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The importance of bank credit for the economic activity in Mexico: A manufacturing sector analysis

La importancia del crédito bancario para la actividad económica en México: Un análisis del sector manufacturero

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Abstract

The general objective of this paper is to estimate, in Mexico's case, the impact of commercial bank credit on economic activity in the whole manufacturing sector, and seven selected manufacturing industries. Unlike the literature that has studied the effects of bank credit in the Mexican economy, this research finds evidence (through ARDL-bounds models) of a positive and significant impact of bank credit on production for the whole sector and the following industries: i) food, ii) beverage and tobacco, iii) paper, iv) non-metallic mineral-based products, and v) transport equipment manufacturing; along with significant effects from fixed investment in machinery and equipment, and the real interest rate. In addition, we did not find evidence that loan concentration affects manufacturing production. Due to these results, this study postulates that bank credit matters as a stimulus for industrial activity, and it would be worth designing policies that strengthen and deepen such impacts.

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Resumen

El objetivo general de este trabajo es estimar, para el caso de México, el impacto del crédito bancario sobre la actividad económica del sector manufacturero y de siete subsectores manufactureros seleccionados. A diferencia de la literatura que ha estudiado los efectos del crédito bancario en la economía mexicana, este trabajo encuentra evidencia (a través de modelos ARDL-bounds) de un impacto positivo y significativo del crédito bancario sobre la producción para el total del sector y las siguientes industrias: i) alimentos, ii) bebidas y tabaco, iii) papel, iv) productos minerales no metálicos, y v) producción de equipo de transporte; junto con efectos significativos de la inversión fija en maquinaria y equipo, y la tasa de interés real. Adicionalmente, no se halló evidencia de que la concentración del crédito afecte a la producción manufacturera. Debido a estos resultados, este trabajo postula que el crédito bancario sí importa como estímulo de la actividad industrial, y valdría la pena diseñar políticas que fortalezcan y profundicen tales impactos.

Introduction

Almost anyone would think that, in a country like Mexico whose financial system is dominated by commercial banks, bank credit has played an essential role in supporting economic activity. This kind of credit facilitates the firms to invest more (and sooner) than their own funds allow them. If firms could use internal funds exclusively, many would have to postpone their growth plans indefinitely or permanently.

Surprisingly, literature does not support this belief. At least ten papers have tried to estimate the possible impacts of bank credit on economic growth in Mexico. Most of these studies have found that credit has not been essential to boost economic activity in this country; some of these works report that bank credit does not influence production, but vice versa, or they find bidirectional causality (Ahmed *et al.,* 2008; Rodríguez y López, 2009; Ramírez, 2017). Other studies have not found any positive impact from credit (Christopoulos y Tsionas, 2004; De la Cruz y Alcántara, 2011; Clavellina, 2013; Loría, 2020). Finally, three studies have found positive evidence of credit as a supporter of economic activity, although this evidence is negligible, it goes together with some restrictions that slow the impact of financing (Venegas *et al.,* 2009; Tinoco-Zermeño *et al.,* 2014; Cisneros-Cepeda, 2022).

On the other hand, we have international evidence: bank credit granted in Mexico to the private sector (including firms and households) is relatively less, as a percentage of Gross Domestic Product (GDP), than credit granted by many other more developed countries, similarly developed, or even ones that are less developed. For instance, during 2019, prior to the Covid pandemic, in Mexico, banks granted credit to the private sector equivalent to 28.5 percent of Mexican GDP.

We can compare this figure with some sets of countries: average of Latin America and Caribbean (50.8); average of low-income countries (44.4); average of upper-middle-income countries (120.8), where Mexico is classified; and average of OECD (78.7), where Mexico is a member (data obtained from World Bank). Among 37 OECD countries, Mexico is last place in this category. All those countries with successful economic expansion during the last decades have at least doubled the volume of bank credit granted by banks established in Mexico. Furthermore, non-financial firms in Mexico received credit equivalent to only 10.5 percent of Mexican GDP in 2019, as the highest level after 15 years of growth.

However, even with the lack of bank credit dynamism, it is not easy to believe that this credit has not represented any impulse to economic activity in Mexico. It is possible some studies have not found positive evidence because they have included credit segments that are not significant (or are less significant) to economic growth, such as household credit. In other cases, they have included lesser sensitive sectors that are affected by the credit, as some activities included in the GDP where credit generates less impulse towards investment, like trade or other services.

In this paper, we sustain the hypothesis that positive effects from bank credit upon economic activity are found in those activities where credit eases investment, generating opportunities for future increments in product value.

The general objective of this study is to estimate, in Mexico's case, the impact of commercial bank credit on economic activity in the whole manufacturing sector and seven selected manufacturing industries: i) food industry, ii) beverage and tobacco industry, iii) paper industry, iv) chemical industry, v) non-metallic mineral-based products, vi) primary metal industries, and vii) transport equipment manufacturing.

These industries represented 79.3 percent of total manufacturing production at the end of 2019, and also absorbed 71.4 percent of the credit directed to this sector. The purpose of these estimations is to verify the positive effect of credit on production and its magnitude. According to the bibliographic revision undertaken, there are no previous studies about bank credit impacts on the manufacturing sector and its industries in Mexico.

This research will contribute to filling this vacuum, proposing evidence to know which areas of the economy have been influenced by bank credit. This knowledge may help design credit programs for stimulating economic growth. Results obtained in this work will also allow extending the evidence upon the effectiveness of bank credit in Latin America, a subject that is scarcely found.

To analyze the relationship between bank credit and economic activity, we have chosen 2009 -2020 (March), using monthly observations. This period was chosen because it does not include the international financial crisis of 2007-2008, and it is before the Covid-19 economic crisis initiated in 2020. This period allows studying the financing-growth relationship in a non-crisis context and, also, it is convenient because series are less problematic concerning structural breaks. In turn, this period brings the benefit of allowing the most recent results possible.

Another advantage is that the time period studied is characterized by low inflation, as annual inflation rates were ranging from 2 – 6 percent (an average of 3.98, a standard deviation of 1.25 – which is our own calculation based on data from INEGI). According to Tinoco-Zermeño et al. (2014), inflation has negatively impacted the Mexican GDP by affecting bank credit in the private sector. Thus, by choosing this study period, inflation should not affect the relationship between bank credit and economic activity.

