ECONSTOR
Make Your Publications Visible.

A Service of

ZBW Leibniz-Informationszentrum Wirtschaft
Leibniz Information Centre for Economics

Colunga, Luis Fernando

Working Paper

The loan puzzle in Mexico

Working Papers, No. 2024-15

Provided in Cooperation with:
Bank of Mexico, Mexico City

Suggested Citation: Colunga, Luis Fernando (2024) : The loan puzzle in Mexico, Working Papers, No. 2024-15, Banco de México, Ciudad de México

This Version is available at:
https://hdl.handle.net/10419/310354

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

WWW.ECONSTOR.EU

Mitglied der Leibniz-Gemeinschaft

Banco de México

Working Papers

N° 2024-15

The Loan Puzzle in Mexico

Luis Fernando Colunga
Banco de México

October 2024

La serie de Documentos de Investigación del Banco de México divulga resultados preliminares de trabajos de investigación económica realizados en el Banco de México con la finalidad de propiciar el intercambio y debate de ideas. El contenido de los Documentos de Investigación, así como las conclusiones que de ellos se derivan, son responsabilidad exclusiva de los autores y no reflejan necesariamente las del Banco de México.

The Working Papers series of Banco de México disseminates preliminary results of economic research conducted at Banco de México in order to promote the exchange and debate of ideas. The views and conclusions presented in the Working Papers are exclusively the responsibility of the authors and do not necessarily reflect those of Banco de México.

Documento de Investigación
2024-15

Working Paper
2024-15

The Loan Puzzle in Mexico*

Luis Fernando Colunga†
Banco de México

Abstract: In some advanced and emerging economies, contrary to expectations, it has been observed that increases in short-term interest rates are accompanied by increases in bank credit; a phenomenon referred to as "the loan puzzle." This study investigates, through the estimation of a structural vector autoregressive model using national and sectoral-level data, whether this phenomenon occurred in the Mexican economy between 2001 and 2019. The results suggest that, in response to a positive shock to short-term interest rates, the volume of bank credit to firms exhibits a positive and short-lived response but subsequently decreases. This response is primarily observed in sectors that had the lowest average delinquency rates during the analysis period. This suggests that banks would grant more loans to relatively safer companies, while, in response to such monetary tightening, they would reduce their investments in riskier and longer-term assets, such as consumer loans and loans to the real estate sector.
Keywords: Monetary Policy, Bank Credit, Vector Autoregressive Model
JEL Classification: E51, E52, E58

Resumen: En algunas economías avanzadas y emergentes se ha observado, contrario a lo esperado, que incrementos en las tasas de interés de corto plazo son acompañados de aumentos en el crédito bancario; efecto que ha sido denominado como "el enigma de los préstamos bancarios" (*the loan puzzle*). Este trabajo investiga, mediante la estimación de un modelo estructural de vectores autorregresivos con información a nivel nacional y sectorial, si este fenómeno se registró en la economía mexicana entre 2001 y 2019. Los resultados sugieren que, ante un choque positivo sobre las tasas de interés de corto plazo, el volumen del crédito bancario a las empresas muestra una respuesta positiva y de corta duración, pero el volumen del crédito bancario se reduce posteriormente. Esta respuesta se observa, principalmente, en los sectores que presentaron las tasas promedio de morosidad más bajas durante el periodo de análisis. Esto sugiere que los bancos otorgarían más préstamos a empresas relativamente más seguras, al tiempo que, ante dicho apretamiento monetario, reducirían sus inversiones en activos más riesgosos y de largo plazo como, por ejemplo, los préstamos al consumo y al sector inmobiliario.
Palabras Clave: Política Monetaria, Crédito Bancario, Modelo de Vectores Autorregresivos

*I am grateful for the support and motivation I received from my advisor, Victor Valcarcel. I also thank Raúl Ibarra, Julio Carrillo, and Leonardo Torre for their guidance in strengthening this paper presented during the Summer 2020 Research Internship Program at Banco de México. I thank Tom Doan for his technical support on the RATS handling, and I also appreciate his support in answering some questions about the use of the code for the estimation of an SVAR with block exogeneity.

† Dirección General de Investigación Económica. Email: lcolunga@banxico.org.mx

1 Introduction

A textbook mechanism suggests that following a monetary tightening, credit volume should decrease. However, Den Haan et al. (2007) examine the role of monetary policy on the level of bank loans for the United States and find that following a monetary tightening, commercial and industrial bank loans increase.[1] This finding is considered a "counterintuitive" reaction and has been called the *loan puzzle*. Den Haan et al. (2007) suggest that in a context of high interest rates and low economic growth, banks may prefer investing more in short-term assets, such as firms loans, that earn a high return and are relatively safe than investing in the real estate sector, characterized by holding long-term and risky assets.

More recently, Leblebicioglu and Valcarcel (2018) analyze the impact of monetary policy on bank loans in emerging economies (Turkey, Mexico, and Chile) from 1986 to March 2016. They find that in the case of a domestic monetary expansion, there is a "counterintuitive response" of commercial and industrial bank loans in all three countries. However, Leblebicioglu and Valcarcel (2018) only consider a historical sample and limit their investigation on aggregate responses. This paper expands on their analysis by considering a more recent period that allows me to include December 2015 to December 2018, when the Central Bank of Mexico started to tighten monetary policy, which is relevant to my research question. Furthermore, it conducts a sectoral study by reviewing which industries (primary sector, mining, manufacturing, commerce, tourism, financial sector, and household consumption) show this counterintuitive reaction. The literature suggests that, in general, sectors that depend most on bank credit, such as manufacturing and small firms tend to be more affected following a monetary tightening. Gertler and Gilchrist (1993) point out that consumers and small businesses generally rely more on bank credit compared to larger businesses because access to other financing sources may be more difficult. Hence, the availability of credit to both consumers and small enterprises demonstrates a heightened sensitivity to monetary tightening,

[1] They also find that consumer and real estate bank loans show a significant reduction following a short-term rate hike.

in contrast to credit extended to larger firms primarily concentrated within the manufacturing sector.

I leverage information from Banco de México and the National Mexican Institute of Statistics (INEGI) spanning July-2001 to December-2019. My approach is similar to that of Cushman and Zha (1997), in which a SVAR model with block exogeneity is estimated for a small open economy. The identification of the SVAR model is similar to that proposed by Den Haan et al. (2007), Cushman and Zha (1997) and Leblebicioglu and Valcarcel (2018). Particularly, the question of interest is whether the *loan puzzle* is widely observed across the different sectors of the economy.

I extend the analysis by answering two important questions. First, I set out to determine whether the *loan puzzle* has been a feature of the Mexican economy in a recent sample.[2] Second, if such a reaction exists, I investigate whether it can be explained through a lending channel mechanism that incorporates sectoral dynamics.

My results suggest that various open-economy structural VAR specifications show evidence of short-lived loan puzzles in a recent sample characterized by an inflation-targeting regime in Mexico. Importantly, these loan puzzles reveal positive responses in credit volume following a monetary tightening, but these effects are transient and limited to the short term. For instance, I find that commercial and industrial bank loans increased during the first seven months following a monetary tightening shock. At the sectoral level, the short-lived loan puzzles are mainly observed in the relatively safer sectors such as manufacturing, commerce, and finance, which aligns with the hypothesis of portfolio reallocation towards safer assets.

The organization of this document is as follows: Section 2 presents a brief literature review regarding the role of monetary policy on bank loans. Section 3 describes the data and sources of information used to carry out this analysis. Section 4 shows the proposed methodology and identification of the SVAR model with block exogeneity that I employ to analyze the impact

[2] Analysis of the Mexican economy is important for two reasons. First, most of the evidence on the *loan puzzle* has centered in advanced economies, such as United States and Canada, and not in emerging economies, in which depending on their degree of financial development, bank loans may be a powerful channel for the monetary policy transmission. Second, analysis of the credit channel for the Mexican case is relevant in the context in which some reforms have been implemented to improve the regulation and development of financial markets, (Ibarra (2016)).

of monetary policy on bank loans by industry. Sections 5 to 7 describe the main findings and conclusions that emerge from this document.

2 Literature Review

The transmission of monetary policy on bank loans can be understood through supply and demand factors. Among the factors that may influence the demand for bank loans, the role of firms' balance sheets is worth highlighting. Following a monetary tightening, firms' cash flows and the value of their assets may decrease. Consequently, the value of the collateral that firms could use to get a bank loan may fall as well. As a result, firms would have more incentives to undertake riskier projects. This could generate an adverse selection problem if riskier firms request bank loans to finance their projects. A volatile environment that makes it more difficult for banks to identify risk may lead to hikes in risk premia as well as increased barriers to access to credit.

On the other hand, the effects of a tight monetary policy can be transmitted via a loan supply reduction through the "lending channel". Following an interest rate increase, it becomes costlier for banks to obtain loanable funds, as explained by Bernanke and Blinder (1988). These higher costs may imply higher interest rates at which banks are willing to lend money. This may restrict access to credit for agents who are more dependent on bank credit, such as consumers and small firms. The transmission of monetary policy through the lending channel may be more effective to the extent that bank lending is one of the most relevant sources for obtaining loans.

Gertler and Gilchrist (1993) analyze the role of the credit market in the transmission of monetary policy. Using information for United States from 1975 to 1991, the authors note that consumers and small businesses generally rely more on bank credit than larger businesses because access to other financing sources may be more difficult for the former. The authors consider this to be a credit market imperfection. Gertler and Gilchrist (1993) suggest that in this context, credit to consumers and small firms is more sensitive to a restrictive monetary policy than credit to large firms.

Gertler and Gilchrist (1994) analyze firms' behavior following a United States monetary tightening with quarterly information for the period 1960 to 1991. Overall, they find that small firms are more sensitive to a monetary tightening. In particular, they observe that small firms' drop in sales and inventories is quicker and more pronounced in relation to larger firms. They argue that small firms are riskier and not very well collateralized, which could represent frictions in the financial markets for them to access credit. On the other hand, they point out that large firms tend to increase debt in the short run to accumulate inventories.

Bernanke and Gertler (1995) analyze the role of the lending channel in the transmission of monetary policy during the period 1965-1993. They find that economic activity and the price level show a reduction following a monetary tightening. However, when decomposing GDP into inventories and final demand, they find that inventories react positively in the first four to eight months, which is considered a "puzzling response", contrary to the suggested textbook prediction.[3] The authors propose a mechanism where after a monetary tightening, firms face a worsening of their cash flows as they have to pay more interest and have lower sales. However, even in such a scenario, firms have to continue paying the financing to accumulate inventories and working capital.[4] This may lead to a greater need for funding, which Bernanke and Gertler (1995) consider as one of the reasons for the delay in the negative response of inventories.

Suzuki (2004) analyzes the effect of a monetary tightening in Japan on bank loans. He finds that after a monetary tightening, there is a significant reduction in the number of new bank loans after the first quarter. He also finds that the interest rate associated with these loans showed an increase during the first four quarters. However, he notes that the interest rate on new bank loans seems to be more rigid than the reference interest rate following a monetary tightening.

[3]However, after eight months, inventories fall.

[4]In the case that following a monetary tightening, firms may want to keep employment and output constant, at least for the short-run, and given that their sales decline because private consumption reduces after the shock, inventories should increase. Therefore, large firms, generally less financially constrained, could increase their necessity for external financing or bank loans. On the other hand, small firms could respond to the monetary shock by reducing output and employment such that inventories would eventually decline. As a result, they may not increase short-term borrowing.

Fernandez (2005) analyzes the transmission of monetary policy through the lending channel in Chile. She determines that a tightening of monetary policy and a decrease in economic growth are factors that exert a negative impact on the volume of bank loans. However, larger, more efficient and banks with more liquid assets tend to be less affected by a monetary tightening. On the other hand, Fernandez (2005) finds that bank loans to the manufacturing and financial services sectors tend to be more sensitive to an increase in interest rates.

