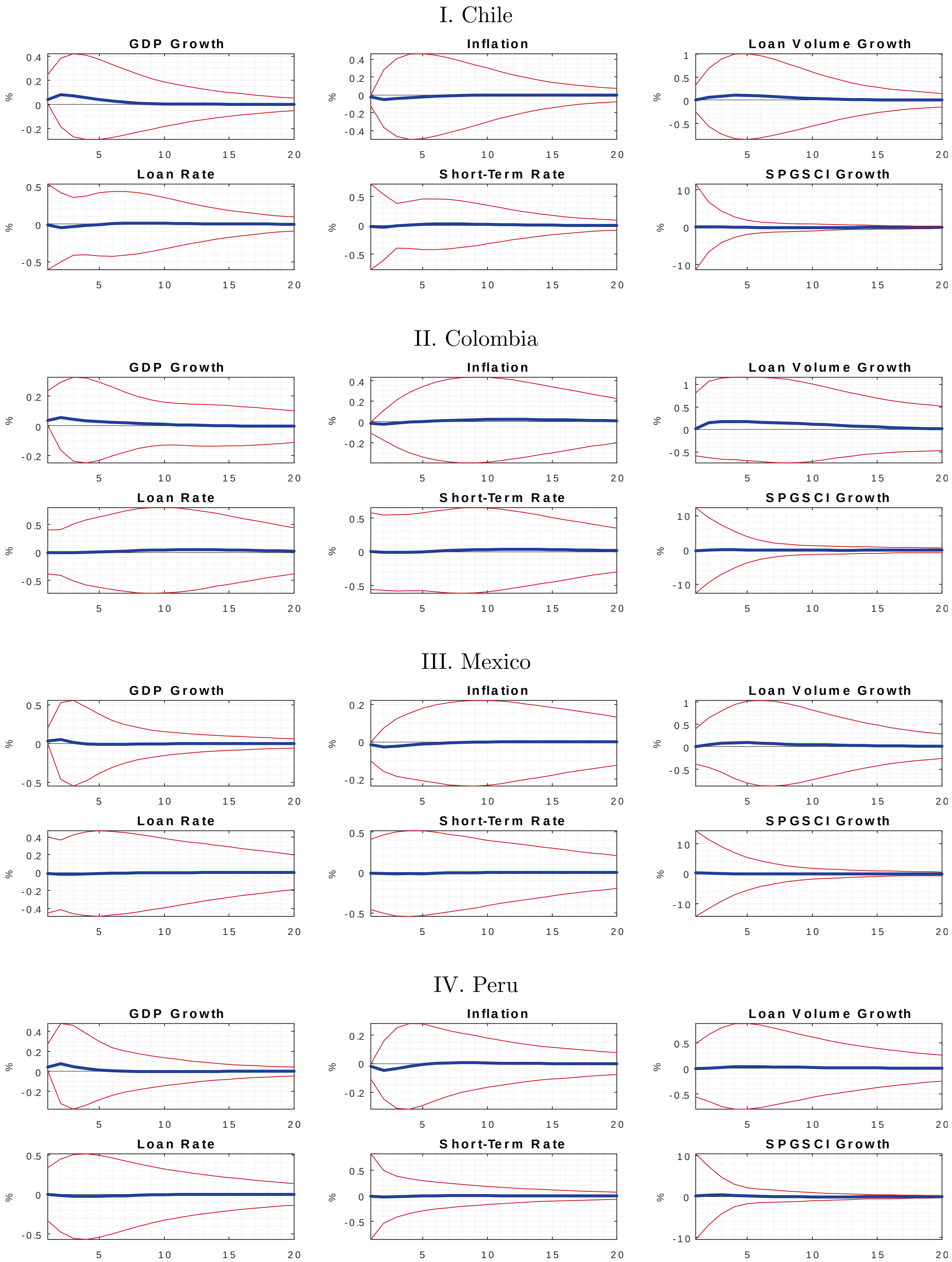


Figure 10. Average Impulse Response to an Aggregate Supply Shock. The blue lines corresponds to the average of median corresponding to every moment of time. The upper and lower red lines represents the confidence intervals that correspond to the 84th and 16th percentiles, respectively.