The main results of this paper show that there is evidence of a long-run relationship between production, bank credit, and other variables and that there is a positive and significant impact of bank credit on production. This evidence holds for the whole manufacturing sector and almost all industries analyzed. Our result for the whole sector is substantially greater than those obtained by other works about Mexico (using the economy's total GDP instead one sector). In addition, we did not find evidence that loan concentration affects manufacturing production. Due to these results, we postulate that bank credit is relevant as a stimulus of economic activity and, consequently, it would be worthwhile to formulate policies that consolidate and strengthen such impacts.

Section 1 highlights some trends of bank credit in Mexico. Section 2 reviews the literature about the link between financial development and economic growth in the manufacturing sector and the evidence in the Mexican economy. Section 3 explains the methodology for obtaining results. Section 4 shows the econometric results. Finally gives conclusions.

1. Bank credit in Mexico and its manufacturing sector

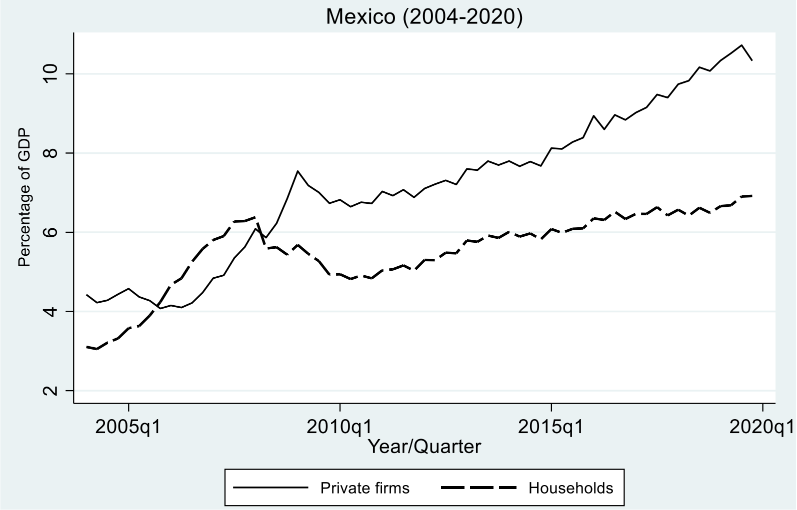
In Mexico, Banco de México (the central bank) defines credit to the non-financial private sector as the sum of credit to non-financial firms and credit to households. Figure 1 shows the evolution of the two components of credit to the non-financial private sector during 2004-2020 (March). Except for two and a half years (from October 2005 to March 2008), credit to firms has been greater than credit to households, reaching the figure of 2 thousand million pesos (about 100 billion dollars) in 2019, in real terms.

These higher levels of credit to firms, as opposed to household credit, are in accordance with international evidence. According to Beck et al. (2012), this happens in low and middle-income countries, while this relation has been inverted in high-income countries.

It should be noted that the annual credit to non-financial private firms is the bank credit to be distributed to the three big economic sectors in the country (primary, secondary, and tertiary). This credit, although it has had a growing tendency in the last 15 years, has not even come to represent 11 percent of GDP.

According to the North American Industrial Classification System, the total economic activity in a country is composed of 20 sectors. Of these sectors, manufacturing is the most important in the reception of credit in Mexico, reaching a magnitude of around 2.5 percent of the GDP at the end of 2019. Additionally, the manufacturing sector has the most outstanding contribution to the GDP; in the last decade, such contribution has been stable at around 16-17 percent.

Figure 1
Bank credit to the non-financial private sector as a percentage of GDP

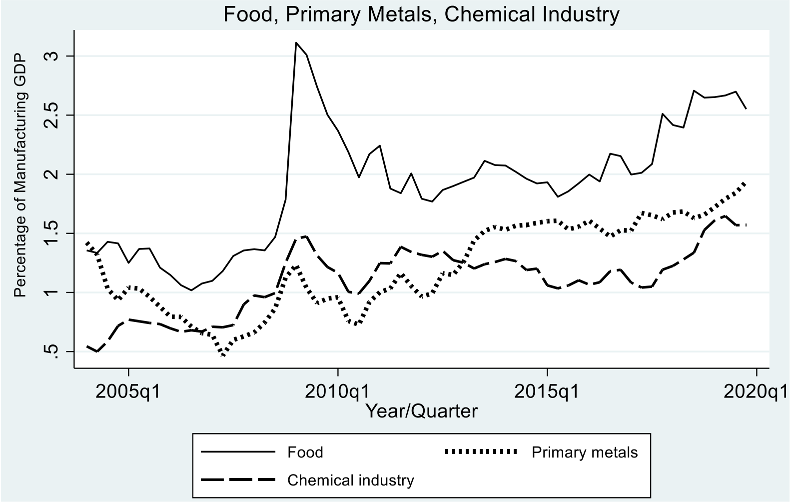


Source: Own calculations based on Banco de México (Sistema de Información Económica).

The whole manufacturing sector comprises of 21 sub-sectors. Concerning the credit behavior in this sector, we selected seven sub-sectors, which together represented 79.3 percent of manufacturing production and absorbed 71.4 percent of credit directed to the manufacturing sector in December 2019. According to credit received at the end of 2019, selected sub-sectors followed this order, from major to minor: i) food industry, ii) primary metal industries, iii) chemical industry, iv) transport equipment manufacturing, v) non-metallic mineral-based products, vi) beverage and tobacco industry, and vii) paper industry.

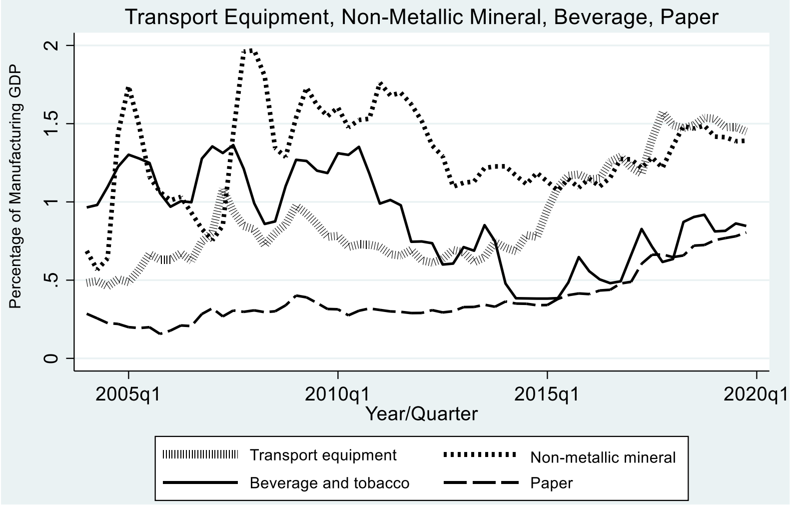
To measure the size of the credit absorbed for these seven sub-sectors, in 2019, the leader (food industry) received credit from banks of about 4 billion dollars (in real terms, 2012 = 100), equivalent to the total credit received by the whole primary sector in the same year. Each of these sub-sectors received bank credit equivalent to 0.8 – 2.7 percent of the manufacturing GDP at the end of 2019 (see figures 2 and 3).