Den Haan et al. (2007) analyze the effect of monetary policy on bank loans in United States during the period 1977 to 2004 and report that following a monetary tightening, consumer and real estate loans showed a significant reduction, while commercial and industrial bank loans increased during some quarters. This last finding is considered a "counterintuitive" reaction of bank loans (*loan puzzle*). Den Haan et al. (2007) explain the "liquidity" dimension of the *loan puzzle* in a context when interest rates are high and economic activity is low, such that banks may prefer to invest in short-term assets, for example, by granting loans to industry and commerce (which pay high-interest rates and are relatively safe sectors) than to the real estate sector (which invests over long-term horizons and could be relatively riskier). On the other hand, Den Haan et al. (2007) also suggest that following a monetary tightening, firms may request more bank loans to finance an inventory increase, as proposed by Bernanke and Gertler (1995), which would lead to an expansion in the bank loan volume, as long as the hike in demand exceeds to the supply's reduction. However, Den Haan et al. (2007) find no evidence in favor of this possibility for the United States case during the period 1Q-1977 to 2Q-2004.

Den Haan et al. (2009) study the transmission of monetary policy on bank loans in Canada during the period 1972 to 2007 and conclude that following a monetary tightening, consumer bank loans tend to decrease, while industrial bank loans increase during some quarters. The authors point out that this finding suggests that consumers are more likely to be more constrained than firms, possibly because of some friction in the credit market.

Leblebicioglu and Valcarcel (2018) analyze the impact of monetary policy on bank loans using monthly data of Turkey and Chile from January 1986 to March 2016, and for Mexico using data starting in 1994 up to 2016. Using a spillover index based on the forecast error

variance decomposition, they find that the United States monetary policy has effects on the bank loan volume in the three countries. They also conclude that following a monetary expansion in United States, there is a puzzling (negative) response of commercial and industrial bank loans for the case of Chile and Turkey. In the case of a domestic monetary expansion, on the other hand, all three countries show a "counterintuitive response" of commercial and industrial bank loans.

Cantú et al. (2019) analyze how specific characteristics of banks affect the loan supply after different economic shocks in Mexico (including a monetary tightening). The authors report that banks with strong balance sheets (well capitalized) and more diversified sources of income generally tend to offer more bank loans. Furthermore, they find that highly capitalized banks with more liquid assets tend to respond less negatively to a monetary tightening. In contrast, banks with higher risk indicators tend to be more sensitive to an interest rates increase. Their analysis also shows that foreign subsidiaries tend to be even more sensitive to domestic and external shocks. One reason for this is that these institutions are more capable of diversifying risk within the bank at the international level. They also indicate that credit growth is greater for firms with long and high credit scores and that during periods of financial stress, large firms are less affected by credit growth.

In addition to Fernandez (2005) and Cantú et al. (2019), there is a large number of authors who have analyzed the transmission of monetary policy through the lending channel from a microeconomic perspective. These authors use panel data information for a set of banks of a specific country. The consensus of these documents is that, generally, banks with highly liquid assets and well-capitalized are the least affected by restrictive monetary policy, that is the case of Uruguay (Lorenzo et al. (2010)), Brazil (Coelho et al. (2010)), Italy (Gambacorta (2005)), Ukraine (Golodniuk (2006)) and Malaysia (Abdul Karim et al. (2011)). It is very important to note that within the studies with panel data, to the best of my knowledge, there is no evidence of the *loan puzzle* for the firms' case. Hence, it seems that the puzzling response of banking credit following a monetary tightening emerges from aggregate data.

Some of the recent literature on the lending channel transmission of monetary policy has centered on microeconomics dynamics. I carry out my analysis using aggregate information at the national level for the Mexican case in the tradition of Leblebicioglu and Valcarcel (2018).

I should also mention that besides bank credit, another relevant financing external source for the Mexican firms is the suppliers' credit. According to the National Survey of Business Financing, in 2018, the main source of external financing for companies was bank credit since 75.4 percent of the firms reported to have used this financing source during that year. On the other hand, companies reported that the second source of external financing was suppliers' credit (30.4 percent).[5] The latter is considered an important financing source to fund working capital, especially for the case of Mexican small and medium-sized companies (Lecuona (2014)). In this regard, there is no evidence for the Mexican case on the effects of monetary policy on suppliers' credit. However, some panel data studies for the case of European countries suggest that following a monetary tightening, bank credit could be more sensitive than suppliers' credit (Mateut et al. (2006) and Sáiz et al. (2017)).

3 Data

I consider a recent sample of monthly frequency data from July-2001 to December-2019.[6] The reasoning behind starting the analysis with data from 2001 is because Banco de México established in 2001 the beginning of an inflation targeting regime as a framework to conduct monetary policy.[7] Specifically, the Central Bank set an annual inflation target no higher than 6.5 percent for 2001, while the one for 2002 was 4.5 percent. Since December 2003 the

[5] Main results of the survey are presented in: *Encuesta Nacional de Financiamiento de las Empresas 2018 (ENAFIN 2018)* downloadable at: `https://www.inegi.org.mx/contenidos/programas/enafin/2018/doc/ENAFIN2018Pres.pdf`.

[6] After 2001, the Mexican economy started a period of lower and more stable inflation rates, which allowed for a better development of the financial markets due to lower uncertainty in the economy (Ibarra (2016)).

[7] For more details about Monetary Policy Implementation through an Operational Interest Rate Target, please refer to the "Programas de Política Monetaria" prior to 2001 available at `https://www.banxico.org.mx/publicaciones-y-prensa/programas-de-politica-monetaria/programas-politica-monetaria-.html`).

inflation target has been 3 percent (+/- 1 percent variability interval).[8] In addition to that, according to Chiquiar et al. (2010), the inflation rate began to show a more stable behavior from 2001.

With respect to the set of variables that I use in this paper, first, I have bank loans (B), which are disaggregated at the industry level. The data corresponding to bank loans by economic sector (primary sector, mining, manufacturing, commerce, tourism, financial sector, construction, and household consumption) come directly from Banco de México.

As a measure of economic activity, I consider (Y), a seasonally adjusted Index for Aggregate Economic Activity at the National Level (IGAE).[9] The source for this variable is INEGI. The price level (P) was obtained directly from INEGI and corresponds to the National Consumer Price Index (INPC).[10] $EXCH$ corresponds to the Bilateral Real Exchange Rate Index with respect to United States. The interpretation of the index is as follows: an increase in the real exchange rate index represents a depreciation, while a decrease in the index represents an appreciation.[11]

[8] For additional information regarding the inflation targeting regime, please refer to the following documents: "Informe sobre la inflación, julio-septiembre 2000," available for download at `https://www.banxico.org.mx/publicaciones-y-prensa/informes-trimestrales/informes-trimestrales-precios.html`, and "Programa de política monetaria para 2002," available for download at `https://www.banxico.org.mx/publicaciones-y-prensa/programas-de-politica-monetaria/programas-politica-monetaria-.html`.

[9] According to INEGI, the Global Indicator of Economic Activity (IGAE) makes it possible to know and follow up on the monthly evolution of the real sector of the economy. The following are used for its calculation: the conceptual scheme, the methodological criteria, the classification of economic activities, and sources of information, which are used in the annual and quarterly calculations of the Gross Domestic Product.

[10] There is not an official seasonally adjusted Consumer Price Index. As a result, the variable used in this research has not that characteristic.

[11] The Bilateral Real Exchange Rate Index is calculated as the product of the nominal exchange rate by the price ratio between the two countries (A).

$$RERI_t = e_t \times \left(\frac{p_t^*}{p_t}\right) \tag{A}$$

Where:

- p_t = National Consumer Price Index of Mexico (INPC) in month "t".
- p_t^* = Consumer Price Index (CPI) of United States in month "t".
- e_t = Index of the average nominal exchange rate in Mexican pesos per US dollar in month "t" (exchange rate to settle obligations denominated in foreign currency, settlement date, monthly average).

I use the annual interest rate of 28-day Treasury Certificates (CETES-28) as the monetary policy indicator (R). This interest rate can be used as a monetary policy indicator in Mexico, given its high correlation with the overnight TIIE, which is the target for the policy rate.[12] The use of this interest rate as the monetary policy indicator in Mexico is consistent with Kamin and Rogers (1996), De Mello and Moccero (2009), Cermeño et al. (2012), Cortés Espada (2013) and Carrillo and Elizondo (2015).[13]

Regarding the evolution of the main Mexican variables, panel (a) of Figure 1 shows that before 2007, the annual growth rate of bank lending to the non-banking sector showed an upward trend, while economic growth remained relatively stable. Once the Global Financial Crisis (GFC) took place, both banking credit and economic activity fell, although economic activity fell faster than bank lending. By the end of 2009, both variables began to show signs of recovery in an environment in which short-term interest rates went down gradually until the beginning of 2016. At the beginning of 2018, economic activity and bank lending began to slow, which occurred in an environment in which interest rates rose. Panel (b) of the Figure 1 shows that both economic activity and short-term interest rates have shown a relatively stable behavior during the whole period of analysis, except for the GFC period, while bank lending to the private sector was relatively much less stable during the first decade of the 2000s.[14]

For United States variables, I incorporate United States Industrial Production (Y^*), United States Consumer Price Index (P^*) and the United States Federal Funds Rate (R^*), all obtained from the Federal Reserve Bank of St. Louis. However, I replace the Federal Funds Rate with the shadow Federal Funds rate of Wu and Xia (2016) during the zero lower bound period. The reason behind that strategy is because the Federal Funds rate was not very informative about the United States monetary policy during the zero lower bound period.

[12] The correlation coefficient between both interest rates is almost equal to 1.

[13] The information on the real exchange rate and the short-term interest rate comes from Banco de México.

[14] Additionally, I calculated a contemporaneous Pearson correlation coefficient between bank lending growth and economic activity at the national level, and it was 0.43 and statistically significant at a 5 percent level. For the case of each sector, a contemporaneous positive and statistically significant correlation coefficient was found only for the construction and commerce sectors. My hypothesis is that the effect of C&I bank loans may have a lagged effect on economic activity.

Except for interest rates, all variables were transformed to indices based on 2019 equal to 100. Then the logarithms of the variables were obtained.[15]

4 Empirical Framework

My approach is similar to that of the seminal work of Cushman and Zha (1997) and Kim and Roubini (2000), who study the impact of monetary policy for the case of small open economies (SOE's).

Cushman and Zha (1997) argue that recursive VAR models to identify monetary policy shocks make sense for relatively large and closed economies, such as United States, given that monetary policy decisions in large economies are unlikely to have some influence from smaller countries. However, in small open economies, shocks from some larger economies may have an impact on their monetary policy decisions.

Kim and Roubini (2000) follow the work done by Cushman and Zha (1997) and analyze the impact of a monetary policy shock on six economies smaller than United States. Kim and Roubini (2000) estimate a SVAR model in which they assume that United States variables may influence the variables of each of these countries, but not vice-versa. Kim and Roubini (2000) find that following a monetary tightening, under this SVAR identification, there is no evidence of puzzling responses on the price level and the exchange rate. As a result, taking seriously the critique about the use of recursive models to identify monetary policy shocks in small open economies (such as Mexico), in this paper, I adopt a methodology in the spirit of Cushman and Zha (1997) and Kim and Roubini (2000), although with some modifications. For this, I initially consider the use of a VAR model. The reduced-form representation of this model is described below:

$$z_t = B_1 z_{t-1} + ... + B_q z_{t-q} + u_t \tag{1}$$

[15]Note that the estimation of the SVAR models will be done using the logarithm of the variables in levels (the logarithm is not applied to the interest rate). This strategy is consistent with the seminal works of Sims (1980) and Sims et al. (1990).The argument is that differencing discards important information concerning the co-movements in the data. However, I recognize that the estimation of the VAR models with the variables in levels implies losing some estimators' efficiency but, importantly, not consistency.

where z_t is the vector of endogenous variables, B is a matrix of coefficients for lagged variables, q is the number of lags, u_t is a vector of residuals for each equation. Since the possibility of some contemporaneous relationship of the variables is omitted in that equation, I have that the variance-covariance matrix is full ($E\left[u_t {u_t}' \mid y(t-s), s>0\right] = V$). To allow for a contemporaneous relationship of the variables by identifying A_0, it is possible to rewrite the previous model in its structural form as follows:

$$A_0 z_t = A_1 z_{t-1} + \ldots + A_q z_{t-q} + \varepsilon_t \tag{2}$$

where the variance-covariance matrix is diagonal for structural shocks. Following Cushman and Zha (1997), z_t is divided into two blocks of variables, z_{1t} and z_{2t}. z_{1t} includes the variables from Mexico, and consequently, z_{2t} refers to the set of variables corresponding to United States.