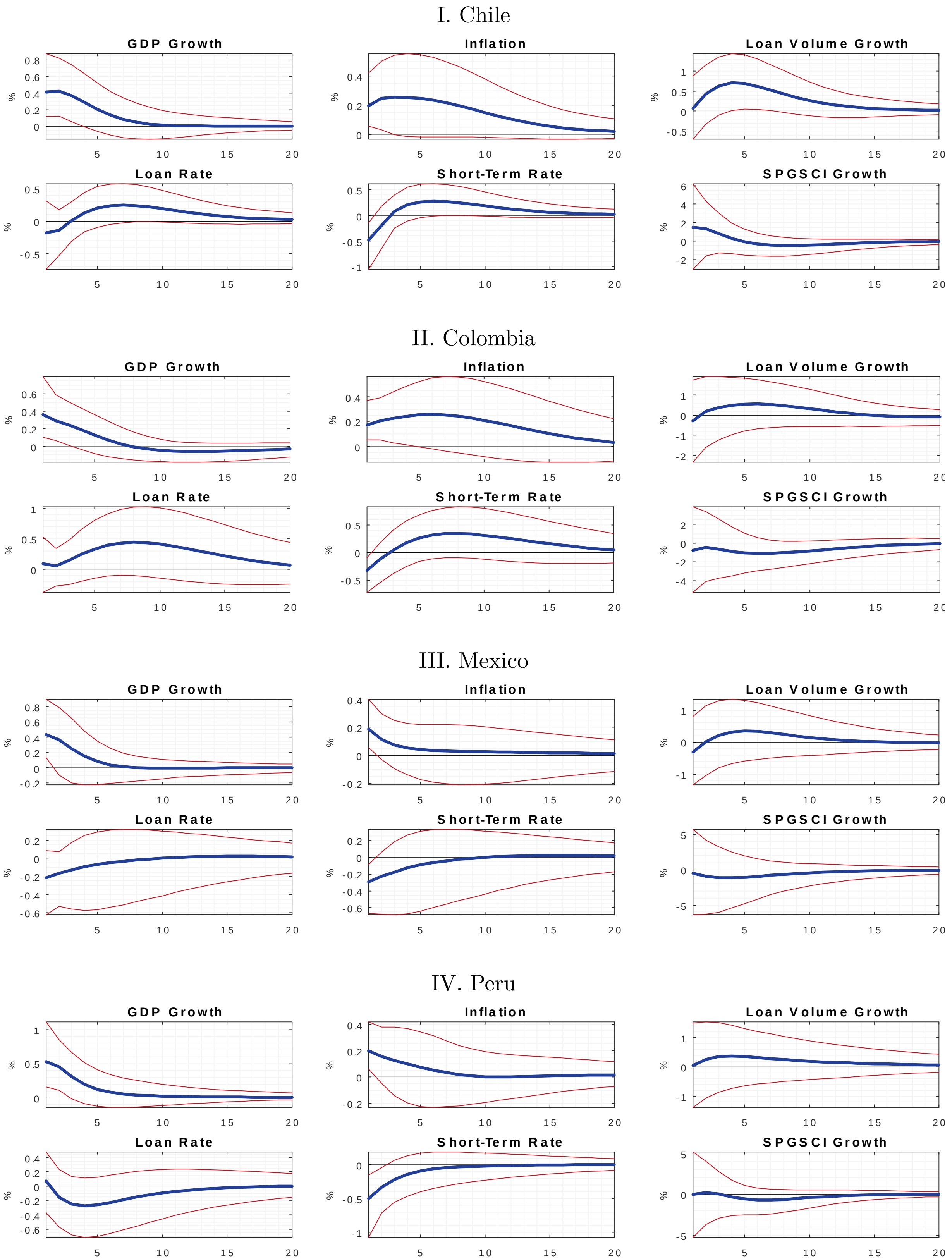
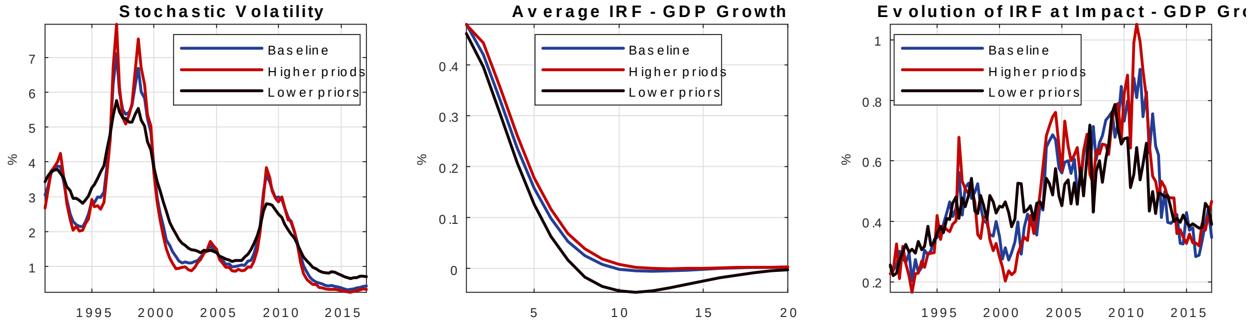