Figure 2
Bank credit to manufacturing industries in Mexico 1 (2004-2020)



Source: Own calculations based on Banco de México (Sistema de Información Económica).

Figure 3
Bank credit to manufacturing industries in Mexico 2 (2004-2020)



Source: Own calculations based on Banco de México (Sistema de Información Económica).

2. The literature on financial development and bank credit

2.1 Impacts on the manufacturing sector around the world

One of the seminal works in the relationship between financial development and economic growth is the paper by Rajan and Zingales (1998), which explores this relationship at a manufacturing sector comprising-industry level. They studied 36 manufacturing industries in 41 countries (including Mexico), using data from the 1980s, including the bank credit to the private sector as proxy of financial development. Using cross-section regressions, they found that the manufacturing industries that are relatively in need of more external finance develop disproportionately faster in countries with more developed financial markets.[1] Their results imply that a well-developed financial market reduces the cost of the firms´ external finance.

A series of subsequent works undertook the same line as the paper by Rajan and Zingales (1998), incorporating their same classification of sectors dependent on external financing. Cetorelli and Gambera (2001) added data on bank concentration, finding evidence that banks with market power promote the growth of those industrial sectors that are primarily in need of external financing by facilitating credit access to younger firms. Claessens and Laeven (2005) obtained the opposite conclusion to Cetorelli and Gambera, as they found that bank competition benefits those manufacturing firms which are in need of external financing. Guiso et al. (2004) confirmed that financial development promotes economic growth in industries more dependable on external financing. Svaleryd and Vlachos (2005) found that economies with well-functioning financial systems tend to specialize in industries highly dependent on external financing. Fisman and Love (2007) substituted the dependency of external financing for growth opportunities (measured as sales growth). Their results showed that financially developed countries experience faster value-added growth in manufacturing industries facing good growth opportunities. Ciccone and Papaioannou (2006) found that financial intermediation eases the reallocation of resources between industries facing better investment opportunities. Ilyina and Samaniego (2011) found that industries that grow faster in more financially developed countries display significant increases in research and development intensity. Strieborny and Kukenova (2016) studied the specific investment relationships between suppliers and buyers of

[1] These authors determined that sub-sectors that depend more on external financing present a greater value of the ratio: (capital expenditures minus cash flow from operations/capital expenditures).

intermediate goods, confirming that industries dependent on specific investment from their suppliers grow disproportionately faster in countries with a well-developed banking sector. Restrepo (2019) found that industries that rely more heavily on external financing or that have fewer tangible assets, grow slower after the implementation of bank account debit taxes.

Other papers followed a different approach to the work of Rajan and Zingales. For instance, Neusser and Kluger (1998) studied the manufacturing sector of 14 OECD countries during 1970-1991. Using autoregressive vectors applied to each country, they found that financial GDP is cointegrated with manufacturing GDP in only four countries, and that it is cointegrated with the total factor productivity of the manufacturing sector in just nine countries. In just four countries, they found causality between the financial sector and the manufacturing sector, and in three other countries, they found evidence of bidirectional causality. These results showed that the relationship between finance and economic growth in the manufacturing sector is more complex than cross-sectional studies suggest.

Another approach refers to studying the link between bank regulation and economic activity. One example of these works is the paper by Igan and Mirzaei (2020). They analyzed 28 manufacturing industries in 50 countries (including Mexico) to study the effects of bank liquidity and capitalization on economic activity during 2000-2010. They found that regulation demanding greater liquidity, and bank capitalization helps certain industries face crises in emerging countries whose financial system is bank-based. Other works follow this line of analysis; for instance, Berger and Bouwman (2013), Kapan and Minoiu (2013), and Sun and Tong (2015).

There are some recent studies about developing economies. For example, Daway-Ducanes and Gochoco-Bautista (2019) studied 77 developing countries. They found that if economies are operating below the minimum efficiency scale (considering credit relative to GDP), bank credit expansion has a negative effect on manufacturing growth. Thampy and Tiwary (2021) analyzed the case of India, finding that sector-specific credit, and not the total credit, has a positive impact on local manufacturing output. Kinghan et al. (2020) studied the case of manufacturing SMEs in Vietnam, finding that the firms with higher investment efficiency are more affected by credit constraints, limiting firms' growth. Wu et al. (2022), exploring effects from specific types of bank credit in China, found that the green credit policy (that is, tightening the credit exposure of high pollution industries) had a significant negative impact on the external financing in the manufacturing industry, but its negative impact on the economic growth was not statistically significant.

2.2 Studies about Mexico

Literature about the relationship between financial development and economic growth in Mexico has not produced concluding evidence, as explained in the following lines.

Christopoulos and Tsionas (2004) studied a ten country panel data (1970-2000 period), including Mexico; analyzing each country individually, they found a positive, but not significant financial development coefficient for Mexico.

Ahmed et al. (2008) reviewed financial liberalization in Brazil, Mexico, and Thailand from 1971 to 2000. In the case of Mexico, they found bidirectional causality between bank credit to the private sector and GDP per capita. Rodríguez and López (2009) also found bidirectional causality during the 1990-2004 period. Clavellina (2013) studied the 1995-2012 period, finding that bank credit does not generate causality, nor is it significant (and its coefficient is negative) to explain the real GDP growth rate. Ramírez (2017) studied the 2001-2016 period, determining that GDP has caused bank credit and not the opposite. By contrast, De la Cruz and Alcántara (2011) studied data from the 1995-2010 period, finding one cointegration relationship between economic activity and bank credit at the general economy level, where credit causes economic growth; however, they mentioned that, in the vector error correction, credit coefficients turned out to be non-significant. At a sectoral analysis level, they found that the economic activity is cointegrated with credit in the tertiary sector, but not with the secondary one, where the manufacturing sector belongs.