Note that Mexico is assumed to be a small economy since, according to the World Bank, Mexico's Gross Domestic Product represented 5.9 percent of the United States' GDP in 2018. Additionally, Mexico is regarded as an open economy, with exports comprising approximately 37 percent of its GDP.

Therefore, I can rewrite equation 2 as follows:

$$A(L)z(t) = \varepsilon(t) \tag{3}$$

$$z(t) = \begin{bmatrix} z_1(t) \\ z_2(t) \end{bmatrix}, A(L) = \begin{bmatrix} A_{11} & A_{12} \\ 0 & A_{22} \end{bmatrix}, \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix} \tag{4}$$

where $z(t)$ is a vector of $m \times l$ observations, z_1 is a vector of $m_1 \times l$ containing the set of domestic variables and z_2 is a $(m - m_1) \times l$ vector containing the set of United States variables. $\varepsilon_1(t)$ and $\varepsilon_2(t)$ are vectors of the structural residuals of dimensions $m_1 \times l$ and $m_2 \times l$, respectively. The dimension of A_{11} is $m_1 \times m_1$; A_{12} dimension is $m_1 \times m_2$; A_{21} dimension is $m_2 \times m_1$; A_{22} dimension is $m_2 \times m_2$, where $m_1 + m_2 = m$.

I also assume that:

$$E\left[\varepsilon(t)\varepsilon(t)' \mid y(t-s), s>0\right] = D, E\left[\varepsilon(t) \mid y(t-s), s>0\right] = 0 \tag{5}$$

The $A_{21} = 0$ restriction implies that United States variables are not affected by Mexican variables neither contemporaneously nor with a lag (under the assumption that Mexico is a small open economy).

In the case of Mexico, the following variables are considered: $B, Y, P, EXCH, R$, in that order. Furthermore, for simplicity, a recursive order is assumed. The order of the variables is similar to that of Carrillo and Elizondo (2015) and assumes that the short-term interest rate —in the spirit of the Taylor Rule approach—can react on impact to production, prices, and the real exchange rate shocks, but these variables react with a lag to monetary policy shocks.[16]

However, given my interest in analyzing heterogeneity in the responses of bank loans at the industry level, I decompose B into an index of bank loans for each industry (primary sector, mining, manufacturing, commerce, tourism, financial sector, construction, and household consumption). A SVAR model with Block Exogeneity is estimated for each economic sector.

In a similar way that for the case of Mexico, I assume a lower triangular order for the United States variables (Y^*, P^*, R^*), which is consistent with Cushman and Zha (1997).

Regarding block A_{12}, I assume that bank loans do not respond to United States variables. Based on the knowledge that 80 percent of Mexican exports to the United States represent more than a third of Mexican domestic production, my identification leaves the relationship between economic activity in Mexico and in United States unrestricted. Similarly, I assume that the price level in Mexico may be influenced by the international prices of goods and services. As a result, the price level of United States is used as a reference for prices at the international level.[17] I also assume that both the real exchange rate and the interest rate respond contemporaneously to the set of United States variables; this assumption is consistent with Cushman and Zha (1997), with the exception that Cushman and Zha (1997) do not assume that

[16] I also allowed for a different variable ordering, $Y, P, EXCH, R, B$, in which bank loans may react on impact to the short-term interest rate. Nonetheless, the results are similar to the ones found under the first specification. These results are shown in Appendix A.

[17] Under this assumption, I allow for the Mexican monetary policy indicator to react on impact to external variables.

the Canadian interest rate responds on impact to the United States industrial production. The following matrix shows in a general form the identification of the SVAR block exogeneity model that will be used throughout this paper.

The first block A_{11} (in the upper left corner) shows how the domestic variables interact with each other. The second block A_{12} (in the upper right corner) establishes how the Mexican variables react to the United States variables. The third block A_{21} (in the lower left corner) is the block exogeneity by which it is established that the variables of United States never react to the Mexican variables. Finally, the fourth block A_{22} (in the lower right corner) shows the relationship of the United States variables with themselves.

$$A(0) = \begin{array}{c} \\ B \\ Y \\ P \\ EXCH \\ R \\ \\ Y^{*} \\ P^{*} \\ R^{*} \end{array} \begin{pmatrix} a_{11} & 0 & 0 & 0 & 0 & . & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & . & a_{26} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & . & 0 & a_{37} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 & . & a_{46} & a_{47} & a_{48} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & . & a_{56} & a_{57} & a_{58} \\ . & . & . & . & . & . & . & . & . \\ 0 & 0 & 0 & 0 & 0 & . & a_{61} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & . & a_{71} & a_{72} & 0 \\ 0 & 0 & 0 & 0 & 0 & . & a_{81} & a_{82} & a_{83} \end{pmatrix} \tag{6}$$

5 The Effects of Monetary Policy Shocks in Mexico

First, I review whether the variables are stationary or not by using the Augmented Dickey-Fuller (ADF) Test. These results suggest that all variables in levels are I(1) (See Table 1), while all variables are stationary in first differences. Hence, I proceeded to estimate the VAR models using variables in log-levels.[18]

[18]The number of optimal lags according to the Akaike criterion (AIC) was obtained for each VAR model. The confidence intervals of the Impulse Response Functions (IRFs) were estimated according to the Bayesian method suggested by Cushman and Zha (1997). The computation is based on 5000 Monte Carlo draws, of

5.1 The Effects of Monetary Policy Shocks in Mexico at the National Level

I proceed to estimate the SVAR model described above with information for the period spanning July-2001 to December-2019, a period characterized by economic stability, at least, relative to the economic situation of the country before 2001, except for the period of the GFC. In fact, Figure 2 shows that before 2001, a period that comprehends the episode of the Mexico Peso Crisis, there was high volatility in the Mexican economy. We can observe, for example, that both inflation and economic growth showed high volatility during that period, which was significantly reduced after 2001. Even though the economic growth volatility increased during the financial crisis of 2008-2009, this volatility was lower in magnitude and less persistent compared to the observed in the 90s.[19] Furthermore, in 2001, the Mexican Central Bank adopted the inflation targeting regime. For the structural VAR estimation, I follow the strategy of Den Haan et al. (2007), and Den Haan et al. (2009) whereby bank loans are disaggregated into consumer, and commercial and industrial loans, as well as proceeding to review the transmission of monetary policy via an increase in short-term interest rates (monetary tightening).[20,21]

Figure 3 shows that following a monetary tightening, consumer bank loans respond negatively with a lag of approximately 4 months after the monetary shock, consistent with Den Haan et al. (2007) and Den Haan et al. (2009).[22] On the other hand, commercial and industrial bank loans respond with a lag of 1 to 3 months, and their response shows an increase that lasts approximately 4 months. This result is contrary to what the textbook suggests and is there-

which 10 percent were discarded. The bands of the coefficients correspond to the 16th and 84th percentiles of the previous computations. Results for the tests for stability of the VAR Models are presented in Table 2.

[19]However, considering that the estimates may be affected by the inclusion of the GFC in the period of analysis, on an alternative specification to that of Equation 2, following Kang et al. (2016), I include a dummy variable that takes the value of 1 during the period spanning from Nov-08 to Nov 09, and otherwise 0. My results are robust to the inclusion or exclusion of the dummy variable.

[20]I assume, for simplicity, that there is no contemporaneous relationship between consumer and commercial and industry bank loans.

[21]Consumer (excluding housing) and commercial and industrial bank loans represent, on average, 74 percent of the total bank credit to the private sector. Housing is excluded because credit to this sector could be more sensitive to long-term interest rates.

[22]I also estimate a SVAR model with block exogeneity by considering the bank credit at the aggregate level (consumer loans plus firms loans), and I find that following a monetary tightening, bank credit increases during the first 4 months, probably influenced by the firms' loans response.

fore known as the *loan puzzle*. It should be noted that an important characteristic of the *loan puzzle* is that it is a short-run phenomenon (Den Haan et al. (2007), Den Haan et al. (2009) and Leblebicioglu and Valcarcel (2018)). However, I find that following a monetary tightening, the duration of the positive response of firms' bank loans in Mexico is shorter than that reported by Den Haan et al. (2007) and Den Haan et al. (2009) for the case of United States and Canada, respectively (the authors report positive responses that seem to last a few years). However, in terms of the duration of the response of the firms' bank loans, my results are more similar to those found by Leblebicioglu and Valcarcel (2018) for emerging economies, Mexico included. Leblebicioglu and Valcarcel (2018) report for the Mexican case, a *loan puzzle* response duration of less than one year, although they analyze the case of a monetary expansion.[23]

As previously noted, the literature suggests that the *loan puzzle* can be interpreted from both supply and demand perspectives. However, due to data limitations, pinpointing the exact mechanism behind its occurrence remains challenging. Our analysis aims to shed light on whether supply or demand factors predominantly drive this phenomenon. To this end, we present some evidence that may help clarify the underlying mechanisms potentially responsible for the emergence of the *loan puzzle* in the context of monetary tightening.

From the supply side, one possibility that the literature provides for observing this differentiated response from consumers and commercial and industrial bank loans is that following a monetary tightening, banks might discriminate between consumers and firms according to their risk level. For example, in Figure 4 it is observed that although during the entire time period of analysis (July-2001 to December-2019) the firms' risk is relatively higher (6.5 percent) compared to the consumers' risk index (5.0 percent), when considering the period January-2006 to December-2019 (which represents the 76 percent of the entire time series),

[23] In this regard, it should be noted that for the United States case, Den Haan et al. (2007) find that the *loan puzzle* is a statistically significant response for at most 4 years. Den Haan et al. (2009) find something similar for the case of Canada since bank loans to firms increase up to seven quarters after a monetary shock. Regarding the evidence for emerging economies, Leblebicioglu and Valcarcel (2018) find that the *loan puzzle* is a statistically significant response that lasts on average up to six months for the case of Mexico and Chile. In this paper, I find that the response of banking credit to firms following a monetary tightening is consistent with what has been found for the above-mentioned emerging economies since the *loan puzzle* is statistically significant only for a few months (less than 6) post-shock.

the consumers' risk is more than twice the firms' risk level.[24] In such a case, when monetary policy tightens, banks could respond by recomposing their loan portfolio. That is, at least for the short run, banks may prefer to invest in short-term assets that earn a high return and are relatively safer, such as firms' bank loans, rather than investing in riskier assets, such as consumer bank loans.

The negative consumer bank loans response that I find is consistent with Gertler and Gilchrist (1993), and Gertler and Gilchrist (1994), who argue that following a monetary tightening, consumers and small businesses are generally affected, in part because their consumption and investment are largely dependent on more bank credit. Den Haan et al. (2009) argue that after an interest rate increase, banks could reduce credit to consumers and use those resources to lend them to firms, which would be more attractive for banks since they would pay high-interest rates at a lower risk.

The supply-side hypothesis regarding portfolio reallocation as an explanation for the puzzling response of credit volume following monetary tightening requires further research and should be approached with caution. However, it's important to highlight the finding of heterogeneous responses in credit volume between consumers and firms after the monetary shock, given the differing risk profiles of these agents, with consumers generally being riskier than firms.

On the other hand, Figure 5 shows that national production (IGAE) seems to respond negatively short after the monetary tightening. In addition, the real exchange rate (EXCH) falls after 8 months, while the price level (INPC) seems to be a more persistent and rigid variable after the short-term interest rates increase.[25]

Under another specification different from the main one, similar to the one of Den Haan et al. (2007) but for a small open economy, I decompose bank credit into consumer loans, mortgage credit, and firms' loans. I find that following a monetary tightening, mortgage credit falls with a delay. The delayed negative response of mortgage credit could be associ-

[24] I use cross-sectional realized loan delinquency rates to approximate credit risk across sectors.