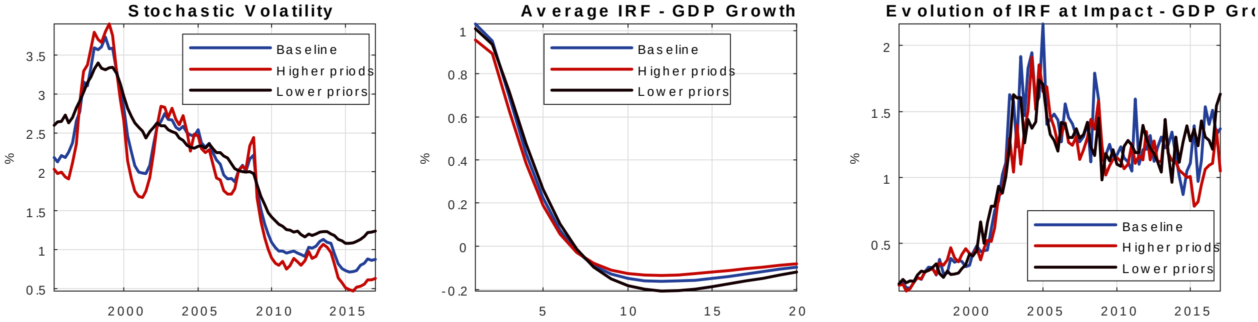