Sánchez-Barajas (2015) studied Mexico comparing economic census data (from 1999 to 2014) on manufacturing firms, pointing out that bank credit has failed to promote entrepreneurial development, as the number of these firms descended between 2009 and 2014. León and Alvarado (2015) analyzed the case of Mexico through bank concentration indexes during the 2001-2014 period, concluding that a bank oligopoly limiting granting of credit in the Mexican economy prevails. According to them, this restriction stops economic growth.

Gómez-Ramírez (2019) analyzed the Mexican case, using data at the firm level for 2005 and 2009-2010. He found that credit restrictions have significantly reduced private investment, affecting economic growth. Loría (2020) also did not find evidence about gross fixed investment growth for the 2014-2019 period, although bank credit did grow in those years.

Venegas et al. (2009) studied the 1961-2007 period. They found the following results: a) There is one cointegration relationship between production, a financial development index, a financial repression index, and other variables. b) Although the magnitude of such impact is negligible, there is a positive significant long-run impact of financial development on production. c) There is a significant negative effect of the financial repression index on production. All these results suggest that financial development stagnation has occasioned economic growth to be lower than expected.

Villalpando (2014) studied a sample of 369 non-financial Mexican firms in 2009. He found evidence that bank credit promotes productivity in firms with investment opportunities. We can infer that the more firms with these characteristics, the greater the economic growth.

Tinoco-Zermeño et al. (2014) studied the long-run effects of inflation on bank credit and economic growth during the 1969-2011 period. Their main results are the following: a) bank credit positively impacts the GDP; b) inflation has harmed bank credit; c) the negative impact of inflation on production occurs through its impact on bank credit in the private sector. According to the authors, the inflation dynamic has distorted bankers' capacity to correctly evaluate firms' investment plans, reducing the resources allocated to the economy.

Cisneros-Zepeda (2022) studied the long-run effects of bank credit granted to industry and consumption on GDP during the 1994-2017 period. His main results are the following: a) there is a positive (although minimal) impact from bank credit on economic activity; b) bank credit granted to industry denotes a change after the financial crisis of 2008, as it stooped having positive effects on economic growth.

In conclusion, the empirical research regarding the relationship between financial development and economic growth in Mexico finds that it is difficult to evaluate this link and suggests various restrictions that impede acquiring all possible benefits from financial development (including bank credit).

3. Methodology

3.1 Purpose of econometric work

The primary aim of this work is to test the possible influence that bank credit has on production value in the manufacturing sector, as well as several sub-sectors. The production value is the dependent variable, and we selected the explanatory variables based on a demand approach. We also tried estimations using a supply approach, considering bank credit as an additional input to capital and labor. However, in general, perhaps due to the lack of better data for these last two inputs, results achieved had a poor explanation level and gave opposite signs to those expected in a Cobb-Douglas production function. According to Loría (2007: 277), severe limitations arise while trying to estimate production functions of this type because there are no official series of capital stocks [at the level of sectors and sub-sectors] and data on labor are not homogeneous.

The aggregate demand approach used in this work is based on the conception that sectoral production responds to internal expenditure and external demand stimulus, as well as possible influences of monetary variables, such as the monetary aggregates and the interest rate. In aggregate demand models, goods and financial markets interact to shape the economy's aggregate demand curve. In this context, bank credit may be considered complementary to variables and monetary-financial mechanisms. Some authors consider that aggregate demand variations affect production and employment through specific transmission mechanisms such as bank credit, real interest rate, and exchange rate (Bain and Howells, 2003). All of them are variables analyzed in this work.

Our objective is to test the possible impact of bank credit, having taken into consideration impacts of gross fixed investment, industrial production in the United States, economy's monetary base, and real interest rate. This demand model is explained by Loría (2007). It is worth mentioning that Tinoco-Zermeño et al. (2014) included in their model bank credit, industry gross fixed investment, and a monetary aggregate as explicative variables. Venegas et al. (2009) included financial development (a composed variable that includes a monetary aggregate), industry gross fixed investment, and real interest rate. Sánchez (2001) found evidence indicating Mexican manufacturer firms respond to changes from the real interest rates. Osorio-Novela et al. (2020) explained how the Mexican manufacturing industry has undergone fundamental structural and operational changes due to its relationship with United States companies, especially since the Northern American Free Trade Agreement (NAFTA) was initiated in the 1990s. So, we start from the following function:

$$y_t = f(x1_t, x2_t, x3_t, x4_t, x5_t),$$

where:

y_t= production value of manufacturing sector or sub-sector
$x1_t$= bank credit directed to manufacturing sector or sub-sector
$x2_t$= industry gross fixed investment
$x3_t$= monetary base
$x4_t$= industrial production of the United States
$x5_t$= real interest rate

The expected effects are the following:

$$\frac{\partial y_t}{\partial x1_t} > 0, \qquad \frac{\partial y_t}{\partial x2_t} > 0, \qquad \frac{\partial y_t}{\partial x3_t} \geq 0, \qquad \frac{\partial y_t}{\partial x4_t} > 0, \qquad \frac{\partial y_t}{\partial x5_t} \gtrless 0$$

It is worth mentioning that instead of using a monetary aggregate, we included the economy's monetary base following Rousseau and Watchel (1998). According to these authors, the monetary base represents the economy's quantity of money before credit creation by financial intermediaries. Including this variable allows for measuring the ability of bank credit to explain output fluctuations that cannot be attributed to monetary movements. Concerning this variable, $\frac{\partial y_t}{\partial x3_t} \geq 0$, we can expect that its long-run effect equals zero from the money neutrality point of view (Romer, 1996). By contrast, from a non-neutrality perspective, a positive impact from this coefficient could be expected. However, most macroeconomic models assume the former perspective.

Concerning the real interest rate, $\frac{\partial y_t}{\partial x5_t} \gtrless 0$, we can expect a positive sign if a decline in inflation causes the rise in the rate level (Rousseau and Watchel, 2002; Ibrahim and Shah, 2012; Tinoco et al., 2014); on the other hand, we can expect a negative sign if the interest rate mainly reflects the cost of money.

It is worth noting that some doubt regarding the base model results being conditioned by the monetary base could prevail, as it presents a high correlation with the gross fixed industry investment (correlation = 0.8706, prob=0.0000). After estimating the base model, the monetary base was excluded from regressions. As explained in section 5.2, the main results were not modified with this change.