[25] The INPC response displays a delayed reaction —consistent with a traditional New Keynesian prediction— before turning in the expected (negative) direction. For a more in-depth analysis of the delayed effects of monetary tightening on prices, please refer to Havranek and Rusnak (2012).

ated with the fact that this sector is more sensitive to long-term interest rates than to short-term interest rates. The negative response of both consumer credit and mortgage credit under this specification is consistent with that of Den Haan et al. (2007). Under this exercise, I still find evidence of the *loan puzzle* for the firms' case, (Figure 6). Regarding this point, I consider it highly relevant to explore in the future to what extent the "liquidity" dimension may have played a role in the Mexican economy as for the United States case version of the loan puzzle.[26]

From the demand perspective, to explore the possibility that demand factors may play a key role in the emergence of the *loan puzzle*, I estimate a SVAR model for a small open economy, following Bernanke and Gertler (1995), using the same variables as in the previous model. However, under this exercise, I decompose GDP into changes in inventories and final demand (GDP minus changes in inventories).[27] To estimate this model, I use quarterly frequency data for the period spanning 3Q-2001 to 4Q-2019. I find that after a monetary tightening, the change in inventories falls (panel (a) of Figure 7).[28] This result contrasts with that found by Bernanke and Gertler (1995), which suggests that after a positive monetary shock, inventories increase during the first 2 to 3 quarters. This finding weakens the possibility that, at least at the aggregate level, the increase in bank loan demand to finance inventories following a monetary tightening could explain the existence of the *loan puzzle*. However, I recognize that this possibility may still hold, particularly for large firms, such as those in the

[26]For example, Den Haan et al. (2007) study the portfolio behavior of bank loans for the United States economy and find that following a monetary tightening, real estate, and consumer loans (long-term and risky assets) decline, while commercial and industrial loans (short-term or more "liquid" assets) increase. This finding suggests that when monetary policy tightens, banks may prefer granting short-term loans that are relatively safe and pay high-interest rates.

[27]This exercise uses a measure of final demand, defined as GDP minus changes in inventories. For consistency, both GDP and inventory changes are sourced from the 2018 Mexican System of National Accounts (for more details, see Sistema de Cuentas Nacionales de México. Fuentes y metodologías. Año base 2018. Available at: https://www.inegi.org.mx/app/biblioteca/ficha.html?upc=889463913825). According to INEGI, changes in inventories (CI) refer to variations in domestic and imported product inventories, including: (1) Raw materials and semi-finished or finished goods purchased for production; (2) Work in progress: goods partially produced during the accounting period that require further processing before sale; (3) Livestock for slaughter: excludes animals used for reproduction or work, which are considered capital goods; (4) Unsold finished goods; (5) Military stocks: single-use items like ammunition and missiles. Inventory changes are calculated from product catalogs and the 2019 Economic Census, measuring the difference between production and sales. Positive or negative variations depend on the balance between output and sales.

[28]Under this strategy, the output response is consistent with the estimated in the previous exercise.

manufacturing sector, as suggested by Bernanke and Gertler (1995). Unfortunately, there is no information at the sectoral level for inventories to replicate these estimates for each industry.

The exercise inspired by Bernanke and Gertler (1995) for the Mexican economy suggests that external funding may not be necessary to increase inventory levels following a monetary shock, at least at the aggregate level. However, alternative demand-side mechanisms could still explain the *loan puzzle*. One such hypothesis proposes that after an unexpected rise in short-term interest rates, firms might anticipate a cycle of further rate increases. Consequently, they may increase their short-term borrowing to secure lower financing costs before rates climb higher. Nevertheless, further research is needed to validate this hypothesis and to gain a deeper understanding of the supply and demand factors contributing to the *loan puzzle*. Expanding this analysis will enhance our ability to identify the mechanisms driving this phenomenon.

6 Effects of Monetary Policy Shocks in Mexico at the Sectoral Level

Once I identified a "puzzling" response of commercial and industrial bank loans at the aggregate level, I proceed to carry out a sectoral analysis, in which I decompose commercial and industrial bank loans for 7 economic sectors: primary (PRIM), mining (MIN), tourism (TUR), financial (FIN), construction (CONST), manufacturing (MAN) and commerce (COM).[29,30] The idea of this exercise is to investigate if the response of commercial and industrial bank loans is heterogeneous across the different sectors or not.[31] These results are shown in Figures 8 and 9, which indicate that bank loans for the manufacturing, commerce, tourism and financial sectors show a positive response after a monetary tightening. The bank loan response of the manufacturing and commerce sectors shows the longest duration, while in the case of the tourism and financial sectors, the *loan puzzle* barely lasts 1 month. On the other hand, bank credit for the primary and mining sectors seems to respond negatively after the mone-

[29] One SVAR model with Block Exogeneity is estimated for each economic sector.

[30] Bank loans to these 7 sectors represent an average of 76 percent of the total firms' bank credit. I consider only these 7 sectors since they concentrate most of the bank credit, and the remaining are relatively very small.

[31] I assume for simplicity that there is not a relationship across the bank loans for each sector.

tary shock. In this regard, it is worth pointing out some reasons that may help to explain this heterogeneous bank loan response across the different sectors.

In the first place, note that, according to Figure 10, during the period July-2001 to December-2019, bank loans for the manufacturing sector have represented on average 28.8 percent of the total firms' bank credit (the highest share with respect to the rest of the sectors). Therefore, it makes sense that since bank credit for manufacturing is the most relevant, bank loans for this sector could significantly account for the commercial and industrial *loan puzzle* at the aggregate level.

Regarding the puzzling response of bank credit in the manufacturing, commerce, tourism, and financial sectors after an interest rate increase, a common feature that those sectors share is that on average, during July-2001 to December-2019, they showed the lowest risk compared to the other sectors. Figure 11 shows that the riskiest economic sectors are the primary (PRIM), construction (CONST), and mining (MIN). In the same line, Figure 12 shows the historical evolution of delinquency rates for each sector. Interestingly, according to Figure 12, delinquency rates before 2006 were close to double digits for all sectors except for the financial sector. However, some sectors registered relatively higher delinquency rates, such as the primary sector, construction, and mining. After 2006, delinquency rates went down significantly compared to the previous period in all sectors, although they increased during the financial crisis of 2008-2009.[32] This finding raises the possibility that, following a monetary tightening, banks might shift their portfolios toward relatively safer assets. In this regard, I would like to focus on the case of the manufacturing sector, given its relevance within the bank loan composition (28.8 percent). Regarding the manufacturing sector, it is convenient to mention, as shown in Figure 13, that in this sector, most of the country's large companies are concentrated (43 percent). And according to Figure 14, large companies are considerably less risky (3.6 percent) than small and medium-sized companies (6.0 percent).[33] This context

[32]It is important to mention that I also tried identifying the industry risk through representative interest rates for each sector, however, the information was not available for the period and the sectors of analysis.

[33]The CNBV calculates the firm's size based on the number of employees and the annual borrower's revenue, according to the following formula: Calculated Firms' Size (CFS) = 0.1*Number of Employees + 0.9*(Revenue/1,000,000). The firm is considered small size if $4.6 < CFS \leq 95$, the firm is considered medium size if $95 < CFS \leq 250$ and the firm is considered large size if $CFS > 250$.

strengthens the hypothesis suggested by Bernanke and Gertler (1995), which establishes that sectors, such as manufacturing, in which large companies are concentrated, could observe greater access to the credit market compared with some other sectors that may be riskier and less relevant.

6.1 The Role of Possible Relationships Among Different Industries to Explain the Sectoral Loan Puzzles

In another strategy, I include the bank credit of all the economic sectors in one VAR model.[34] In order to carry out that sectoral analysis, since decomposing bank credit by economic sector would imply a high number of variables and a significant loss of degrees of freedom, I proceed to estimate a Bayesian VAR (BVAR) model similar to the one previously estimated, with the difference that in this exercise, United States variables are treated strictly as exogenous.[35] The idea is to use an informative prior to shrink the unrestricted VAR model towards a parsimonious naive benchmark, thus reducing parameter uncertainty. That is, I assume that each endogenous variable in the model presents a unit root in its first own lag, and as a result, my prior for those coefficients is equal to 1. I also assume that parameters for lags higher than 1 and cross-variable (included exogenous variables) lag coefficients are equal to zero. Hence, I also assume that the variance of those priors has to be relatively small. The reduced form representation of this model is described below:

$$z_t = B_1 z_{t-1} + ... + B_q z_{t-q} + C x_t + u_t \tag{7}$$

where z_t is a vector of Mexican endogenous variables, x_t is a vector of United States exogenous variables, B is a matrix of coefficients for lagged variables, q is the number of

[34] Under this strategy, United States variables are treated as exogenous variables. This is different from the previous strategy in which all variables were treated as endogenous. Nevertheless, we find that United States variables have a modest contribution explaining the firms' *loan puzzle*.

[35] Bayesian techniques help to solve the dimensionality issue of a frequentist VAR model. The total number of iterations is 20,000, and the number of burn-in iterations is 19,000.

lags, u_t is a vector of residuals for each equation.[36] To allow for a contemporaneous relationship of the variables, I assume a recursive order of the endogenous variables and a Cholesky decomposition is used to identify the Mexican monetary policy shock.

The variance of parameters in B that relate endogenous variables to their own and cross-lags is defined as follows:

$$\sigma_{a_{ij}}^2 = \left(\frac{1}{\sigma_j^2}\right)\left(\frac{\lambda_1}{\lambda_3}\right)^2 \tag{8}$$

where λ_1 is an overall tightness parameter, l is the lag for each coefficient and λ_3 defines the rate at which coefficients higher than 1 (second lag, third lag...) converge to zero with greater certainty. σ_j^2 is the unknown residual variance for variable j in the Bayesian VAR model. That variance is approximated by individual auto-regressive models.

For the exogenous variables, such as in this case, the United States variables, the variance for their coefficients is defined as follows:

$$\sigma_c^2 = (\lambda_1\lambda_4)^2 \tag{9}$$

where λ_4 is a large or infinite variance parameter.

I assume a Normal Inverse-Wishart prior distribution for the variance of the parameters.[37] I also assume the following hyper-parameters for the coefficients in B: Auto-regressive coefficient: 1; Overall tightness (λ_1): 0.2; Lag decay (λ_3): 2; Exogenous variable tightness (λ_4): 100; Block exogeneity shrinkage (λ_5): 0.001.[38]

From this second strategy, I provide evidence of robustness for the previous industry results (Figures 15 and 16). As we can observe in Figure 15, the sectors in which I find the puzzling response are the same that I previously indicated (manufacturing, commerce, tourism,

[36] Under this specification I also included a trend variable t as an exogenous variable, and I find that results are robust to its exclusion or inclusion. I also did the same when decomposing bank credit into consumer and firm loans. The results, again, do not change after including the trend variable.

[37] The normal-Wishart variance-covariance matrix of B is a special case of the Minnesota variance-covariance matrix where λ_2 is equal to 1.

[38] Priors for hyper-parameters λ_3, λ_4, λ_5 are the ones suggested by Dieppe et al. (2016). The prior for λ_1 is similar to Dieppe et al. (2016), but instead of using λ_1 = 0.1, I assume λ_1 = 0.2 to allow for less shrinkage of the parameters, λ_1 = 0.2 is consistent with Canova (2011).

and finance). However, under this second strategy, bank loan volume in the manufacturing sector seems to respond faster than in the first strategy. On the other hand, responses of bank loans of the mining and primary sectors are very similar (in terms of timing, direction, and duration) to the ones of the first strategy (Figure 16).

7 Concluding Remarks

This paper expands on the research that Leblebicioglu and Valcarcel (2018) conducted for the Mexican economy, in which the authors analyze the transmission of monetary policy through bank credit to the private sector.

This paper addresses a number of questions. One is to determine whether the *loan puzzle* is a feature of the modern Mexican economy. In addition, it is asked whether an open-economy model can shed light on its dynamics. Finally, it is asked if such a counterintuitive reaction can be explained in a lending channel mechanism incorporating sectoral dynamics.