Figure 11. Average Impulse Response to a Monetary Policy Shock. The blue lines correspond to the average of median corresponding to every moment of time. The upper and lower red lines represents the confidence intervals that correspond to the 84th and 16th percentiles, respectively.

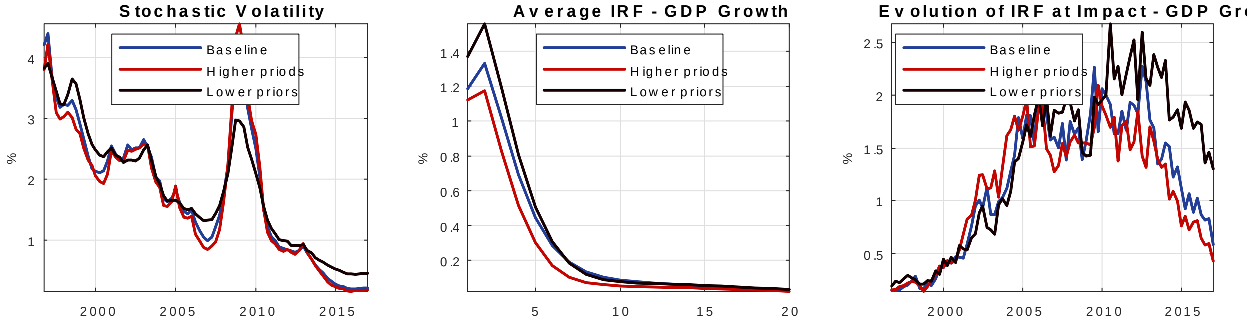
I. Chile



II. Colombia



III. Mexico



IV. Peru

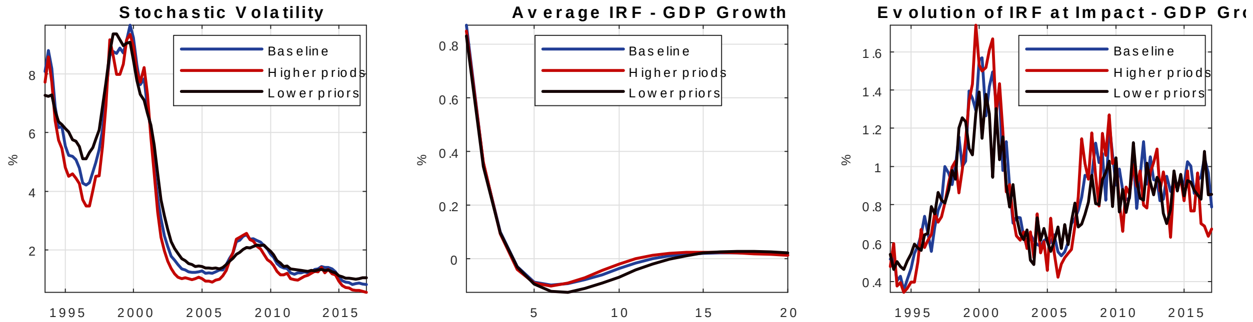
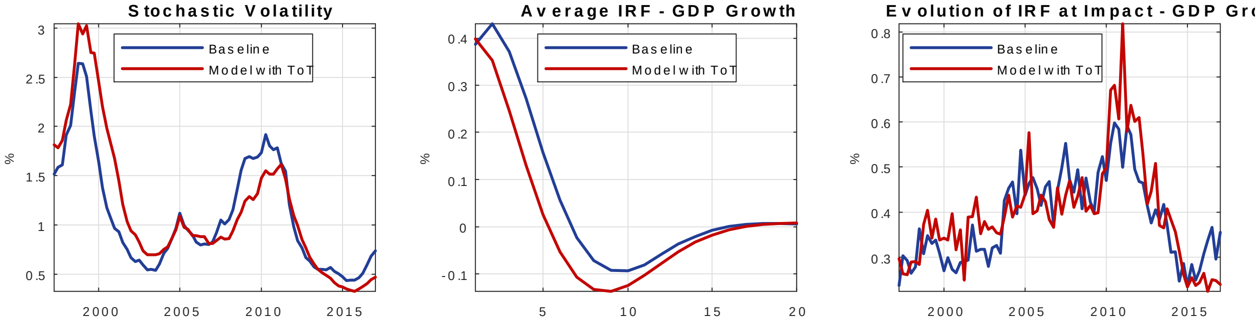
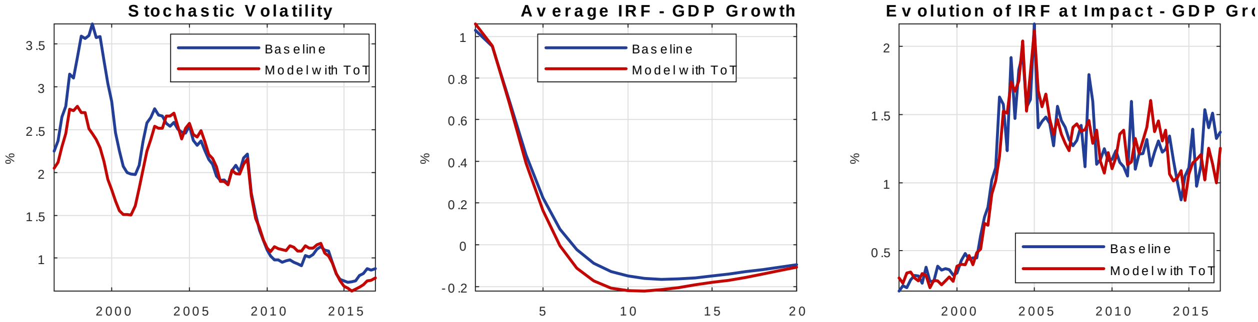


Figure 12. Sensibility 1: Baseline, Higher and Lower priors. The Blue line represents the results using the Baseline specification. The Red line represents the estimation using higher priors. The Black line represent the results usig lower priors.