After estimating the base model, we also included an additional variable $x6_t$:

$$y_t = f(x1_t, x2_t, x3_t, x4_t, x5_t, x6_t),$$

where:

$x6_t$= real exchange rate or the bank loan concentration index.

The expected effects for this variable are:

$\frac{\partial y_t}{\partial x6_t} > 0$, when it represents the real exchange rate. An increment in this variable indicates a depreciation, which, theoretically, would increase the external demand for goods manufactured in Mexico.

$\frac{\partial y_t}{\partial x6_t} \lesseqgtr 0$, when it represents the bank loan concentration index. The concentration in this market may have a negative effect due to market power-related reasons, but concentration may also provoke a positive impact because of the greater efficiency in credit allocation (Cetorelli y Gambera, 2001).

Finally, another issue to consider is that, as pointed out by Beck (2009: 1192), unlike the cross-country panel regressions, time series models "do not control for omitted variable bias by directly including other variables or by controlling with instrumental variables. Rather, by including a rich lag structure, which is lacking in the cross-sectional approach, the time series approach hopes to capture omitted variables." Precisely, this work uses a time series approach.

3.2 Data processing

Using time-series techniques allows for resolving several cross-section and panel data limitations when studying the relationship between financial development and economic growth (Beck, 2009). As mentioned before, the models constructed in this work are based precisely on time series techniques. The variables (and their sources) included in the empirical analysis are in Appendix A (table A.1). The study period is 2009 (July)-2020 (March), using monthly observations.

Before starting the statistical series' analysis, we made the following procedures: a) the base year of the series corresponding to production value was homologated; b) all series representing money were expressed in million pesos; c) all series representing money were expressed in real terms (2013 = 100); d) series corresponding to production value and monetary base were seasonal-adjusted (series about bank credit did not show evidence of seasonal behavior); and e) excepting the real interest rate, all variables were converted to logarithms. We display the graph of each series in Appendix B (figures B.1-B.5).

Table 1 contains the descriptive statistics of dependent variables included in the econometric analysis. Table 2 contains the descriptive statistics of explicative variables.

Table 1
Descriptive statistics of dependent variables

Variable	*Number of observations*	*Mean*	*Standard deviation*	*Minimun*	*Maximun*
Production value of manufacturing sector	129	13.1315	0.2203	12.6559	13.4512
Production value of food industry	129	11.3064	0.1781	10.9678	11.6231
Production value of beverage and tobacco industry	129	10.2232	0.2632	9.8237	10.6814
Production value of paper industry	129	9.6166	0.2242	9.2499	9.9802
Production value of chemical industry	129	10.9702	0.0913	10.7839	11.1340
Production value of non-metallic mineral-based products	129	9.7211	0.2236	9.3870	10.0400
Production value of primary metal industries	129	10.5679	0.1843	10.0881	10.9589
Production value of transport equipment manufacturing	128	11.8331	0.4210	10.8350	12.4341

Table 2
Descriptive statistics of explicative variables

Variable	*Number of observations*	*Mean*	*Standard deviation*	*Minimun*	*Maximun*
Bank credit to the manufacturing sector	129	12.6843	0.2311	12.3722	13.1506
Bank credit to the	129	10.9917	0.2147	10.6428	11.4209

food industry					
Bank credit to the beverage and tobacco industry	129	9.8970	0.3413	9.2272	10.44889
Bank credit to the paper industry	129	9.3657	0.4738	8.7446	10.1662
Bank credit to the chemical industry	129	10.4430	0.2087	10.0065	10.9912
Bank credit to the non-metallic mineral-based products	129	10.5139	0.1561	10.2338	10.9009
Bank credit to the primary metal industries	129	10.5418	0.3829	9.6898	11.1330
Bank credit to the transport equipment manufacturing	129	10.1842	0.4591	9.6046	10.8430
Index of investment in machinery and equipment	129	4.6360	0.1648	4.1944	4.8662
Index of industrial production of United States	129	4.6272	0.0519	4.4888	4.7054
Monetary base	129	13.7155	0.2393	13.3481	14.0410
Real interest rate	129	1.3967	1.5025	-1.0000	5.2100
Real Exchange rate	129	6.3007	0.1909	6.0423	6.6630
Index of bank loan concentration	120	7.8963	0.0778	7.7377	8.0775

3.3 Unit root tests, Granger causality, and cointegration

In the first place, each series was analyzed through the following tests: a) Modified Dickey-Fuller (DF-GLS), which is a test that does not consider structural breaks. b) Kwiatkowski-Phillips-Schmidt-Shin (KPSS), which is a test that does not consider structural breaks. c) Zivot-Andrews (Z-A), which is a test that considers one endogenous structural break (in the intercept, the slope, or both cases). d) Clemente-Montañés-Reyes (CMR), which is a test that considers two structural breaks (additive or innovational).

In the second place, various studies about the relationship between financial development and economic activity have documented reverse causality and even bidirectional causality between these two variables. For this reason, a fundamental requirement for the adequate estimation of the models is precisely testing possible causality problems. To analyze this issue we employed Granger causality, coming from Granger (1969), which tests whether lagged values of one variable improve the forecast of another variable, after considering the lagged values of the latter variable. It is worth mentioning that, before testing Granger causality, we need to check if the variables are non-stationary and that there is one cointegration relationship between them.

In the third place, complementary to the bounds test (see section 4.4), we applied the Gregory-Hansen cointegration test, which includes one endogenous structural break. This test is valid for three possible changes into the cointegrating vector (Gregory and Hansen, 1996): a) a change in the slope, b) a regime shift (considering a change in the intercept and the slope), and c) a regime-trend shift (considering a change in the intercept, the slope, and the time trend). As the Gregory-Hansen test provides information about dates of possible structural breaks in the cointegration relationship, it is possible to incorporate such information into the ARDL-bounds model by including dummies.

3.4 ARDL-bounds models

We used ARDL-bounds models based on Pesaran and Shin (1999) and Pesaran et al. (2001) to estimate the relationship between bank credit and manufacturing production. These dynamic models allow us to estimate the effects of explicative variables (including the lagged dependent variable) upon the dependent variable, but into a cointegration analysis background. The advantages of using this methodology compared to the vector error correction (VEC) models, are the following (Philips, 2018): i) it can be estimated even if some regressors are I(0); ii) it is based on a single-equation model,[2] instead of estimating one vector of equations; iii) it generates a specific lag structure for each regressor; iv) there are no endogeneity problems if we get regressions without serial correlation; v) the bounds test for cointegration remains robust to short series and multiple regressors; vi) the bounds test for cointegration has lower Type I error than other tests; and vii) it provides a solid test to avoid spurious cointegration when having exogenously weak regressors. It is worth mentioning that Tinoco-Zermeño et al. (2014) employed ARDL-bounds models for obtaining their results.