Using information from July-2001 to December-2019, I find that commercial and industrial bank loans increase during the first seven months after a monetary shock, before eventually declining. This suggests the existence of a short-lived *loan puzzle* in Mexico.

To obtain more information on the *loan puzzle* identified for the firms' case, I also disaggregate bank loans by economic sector. I find different responses across sectors. For instance, following a monetary tightening, we observe that the manufacturing and financial sectors show a positive credit response within a few months of the shock, which eventually turns negative. In contrast, the primary and mining sectors consistently exhibit a negative response throughout. This is interesting since the manufacturing and financial sectors historically have shown to be less risky. On the other hand, the primary and the mining sectors have registered higher delinquency rates.

The literature identifies both supply and demand factors as potential explanations for the *loan puzzle*. On the supply side, Den Haan et al. (2009) suggests that following a monetary tightening, banks may reallocate their portfolios toward safer, short-term assets like firms' bank loans, rather than riskier consumer and mortgage loans. On the demand side, Bernanke

and Gertler (1995) proposes that external funding might be needed to finance inventory increases after a monetary shock. Additionally, firms may increase short-term borrowing in anticipation of further interest rate hikes, further contributing to the *loan puzzle*.

This research finds that following monetary tightening, the response of credit volume varies across sectors. A common feature among industries where credit volume increases in the short run after the shock is that these sectors typically have relatively lower delinquency rates. While the evidence provided by this paper does not point to an increase in inventories following monetary tightening, which would suggest a need for external funding, the possibility remains open that other demand channels could be at play to further investigate the role of expectations in driving increased bank lending. In the future, it would be beneficial to use alternative inventory measures for a more granular analysis of sectors where the *loan puzzle* is observed, such as manufacturing.

This paper broadens the understanding of monetary policy transmission through the credit channel by highlighting how different economic sectors may respond to changes in monetary policy. Since the estimations do not cover the COVID-19 pandemic era, further research is needed to assess whether the *loan puzzle* persists when the pandemic period is considered.

Future research should further explore the supply and demand factors driving the *loan puzzle*. A promising approach would involve analyzing panel data of bank loans, segmented by firm size, to gain a more detailed and granular understanding of the phenomenon. This microdata analysis is essential, as it would allow for the comparison of the results from aggregated data, like those in this study, with findings at the individual loan level. By doing so, researchers could broaden their understanding of the *loan puzzle*, moving beyond the aggregate perspective to offer a more robust, firm-specific analysis. Additionally, exploring the potential asymmetric effects of monetary tightening on the volume of bank credit could provide another valuable avenue for investigation.

References

Abdul Karim, Z., Azman-Saini, W., and Abdul Karim, B. (2011). Bank Lending Channel of Monetary Policy: Dynamic Panel Data Study of Malaysia. *Journal of Asia-Pacific Business*, 12(3):225–243.

Bernanke, B. and Blinder, A. S. (1988). Credit, Money, and Aggregate Demand. *American Economic Review*, 78(2):435–439.

Bernanke, B. S. and Gertler, M. (1995). Inside the Black Box: The Credit Channel of Monetary Policy Transmission. *Journal of Economic Perspectives*, 9(4):27–48.

Canova, F. (2011). *Methods for Applied Macroeconomic Research*. Princeton University Press.

Cantú, C., Lobato, R., López, C., and López-Gallo, F. (2019). A Loan-Level Analysis of Bank Lending in Mexico.

Carrillo, J. A. and Elizondo, R. (2015). How Robust are SVARs at Measuring Monetary Policy in Small Open Economies? Technical report, Working Papers.

Cermeño, R., Villagómez, F. A., and Polo, J. O. (2012). Monetary Policy Rules in a Small Open Economy: An Application to Mexico. *Journal of Applied Economics*, 15(2):259–286.

Chiquiar, D., Noriega, A. E., and Ramos-Francia, M. (2010). A Time-Series Approach to Test a Change in Inflation Persistence: The Mexican Experience. *Applied Economics*, 42(24):3067–3075.

Coelho, C. A., De Mello, J. M., Garcia, M. G., and Galindo, A. J. (2010). Identifying the Bank Lending Channel in Brazil through Data Frequency. *Economía*, 10(2):47–79.

Cortés Espada, J. F. (2013). Estimating the Exchange Rate Pass-Through to Prices in Mexico. *Monetaria*, 1(2):287–316.

Cushman, D. O. and Zha, T. (1997). Identifying Monetary Policy in a Small-Open Economy under Flexible Exchange Rate. *Journal of Monetary Economics*, 39(3):433–48.

De Mello, L. and Moccero, D. (2009). Monetary Policy and Inflation Expectations in Latin America: Long-Run Effects and Volatility Spillovers. *Journal of Money, Credit and Banking*, 41(8):1671–1690.

Den Haan, W. J., Sumner, S. W., and Yamashiro, G. M. (2007). Bank Loan Portfolios and the Monetary Transmission Mechanism. *Journal of Monetary Economics*, 54(3):904–924.

Den Haan, W. J. D., Sumner, S. W., and Yamashiro, G. M. (2009). Bank Loan Portfolios and the Canadian Monetary Transmission Mechanism. *Canadian Journal of Economics/Revue canadienne d'économique*, 42(3):1150–1175.

Dieppe, A., Legrand, R., and Van Roye, B. (2016). The BEAR toolbox.

Fernandez, V. (2005). Monetary Policy and the Banking Sector in Chile. *Emerging Markets Finance and Trade*, 41(3):5–36.

Gambacorta, L. (2005). Inside the Bank Lending Channel. *European Economic Review*, 49(7):1737–1759.

Gertler, M. and Gilchrist, S. (1993). The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence. *The Scandinavian Journal of Economics*, pages 43–64.

Gertler, M. and Gilchrist, S. (1994). Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms. *The Quarterly Journal of Economics*, 109(2):309–340.

Golodniuk, I. (2006). Evidence on the Bank-Lending Channel in Ukraine. *Research in International Business and Finance*, 20(2):180–199.

Havranek, T. and Rusnak, M. (2012). Transmission Lags of Monetary Policy: A Meta-Analysis. International Journal of Central Banking Working Paper.

Ibarra, R. (2016). How Important is the Credit Channel in the Transmission of Monetary Policy in Mexico? *Applied Economics*, 48(36):3462–3484.

Kamin, S. B. and Rogers, J. H. (1996). Monetary Policy in the End-Game to Exchange-Rate Based Stabilization: The Case of Mexico. *Journal of International Economics*, 41(3-4):285–307.

Kang, W., Ratti, R. A., and Vespignani, J. (2016). The Impact of Oil Price Shocks on the US Stock Market: A Note on the Roles of US and Non-US Oil Production. *Economics Letters*, 145:176–181.

Kim, S. and Roubini, N. (2000). Exchange Rate Anomalies in the Industrial Countries: A Solution with a Structural VAR Approach. *Journal of Monetary Economics*, 45(3):561–586.

Leblebicioglu, A. and Valcarcel, V. J. (2018). An International Perspective on the Loan Puzzle in Emerging Markets. In *Banking and Finance Issues in Emerging Markets*, volume 25, pages 163–191. Emerald Publishing Limited.

Lecuona, R. (2014). Algunas Lecciones de la Experiencia Reciente de Financiamiento a las PYMES: Colombia, Costa Rica y México.

Lorenzo, F., Capurro, A., Carlomagno, G., Garda, P., Lanzilotta, B., and Zunino, G. (2010). Transmisión de la Política Monetaria a Través del Crédito. Enfoques microeconómicos. Technical report.

Mateut, S., Bougheas, S., and Mizen, P. (2006). Trade Credit, Bank Lending and Monetary Policy Transmission. *European Economic Review*, 50(3):603–629.

Sáiz, M. C., Azofra, S. S., Olmo, B. T., and Gutiérrez, C. L. (2017). Trade Credit, Sovereign Risk and Monetary Policy in Europe. *International Review of Economics and Finance*, 52:39–54.

Sims, C. A. (1980). Macroeconomics and Reality. *Econometrica: Journal of the Econometric Society*, pages 1–48.

Sims, C. A., Stock, J. H., and Watson, M. W. (1990). Inference in linear time Series Models with Some Unit Roots. *Econometrica: Journal of the Econometric Society*, pages 113–144.

Suzuki, T. (2004). Credit Channel of Monetary Policy in Japan: Resolving the Supply versus Demand Puzzle. *Applied economics*, 36(21):2385–2396.

Wu, J. C. and Xia, F. D. (2016). Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. *Journal of Money, Credit and Banking*, 48(2-3):253–291.

Tables and Figures

Variables in Levels				First Differences		
	ADF Test			ADF		
Variable	**t-Statisitc**	**C.V.**	**Result**	**t-Statisitc**	**C.V.**	**Result**
Short-Term Interest Rate	-1.8755	-2.8753	Unit Root	-3.9662	-2.8753	Stationary
INPC	-0.7039	-2.8753	Unit Root	-3.3075	-2.8753	Stationary
IGAE	-0.9110	-2.8753	Unit Root	-6.1428	-2.8753	Stationary
Exchange Rate	-0.8335	-2.8753	Unit Root	-10.1587	-2.8753	Stationary
US Industrial Production	-2.1165	-2.8753	Unit Root	-3.9191	-2.8753	Stationary
US CPI	-1.1635	-2.8753	Unit Root	-9.7781	-2.8753	Stationary
Federal Funds Rate	-2.1681	-2.8753	Unit Root	-3.5629	-2.8753	Stationary
Consumer Loans	-2.1998	-2.8753	Unit Root	-2.1757	-1.9424	Stationary
Firms Loans	-0.1920	-2.8753	Unit Root	-12.0938	-2.8753	Stationary
Primary Loans	0.2760	-2.8753	Unit Root	-5.3419	-2.8753	Stationary
Mining Sector Loans	-0.9568	-2.8753	Unit Root	-9.2494	-2.8753	Stationary
Finance Sector Loans	-0.8636	-2.8753	Unit Root	-12.7288	-2.8753	Unit Root
Manufacturing Sector Loans	0.0964	-2.8753	Unit Root	-7.7511	-2.8753	Stationary
Construction Sector Loans	-1.7160	-2.8753	Unit Root	-3.5757	-2.8753	Stationary
Commerce Sector Loans	-1.3440	-2.8753	Unit Root	-5.5585	-2.8753	Stationary
Tourism Sector Loans	-0.2588	-2.8753	Unit Root	-16.2363	-2.8753	Stationary

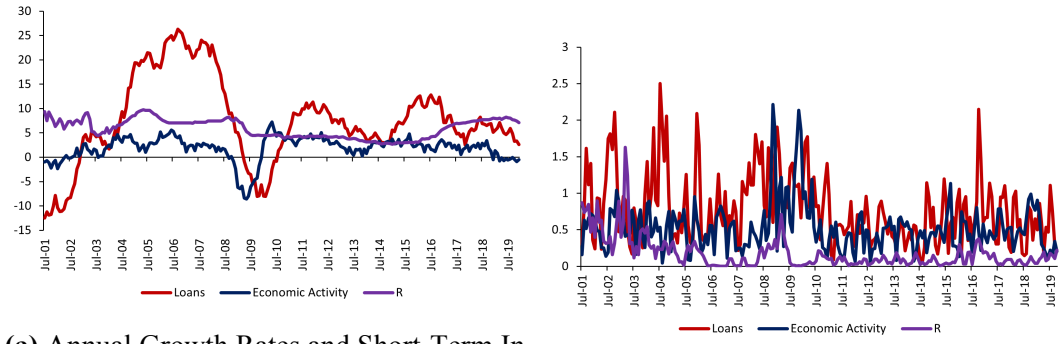
Table 1: Augmented Dickey Fuller Tests.

Source: Own calculations based on data from INEGI, Banco de México, and the Federal Reserve of St. Louis.

Note: For the ADF tests an intercept was included and the selected number of lags was according to the Akaike Criterion (the maximum number of lags established was 14), MacKinnon (1996) one-sided p-values were considered to test the null hypothesis. Critical Values (C.V.) are at the 95 percent confidence level. First difference of Construction Sector Loans is stationary without including intercept and trend.