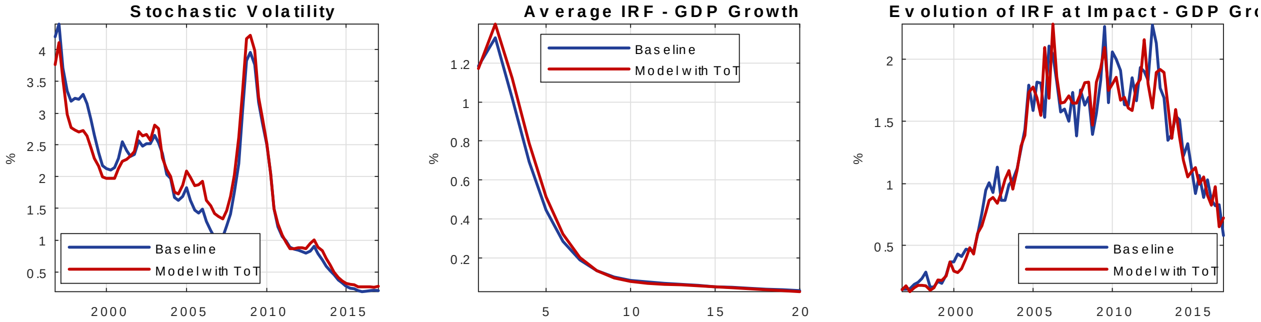
I. Chile



II. Colombia



III. Mexico



IV. Peru

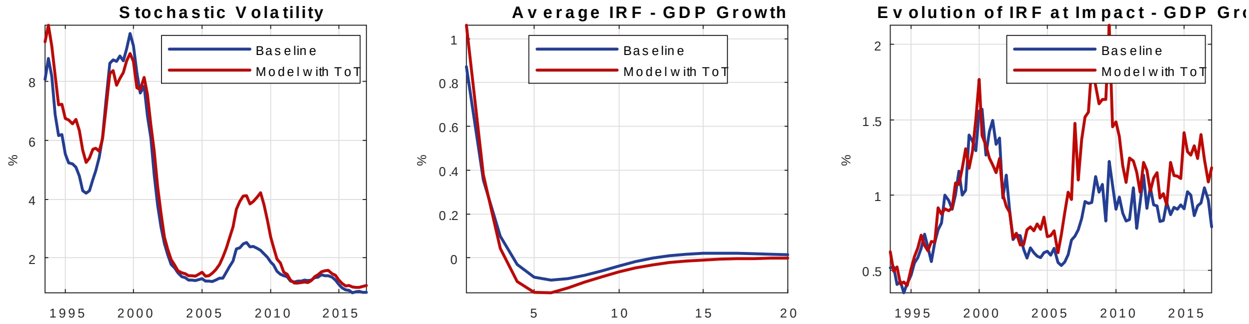
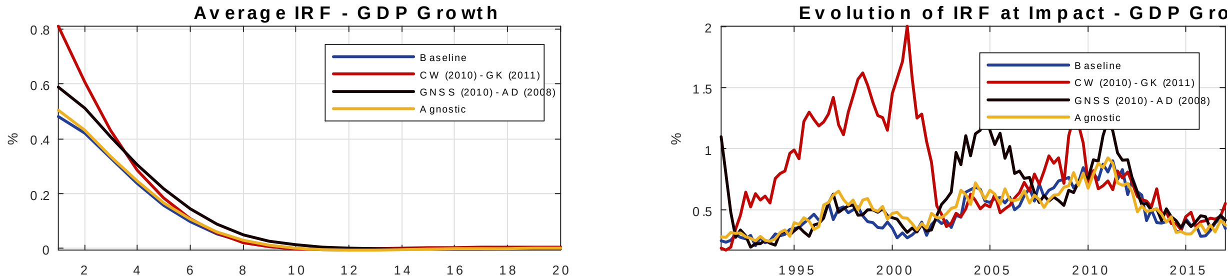
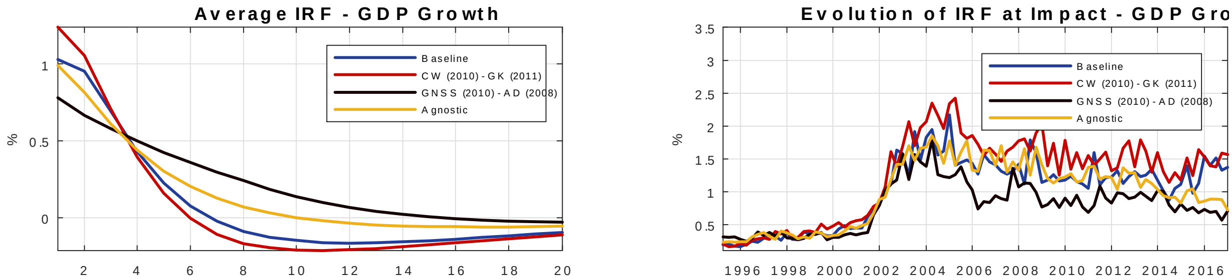