ARDL-bounds model estimation needs fulfillment of previous requirements, basically: a) series with no-seasonal unit-roots, and b) the dependent variable to be I(1) and explanatory variables not to be higher than I(1). Then, we need to formulate an unrestricted error correction model determining the appropriate lag structure (minimizing an information criterion over the log-likelihood function). The unrestricted model is the following:

[2] Studying the impact of a set of variables on one dependent variable may be undertaken using just one equation if the explanatory variables are exogenously weak. In fact, weak exogeneity validates the process of making inferences about the equation parameters (Engle et al., 1983).

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{j=0}^{q_1} \gamma_j \Delta x1_{t-j} + \sum_{k=0}^{q_2} \delta_k \Delta x2_{t-k} + \sum_{l=0}^{q_3} \eta_l \Delta x3_{t-l} + \sum_{m=0}^{q_4} \lambda_m \Delta x4_{t-m} + \sum_{n=0}^{q_5} \mu_n \Delta x5_{t-n} + \theta_0 y_{t-1} + \theta_1 x1_{t-1} + \theta_2 x2_{t-1} + \theta_3 x3_{t-1} + \theta_4 x4_{t-1} + \theta_5 x5_{t-1} + e_t \quad (1)$$

where:

y_t= the logarithm of production value of manufacturing sector or sub-sector
$x1_t$= the logarithm of bank credit directed to the manufacturing sector or sub-sector
$x2_t$= the logarithm of industry gross fixed investment
$x3_t$= the logarithm of monetary base
$x4_t$= the logarithm of industrial production of the United States
$x5_t$= real interest rate
e_t = residuals

The model described by equation 1 must not contain serial autocorrelation and must be dynamically stable.

It is important to note that although the model is called ARDL-bounds, the estimation of the coefficients of the independent variables is based on an ARDL model, while the bounds part of the model is an associated test, which tests the null hypothesis of no cointegration between the dependent variable and any regressors included in the cointegrating equation. The bounds test consists of an F-test on the following restriction from equation 1:

$$H_0 = \theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$$

As a complementary part of the bounds test, a one-sided t-test must be applied:

$$H_0 = \theta_0 = 0$$

Rejecting both tests implies a long-run relationship between the analyzed variables.[3] The long-run estimation involves the following expression:

$$y_t = \alpha_0 + \alpha_1 x1_t + \alpha_2 x2_t + \alpha_3 x3_t + \alpha_4 x4_t + \alpha_5 x5_t + v_t, \quad (2)$$

[3] Critical values of both tests (F and t) rely on non-standard distributions. In this paper, we employed the critical values of Kripfganz and Schneider (2020). These values cover a whole range of possible sample sizes and lag orders, allowing for any number of variables.

The error correction model corresponds to the following expression:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{j=0}^{q_1} \gamma_j \Delta x1_{t-j} + \sum_{k=0}^{q_2} \delta_k \Delta x2_{t-k} + \sum_{l=0}^{q_3} \eta_l \Delta x3_{t-l} + \sum_{m=0}^{q_4} \lambda_m \Delta x4_{t-m} + \sum_{n=0}^{q_5} \mu_n \Delta x5_{t-n} + \varphi z_{t-1} + e_t, \quad (3)$$

where φ is the adjustment coefficient of the model, obtained from the residuals (z_{t-1}) of the long-run equation:

$$z_{t-1} = y_{t-1} - \alpha_0 - \alpha_1\, x1_{t-1} - \alpha_2\, x2_{t-1} - \alpha_3\, x3_{t-1} - \alpha_4\, x4_{t-1} - \alpha_5\, x5_{t-1}, \quad (4)$$

It is worth mentioning that it is possible to include dummies as exogenous variables into the model without compromising the asymptotic properties of the tests (Pesaran et al., 2001).

4. Results

4.1 Procedures before estimating the ARDL-bounds model

Unit-root test results' tables, for the whole sector and each sub-sector analyzed, are shown in tables 3, 4 and 5. The evidence produced by the four applied tests indicates that all variables are I(1) in all models, even considering one or two endogenous structural breaks.

Table 3
Unit root tests of production variables

Variable	*DF-GLS test (number of lags/critical value at 5%)*	*KPSS test (number of lags/critical value at 5%)*	*Z-A test (critical value at 5%)*	*CMR test (critical value at 5%)*	*Cointegration order of the variable*
Production value of manufacturing sector	-0.902 (12/-2.787)	0.155*** (4/0.146)	-3.796 (-5.08)	-3.991 (-5.49)	I(1)
Production value of food industry	-2.556 (12/-2.787)	0.165*** (4/0.146)	-4.050 (-5.08)	-2.818 (-5.49)	I(1)
Production value of beverage and tobacco industry	-2.285 (12/-2.784)	0.207*** (12/0.146)	-1.987 (-5.08)	-3.380 (-5.49)	I(1)
Production value of paper industry	-2.315 (12/-2.787)	0.186*** (12/0.146)	-2.919 (-5.08)	-3.401 (-5.49)	I(1)
Production value of chemical industry	-2.428 (8/-2.875)	0.163*** (2/0.146)	-4.143 (-5.08)	-3.557 (-5.49)	I(1)
Production value of non-metallic	-1.649 (12/-2.787)	0.152*** (9/0.146)	-3.598 (-5.08)	-3.761 (-5.49)	I(1)

mineral-based products					
Production value of primary metal industries	-1.911 (12/-2.787)	0.162*** (4/0.146)	-3.711 (-5.08)	-4.322 (-5.49)	I(1)
Production value of transport equipment manuf.	-0.447 (12/-2.787)	0.179*** (12/0.146)	-3.997 (-5.08)	-4.039 (-5.49)	I(1)

Notes: 1) Results correspond to tests in levels. These results were confirmed by tests in first differences. 2) Test Z-A was run in three versions: including intercept, including tendency, and including intercept and tendency; we only reported the results from the third case, although the other two cases bring about the same conclusions. 3) Test CMR was run in two versions: including an additive shift and including an innovative shift; we only reported the results from the first case, although the other case brings the same conclusions.
* = Significance at 10% level, ** = Significance at 5% level, *** = Significance at 1% level