VAR Model	Significance Level Q-Test
IRF's on Figures 3,5	0.76
IRF's on Figures 6,7	0.69
IRF's on Figure 8	0.16
IRF's on Figure 9 (a)	0.74
IRF's on Figure 9 (b)	0.69
IRF's on Figure 9 (c)	0.92
IRF's on Figure 9 (d)	0.91
IRF's on Figure 10 (a)	0.69
IRF's on Figure 10 (b)	0.94

Table 2: Autocorrelation Tests.
Source: Own calculations based on data from INEGI, Banco de México, and the Federal Reserve of St. Louis.
Note: The null hypothesis is that residuals from the VAR models are not serially correlated.



(a) Annual Growth Rates and Short-Term Interest Rate (R)

(b) Volatility

Figure 1: Evolution of Annual Growth Rates of Bank Lending and Economic Activity and the Short-Term Interest Rate (R).
Source: Own calculations based on data from INEGI, and Banco de México.
Note: Volatility was calculated as the 3-month rolling standard deviation for each variable.

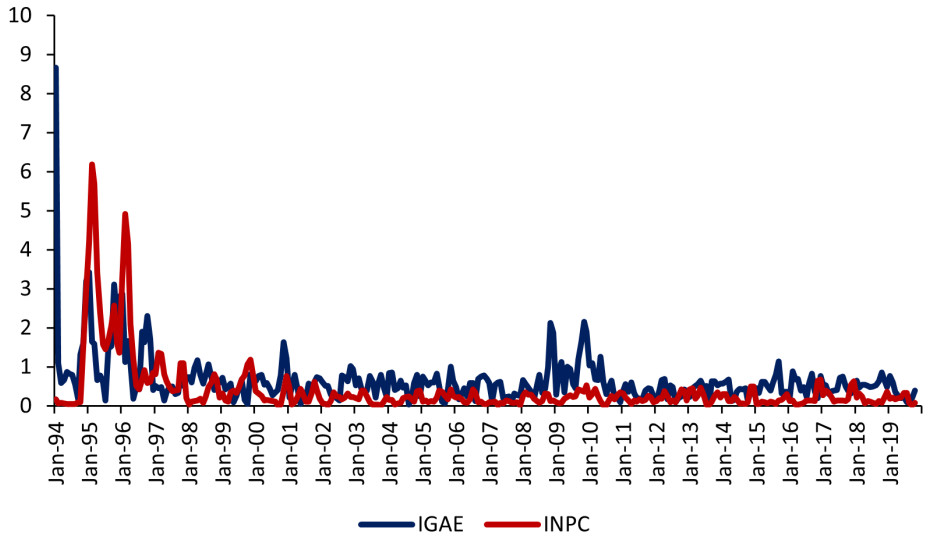
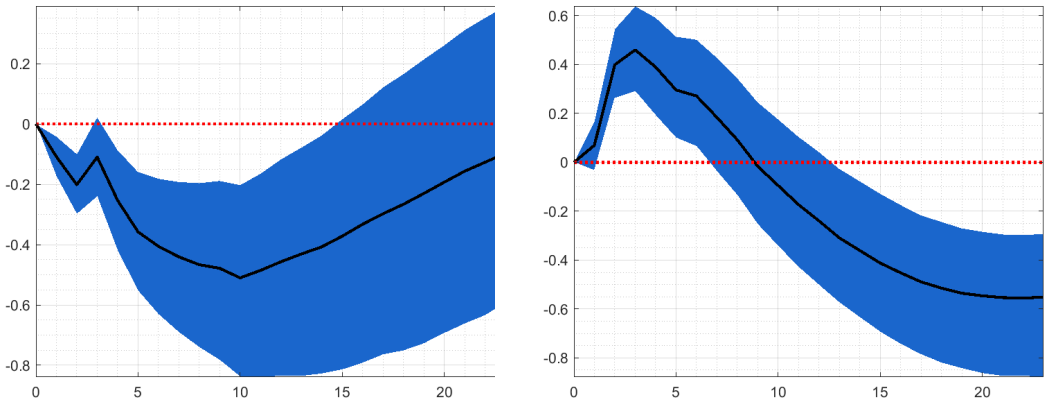


Figure 2: Volatility of Annual Economic Growth and Annual Inflation Rate
Source: Own calculations based on data from INEGI.
Note: Volatility was calculated as the 3-month rolling standard deviation for each variable.



(a) Consumer Loans **(b)** Firms Loans

Figure 3: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model with block exogeneity for a Small Open Economy.
Source: Own estimates based on data from INEGI, and Banco de México, and the Federal Reserve of St. Louis.
Note: Time in months (horizontal axis) and units in percent (vertical axis).

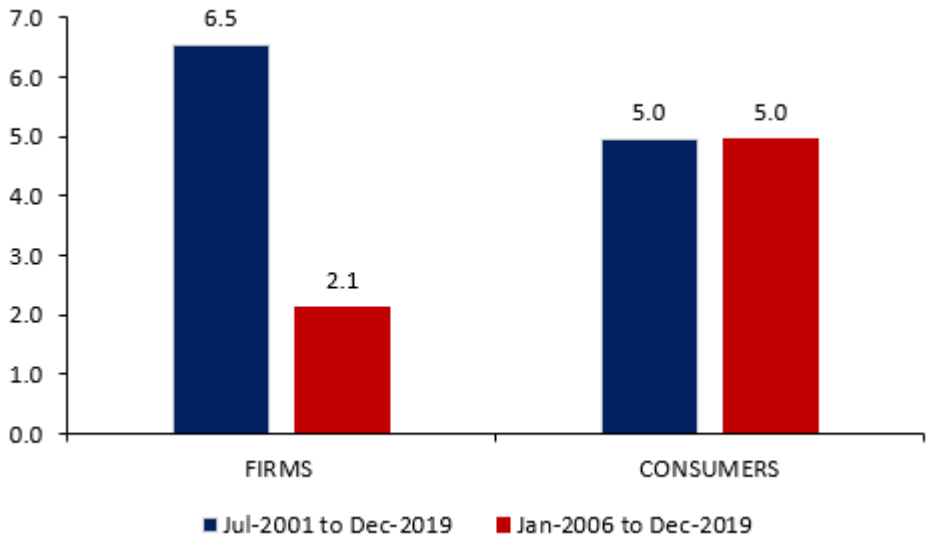
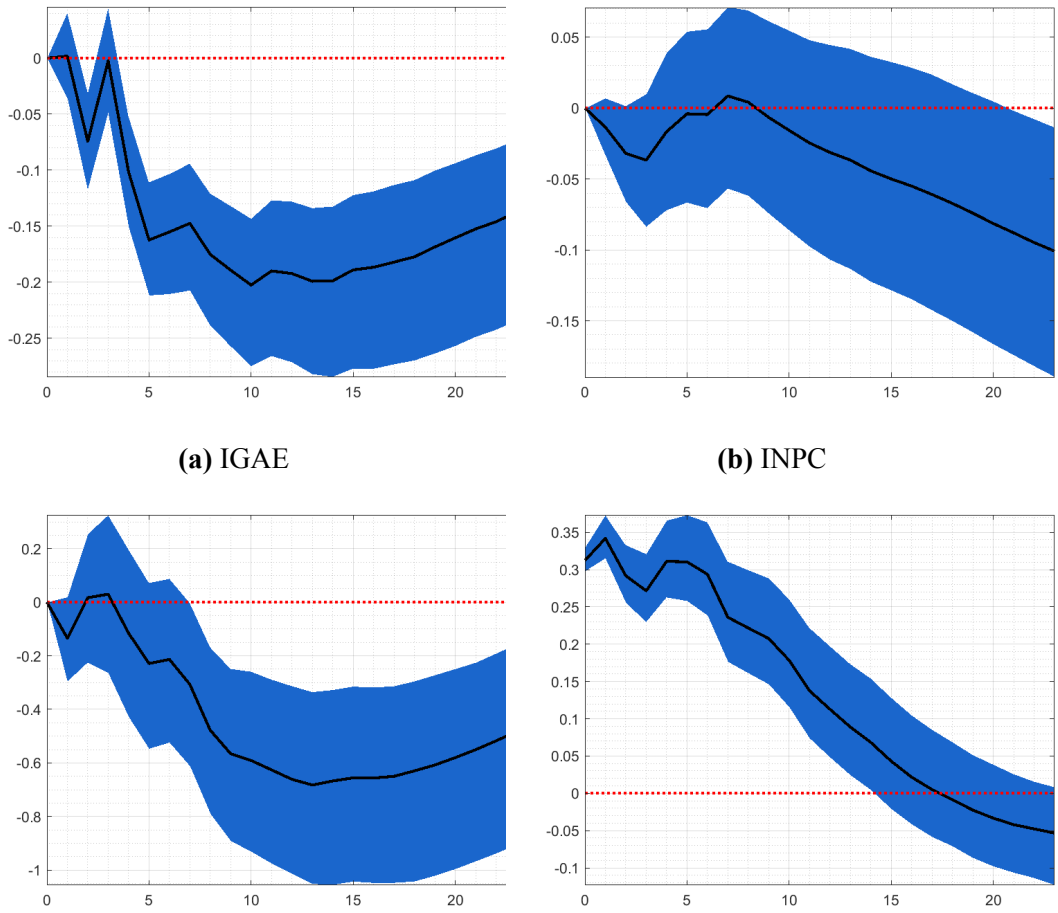


Figure 4: Loan Delinquency Rate by Economic Sector
Source: Banco de México.



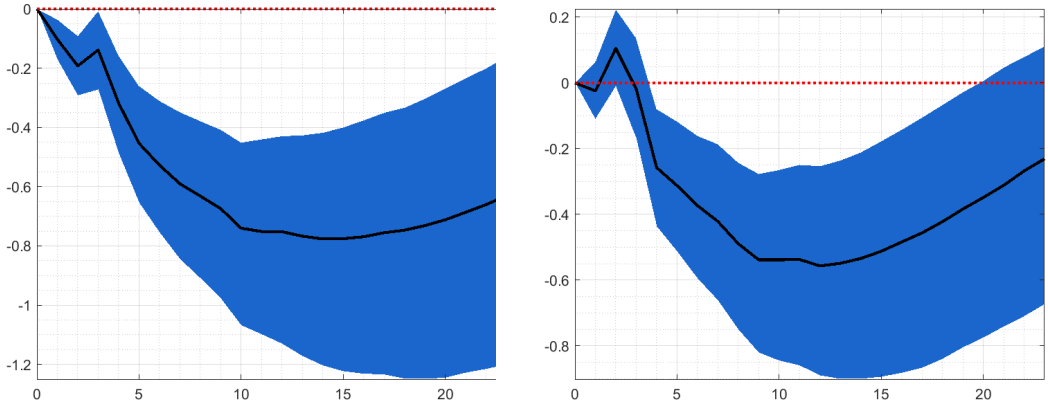
(a) IGAE **(b)** INPC

(c) EXCH **(d)** R

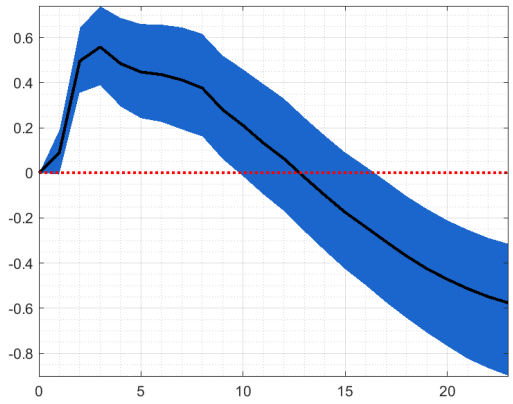
Figure 5: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model with block exogeneity for a Small Open Economy.

Source: Own estimates based on data from INEGI, Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis).