Figure 13. Sensibility 2: Model including Terms of Trade. The blue line represents the results using the baseline specification. The red line represents the stimation using terms of trade instead of using SPGSCI.

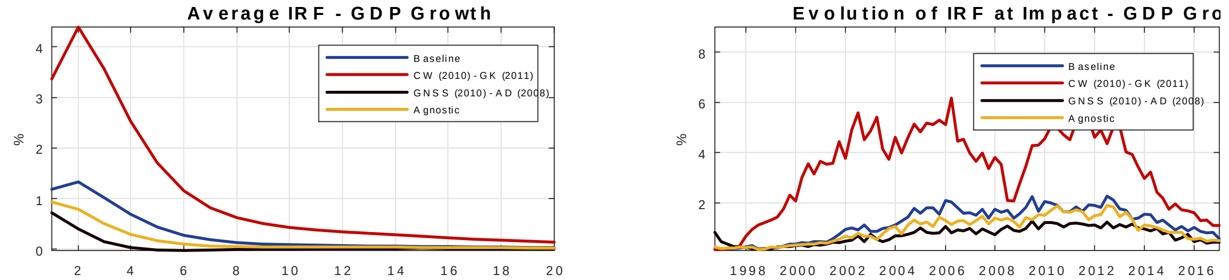
I. Chile



II. Colombia



III. Mexico



IV. Peru

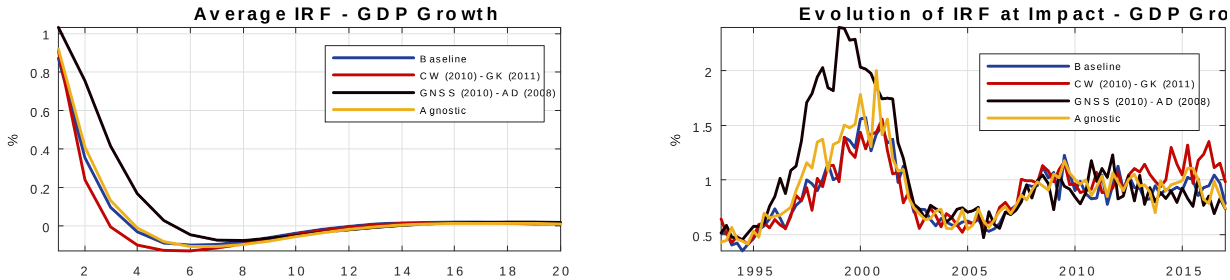


Figure 14. Sensibility 3: Different Sets of Sign restrictions. The Blue line represents results from Baseline specification. The Red line represents results using sign restrictions used in Cúrdia and Woodford (2010) and Gertler and Karadi (2011), both denoted by CW (2010)-GK (2011). The Black line represents results using sign restrictions used in Gerali et al. (2010) and Atta-Mensah and Dib (2008), both denoted by GNSS (2010)-AD (2008). The Yellow line represents results considering an agnostic specification where GDP Growth and Inflation responses to LS shocks are set to be unrestricted.

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