Table 4
Unit root tests of credit variables

Variable	*DF-GLS test (number of lags/critical value at 5%)*	*KPSS test (number of lags/critical value at 5%)*	*Z-A test (critical value at 5%)*	*CMR test (critical value at 5%)*	*Cointegration order of the variable*
Bank credit to the manufacturing sector	-0.898 (12/-2.787)	0.241*** (12/0.146)	-4.997 (-5.08)	-3.599 (-5.49)	I(1)
Bank credit to the food industry	-1.111 (12/-2.787)	0.225*** (12/0.146)	-4.093 (-5.08)	-5.270 (-5.49)	I(1)
Bank credit to the beverage and tobacco industry	-1.014 (12/-2.787)	0.248*** (12/0.146)	-5.076 (-5.08)	-3.759 (-5.49)	I(1)
Bank credit to the paper industry	-0.876 (12/-2.787)	0.244*** (12/0.146)	-4.151 (-5.08)	-3.855 (-5.49)	I(1)
Bank credit to the chemical industry	-1.439 (12/-2.787)	0.148*** (11/0.146)	-3.499 (-5.08)	-5.129 (-5.49)	I(1)
Bank credit to the non-metallic mineral-based products	-1.361 (12/-2.787)	0.218*** (12/0.146)	-4.616 (-5.08)	-3.002 (-5.49)	I(1)
Bank credit to the primary metal industries	-1.617 (12/-2.787)	0.238*** (12/0.146)	-5.022 (-5.08)	-3.889 (-5.49)	I(1)
Bank credit to the fabrication of transport equipment man.	-1.278 (12/-2.787)	0.159*** (12/0.146)	-4.660 (-5.08)	-5.437 (-5.49)	I(1)

Notes: 1) Results correspond to tests in levels. These results were confirmed by tests in the first differences. 2) Test Z-A was run in three versions: including intercept, tendency, and intercept and tendency; we only reported the results from the third case, although the other two cases bring about the same conclusions. 3) Test CMR was run in two versions: including an additive shift and including an innovative shift; we only reported the results from the first case, although the other case conduits to the same conclusions.
* = Significance at 10% level, ** = Significance at 5% level, *** = Significance at 1% level

Table 5
Unit root tests of control variables

Variable	*DF-GLS test (number of lags/critical value at 5%)*	*KPSS test (number of lags/critical value at 5%)*	*Z-A test (critical value at 5%)*	*CMR test (critical value at 5%)*	*Cointegration order of the variable*
Index of investment in machinery and equipment	-0.472 (12/-2.787)	0.226*** (12/0.146)	-2.844 (-5.08)	-3.838 (-5.49)	I(1)
Index of industrial production of United States	-1.002 (12/-2.787)	0.154*** (11/0.146)	-3.851 (-5.08)	-3.504 (-5.49)	I(1)
Monetary base	-1.574 (12/-2.787)	0.228*** (12/0.146)	-4.293 (-5.08)	-3.078 (-5.49)	I(1)
Real interest rate	-1.495 (12/-2.787)	2.226*** (12/0.146)	-4.065 (-5.08)	-1.335 (-5.49)	I(1)
Real Exchange rate	-1.239 (12/-2.787)	0.151*** (11/0.146)	-4.543 (-5.08)	-5.229 (-5.49)	I(1)
Index of bank loan concentration	-1.951 (12/-2.777)	0.226*** (7/0.146)	-4.135 (-5.08)	-4.842 (-5.49)	I(1)

Notes: 1) Results correspond to tests in levels. These results were confirmed by tests in first differences. 2) Test Z-A was run in three versions: including intercept, tendency, and intercept and tendency; we only reported the results from the third case, although the others two cases conduit to the same conclusions. 3) Test CMR was run in two versions: including an additive shift and including an innovative shift; we only reported the results from the first case, although the other case conduits to the same conclusions.
* = Significance at 10% level, ** = Significance at 5% level, *** = Significance at 1% level

According to cointegration tests (Johansen, Gregory-Hansen, and bounds), there is one cointegration relationship in all base models, exempting primary metal industries, whose models did not approve bounds tests. To save space, we are not reporting the results of tests by Johansen, but we report those by Gregory-Hansen in table 6, and we do include the bounds tests results when reporting the ARDL model results (see tables 8, 9 and 10).

Concerning weak exogeneity tests, the whole sector and each sub-sector's results are shown in Appendix C (table C.1). There were problems in two variables: a) the industrial production of the United States rejects the null hypothesis of exogeneity at the 1 percent level in the whole sector, food industry, beverage industry, chemical industry, non-metallic mineral-based products, and primary metal industries; b) the real exchange rate rejects the null hypothesis of exogeneity at the 1 percent level in the whole sector and paper industry.

Concerning Granger causality tests, the whole sector and each sub-sector's results are shown in table 7. We highlight the following results: a) credit causes the production in the whole sector, beverage and tobacco industry, and non-metallic mineral-based products; b) there are no reverse causality problems between production and credit in any sub-sector; c) the only variable that presents reverse causality problems is the real exchange rate (total sector, food industry, beverage and tobacco industry, non-metallic mineral-based products, and transportation equipment manufacturing) (results not reported).

The results from these tests conducted us to re-specify several models in a parsimonious fashion, excluding in each case the variables that did not approve one test.