(a) Consumer Loans **(b)** Mortgage Loans

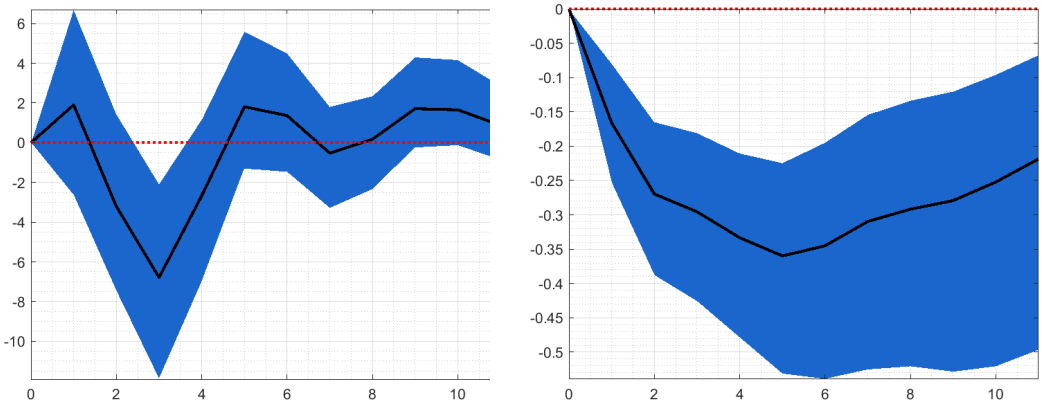


(c) Firms Loans

Figure 6: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model with block exogeneity for a Small Open Economy.

Source: Own estimates based on data from INEGI, and Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis).

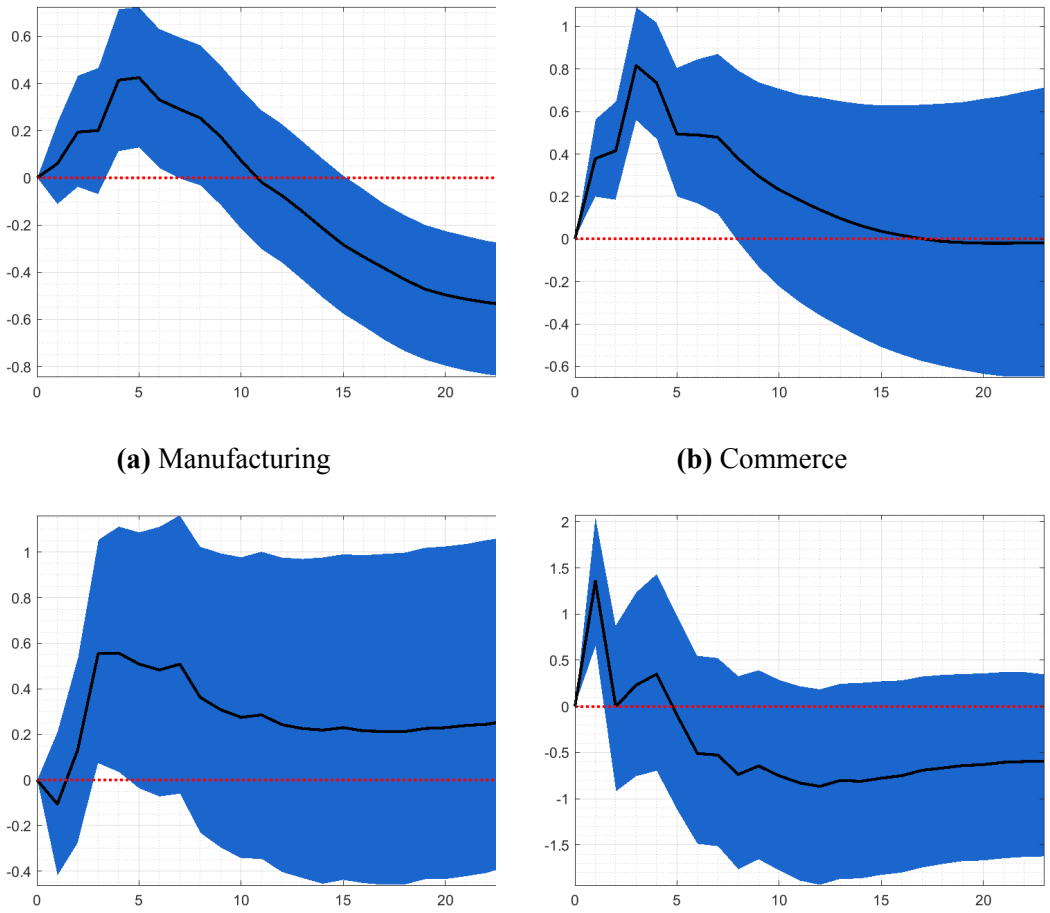


(a) Change in Inventories **(b)** Final Demand

Figure 7: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model with block exogeneity for a Small Open Economy.

Source: Own estimates based on data from INEGI, and Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis).



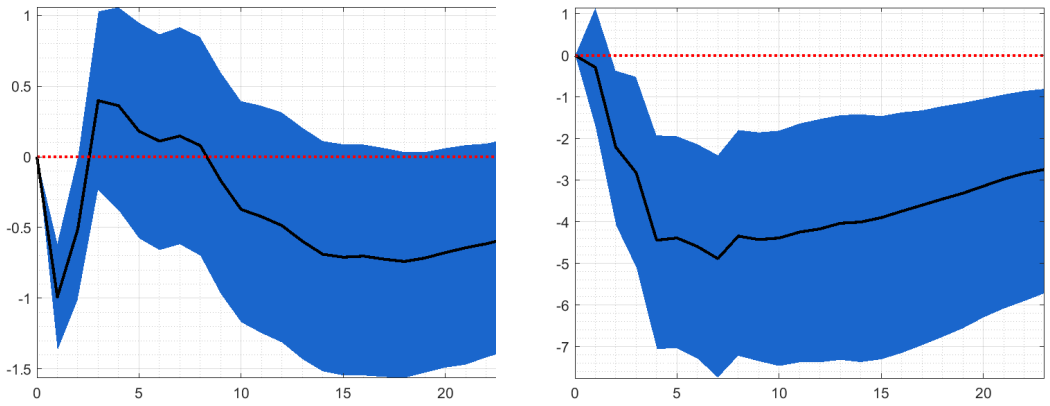
(a) Manufacturing **(b)** Commerce

(c) Tourism **(d)** Finance

Figure 8: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model for a Small Open Economy for each economic sector.

Source: Own estimates based on data from INEGI, and Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis).



(a) Primary **(b)** Mining

Figure 9: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model for a Small Open Economy for each economic sector.

Source: Own estimates based on data from INEGI, and Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis). The SVAR model for the construction sector was not stable, as a result, estimations for this sector are omitted.

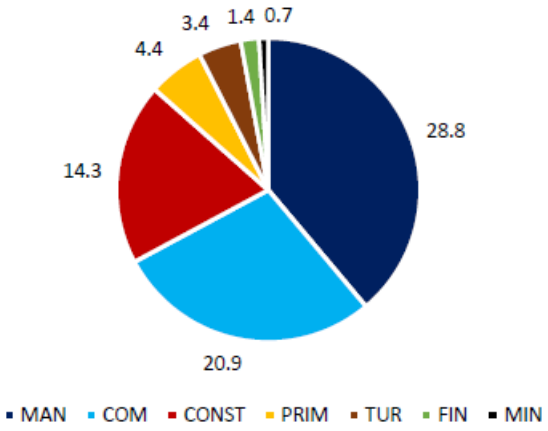


Figure 10: Credit's Share by Economic Sector

Source: Banco de México.

Note: Average values for the period July-2001 to December-2019. PRIM = Primary Sector. MIN = Mining Sector. MAN = Manufacturing Sector. CONST = Construction Sector. COM = Commerce Sector. TUR = Tourism Sector. FIN = Finance Sector.

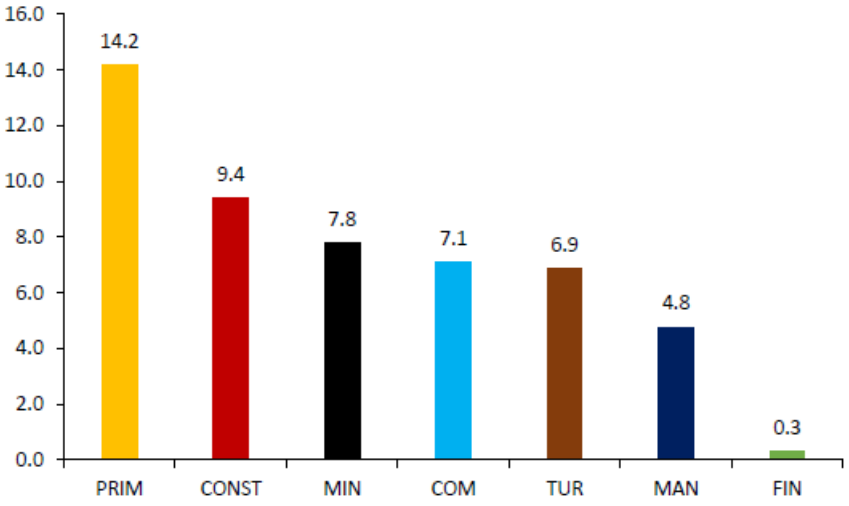
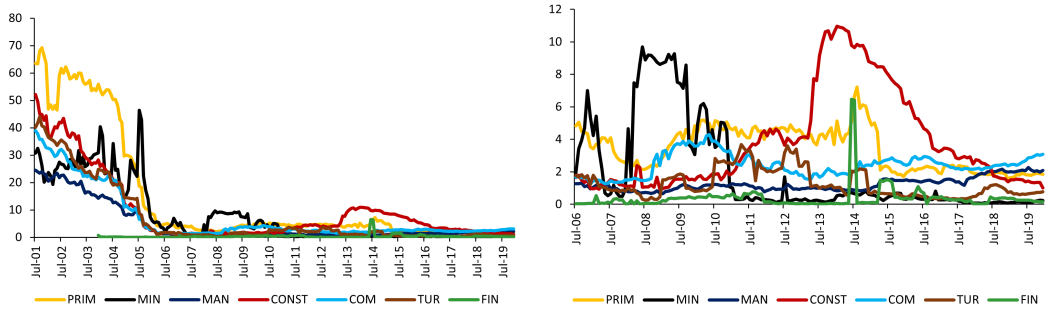


Figure 11: Loan Delinquency Rate by Economic Sector

Source: Banco de México.

Note: Average values for the period July-2001 to December-2019. PRIM = Primary Sector. MIN = Mining Sector. MAN = Manufacturing Sector. CONST = Construction Sector. COM = Commerce Sector. TUR = Tourism Sector. FIN = Finance Sector.



(a) Jul-01 to Dec-19 **(b)** Jul-06 to Dec-19

Figure 12: Loan Delinquency Rate by Economic Sector

Source: Banco de México.

Note: Average values for the indicated period. PRIM = Primary Sector. MIN = Mining Sector. MAN = Manufacturing Sector. CONST = Construction Sector. COM = Commerce Sector. TUR = Tourism Sector. FIN = Finance Sector.

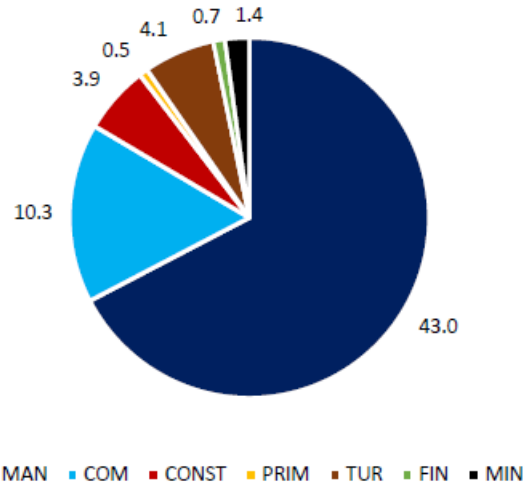


Figure 13: Large Firms Distribution by Economic Sector
Source: Economic Census, 2019 (INEGI).
Note: PRIM = Primary Sector. MIN = Mining Sector. MAN = Manufacturing Sector. CONST = Construction Sector. COM = Commerce Sector. TUR = Tourism Sector. FIN = Finance Sector.

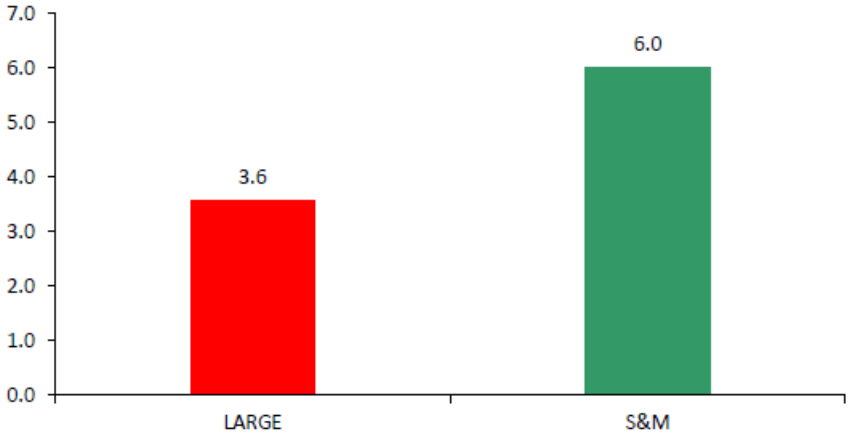
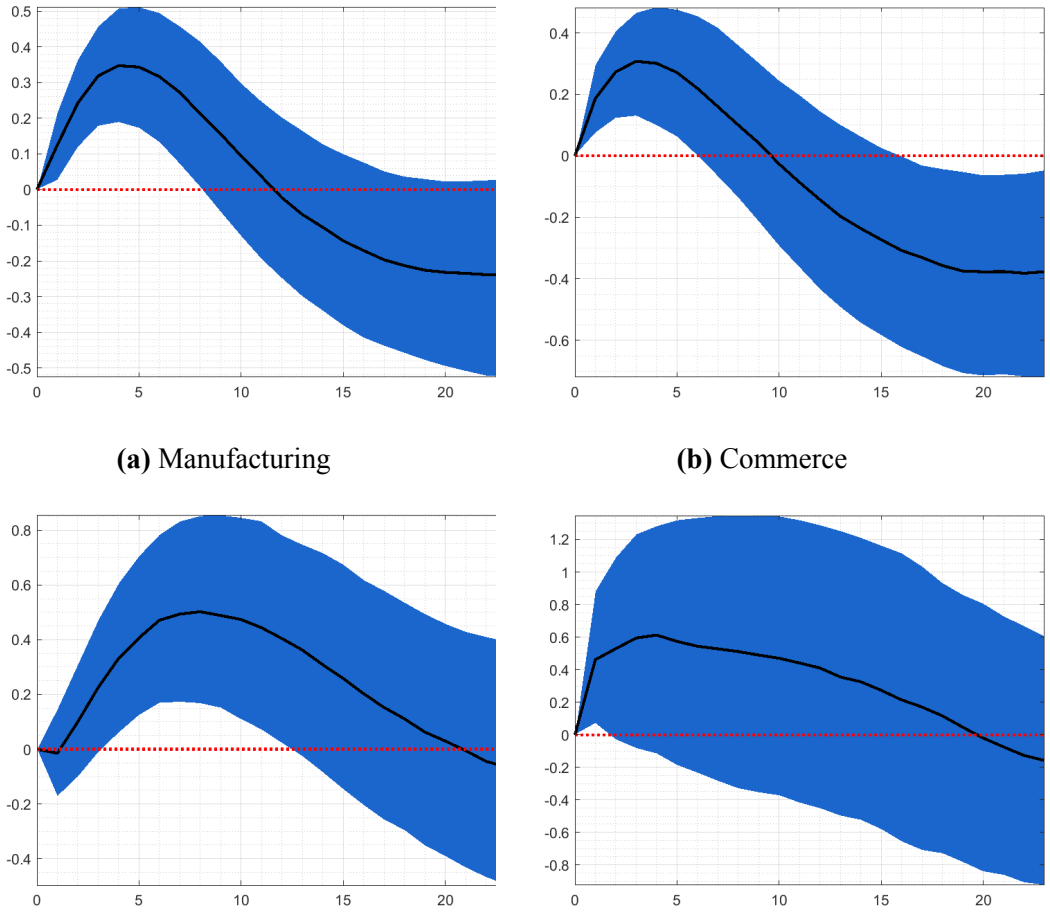


Figure 14: Loan Delinquency Rate by Firm Size
Source: Comisión Nacional Bancaria y de Valores (CNBV).
Note: Average values for the period January-2007 to December-2019. LARGE = Large Firms. S&M = Small and Medium-sized Firms.



(a) Manufacturing

(b) Commerce

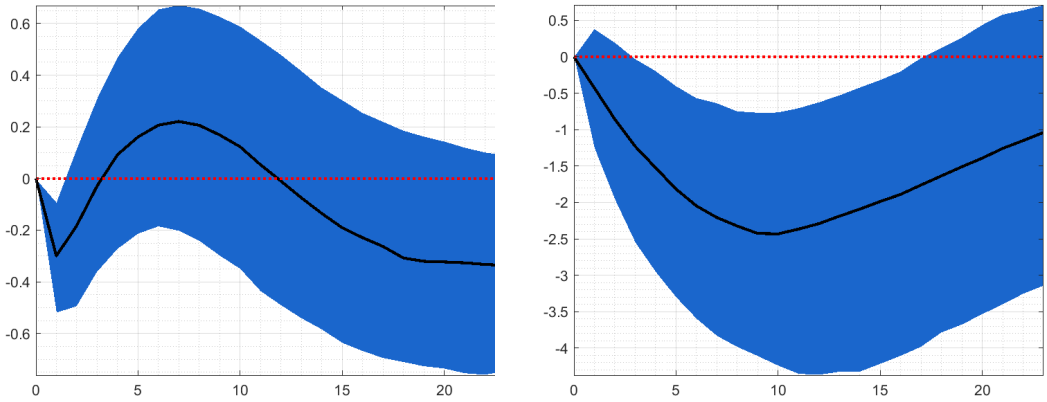
(c) Tourism

(d) Finance

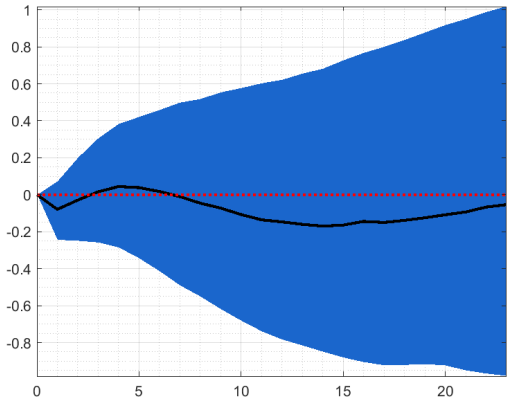
Figure 15: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a Bayesian SVAR model including United States variables as exogenous.

Source: Own estimates based on data from INEGI, Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis).



(a) Primary **(b)** Mining



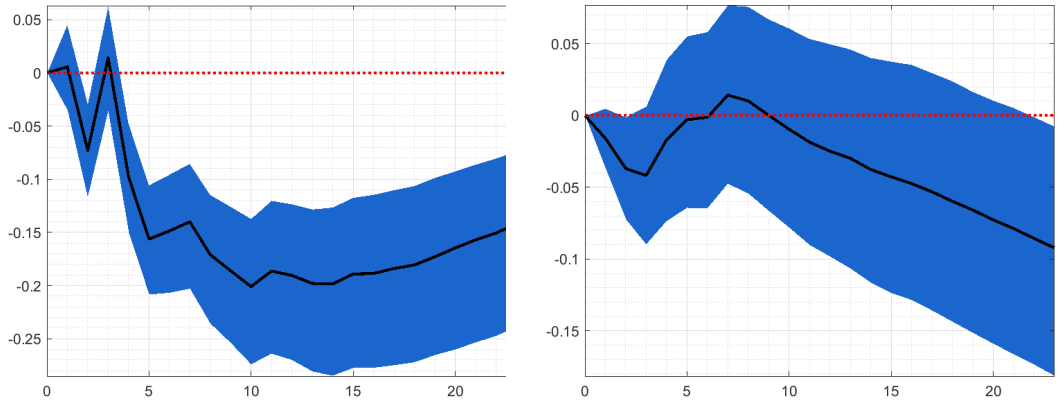
(c) Construction

Figure 16: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a Bayesian SVAR model including United States variables as exogenous.

Source: Own estimates based on data from INEGI, Banco de México, and the Federal Reserve of St. Louis.

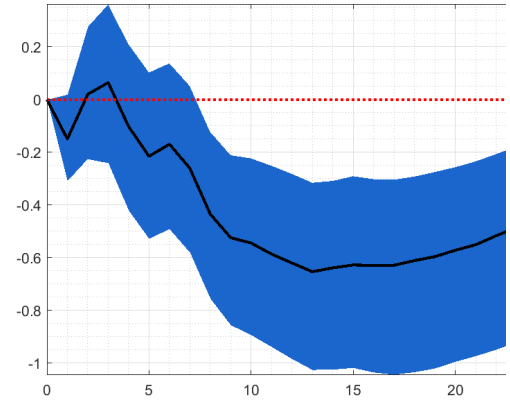
Note: Time in months (horizontal axis) and units in percent (vertical axis).

Appendix A

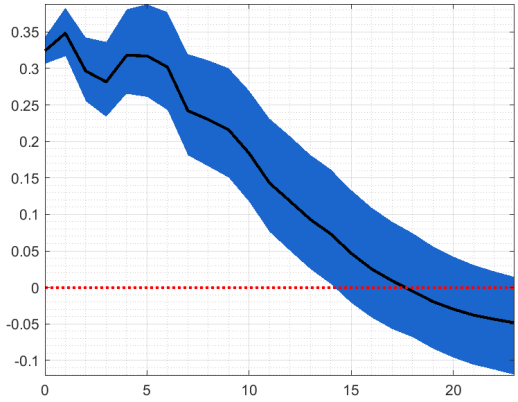


(a) IGAE

(b) INPC



(c) EXCH

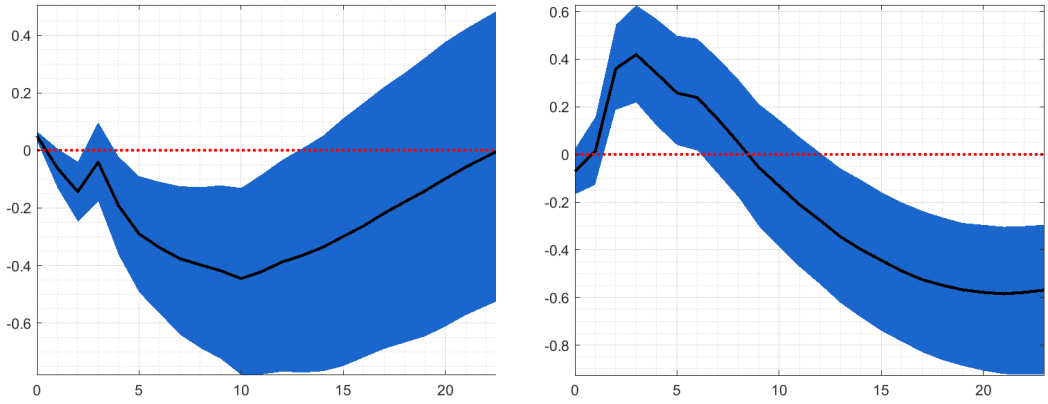


(d) R

Figure A1: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model with block exogeneity for a Small Open Economy.

Source: Own estimates based on data from INEGI, and Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis).



(a) Consumer Loans **(b)** Firms Loans

Figure A2: Responses to a One Standard Deviation Increase in the Short-Term Interest Rate. The IRF's come from the estimation of a SVAR model with block exogeneity for a Small Open Economy.

Source: Own estimates based on data from INEGI, and Banco de México, and the Federal Reserve of St. Louis.

Note: Time in months (horizontal axis) and units in percent (vertical axis).