Table 6
Gregory-Hansen cointegration tests

	Value of statistic ADF			***Value of statistic Zt***		
Sector or sub-sector	Considering break in regimetrend *(critical value at 5%) (critical value at 10%) (date of the break)*	Considering break in regime *(critical value at 5%) (critical value at 10%) (date of the break)*	Considering break in trend *(critical value at 5%) (critical value at 10%) (date of the break)*	Considering break in regimetrend *(critical value at 5%) (critical value at 10%) (date of the break)*	Considering break in regime *(critical value at 5%) (critical value at 10%) (date of the break)*	Considering break in trend *(critical value at 5%) (critical value at 10%) (date of the break)*
Total of the manufacturing sector	-6.87** (-6.32) (-6.16) (2014m5)	-6.28** (-6.00) (-5.75) (2014m4)	-6.17*** (-5.57) (-5.33) (2014m5)	-6.67** (-6.32) (-6.16) (2014m5)	-6.27** (-6.00) (-5.75) (2014m1)	-6.20*** (-5.57) (-5.33) (2014m4)
Food industry	-6.86** (-6.32) (-6.16) (2011m2)	-6.38** (-6.00) (-5.75) (2013m12)	-5.92** (-5.57) (-5.33) (2011m1)	-6.40** (-6.32) (-6.16) (2011m6)	-6.34** (-6.00) (-5.75) (2014m4)	-5.86** (-5.57) (-5.33) (2011m3)
Beverage and tobacco industry	-8.77*** (-6.32) (-6.16) (2013m3)	-6.28** (-6.00) (-5.75) (2013m3)	-6.20*** (-5.57) (-5.33) (2013m8)	-8.81*** (-6.32) (-6.16) (2013m3)	-6.38** (-6.00) (-5.75) (2013m4)	-6.09*** (-5.57) (-5.33) (2013m8)
Paper industry	-6.74** (-6.32) (-6.16) (2013m11)	-6.62*** (-6.00) (-5.75) (2013m11)	-5.96** (-5.57) (-5.33) (2013m11)	-6.76** (-6.32) (-6.16) (2013m11)	-5.41** (-6.00) (-5.75) (2013m6)	-5.41* (-5.57) (-5.33) (2013m11)
Chemical industry	-6.33** (-6.32) (-6.16) (2012m7)	-5.89* (-6.00) (-5.75) (2014m1)	-5.56* (-5.57) (-5.33) (2014m1)	-6.36** (-6.32) (-6.16) (2012m7)	-5.91* (-6.00) (-5.75) (2014m1)	-5.53* (-5.57) (-5.33) (2014m1)
Primary metal industries	-5.35 (-6.32) (-6.16) (2013m8)	-5.21 (-6.00) (-5.75) (2013m9)	-4.40 (-5.57) (-5.33) (2014m4)	-6.90*** (-6.32) (-6.16) (2012m10)	-6.11** (-6.00) (-5.75) (2014m5)	-5.44* (-5.57) (-5.33) (2014m7)
Non-metallic mineral-based products	-7.15*** (-6.32) (-6.16) (2012m4)	-5.87* (-6.00) (-5.75) (2012m7)	-5.79** (-5.57) (-5.33) (2013m4)	-7.17*** (-6.32) (-6.16) (2012m4)	-6.10** (-6.00) (-5.75) (2012m8)	-5.68** (-5.57) (-5.33) (2013m4)
Transportation equipment manufacturing	-8.18*** (-6.32) (-6.16) (2014m5)	-6.69*** (-6.00) (-5.75) (2014m4)	-7.83*** (-5.57) (-5.33) (2014m4)	-8.13*** (-6.32) (-6.16) (2014m5)	-6.72*** (-6.00) (-5.75) (2014m4)	-7.86*** (-5.57) (-5.33) (2014m4)

Significance at *10%, **5%, ***1% levels.

Table 7
Granger-causality tests

Dependent variable	*Variable that causes*	*Chi²*	*Probability*
	Total manufacturing sector		
Production value of manufacturing sector	Credit to the manufacturing sector	2.633*	0.098
	Investment in machinery and equipment	6.8372***	0.009
	Monetary base	4.350**	0.037
	Real interest rate	0.837	0.360
	ALL	34.751***	0.000
Credit to the manufacturing sector	Production of manufacturing sector	1.552	0.213
	Investment in machinery and equipment	1.476	0.224
	Monetary base	12.895***	0.000
	Real interest rate	2.447	0.118
	Food industry		
Production value of food industry	Credit to the food industry	0.077	0.780
	Investment in machinery and equipment	2.108	0.146
	Monetary base	11.861***	0.001
	Real interest rate	10.157***	0.001
	ALL	24.551**	0.000
Credit to the food industry	Production of food industry	0.787	0.375
	Investment in machinery and equipment	3.545*	0.060
	Monetary base	9.806***	0.002
	Real interest rate	0.037	0.847
	Beverage and Tobacco industry		
Production value of beverage and tobacco industry	Credit to the Beverage industry	6.069**	0.014
	Investment in machinery and equipment	0.524	0.469
	Monetary base	36.144***	0.000
	Real interest rate	5.606**	0.018
	ALL	43.807***	0.000
Credit to the beverage and tobacco industry	Production of beverage industry	0.070	0.791
	Investment in machinery and equipment	5.193**	0.023
	Monetary base	0.118	0.730
	Real interest rate	4.683**	0.030
	Paper industry		
Production value of paper industry	Credit to the paper industry	1.534	0.215
	Investment in machinery and equipment	0.249	0.617
	Monetary base	11.768	0.001
	Industrial production of U.S.	0.527	0.468
	Real interest rate	1.020	0.312
	ALL	15.379***	0.009
Credit to the paper industry	Production of paper industry	2.084	0.149
	Investment in machinery and equipment	1.629	0.202
	Monetary base	2.742*	0.098
	Industrial production of U.S.	0.047	0.828
	Real interest rate	0.075	0.784
	Chemical industry		
Production value of chemical industry	Credit to the chemical industry	0.439	0.507
	Investment in machinery and equipment	1.329	0.249

	Monetary base	1.510	0.219
	Real interest rate	0.090	0.764
	ALL	13.940***	0.007
Credit to the chemical industry	Production of chemical industry	1.311	0.252
	Investment in machinery and equipment	5.352**	0.021
	Monetary base	0.409	0.522
	Real interest rate	14.129***	0.000
	Non-metallic mineral-based products		
Production value of non-metallic mineral-based products	Credit to the non-metallic mineral-based	10.000***	0.002
	Investment in machinery and equipment	0.200	0.654
	Monetary base	34.690***	0.000
	Real interest rate	0.444	0.505
	ALL	37.508***	0.000
Credit to the non-metallic mineral-based products	Production of non-metallic mineral-based	2.8511	0.101
	Investment in machinery and equipment	2.119	0.145
	Monetary base	1.029	0.310
	Real interest rate	3.424*	0.064
	Primary metal industries		
Production value of primary metal industries	Credit to the primary metal industries	1.108	0.292
	Investment in machinery and equipment	0.588	0.443
	Monetary base	3.692*	0.055
	Real interest rate	1.492	0.221
	ALL	12.319**	0.015
Credit to the primary metal industries	Production of primary metal industries	0.436	0.509
	Investment in machinery and equipment	6.173**	0.013
	Monetary base	1.529	0.216
	Real interest rate	0.356	0.550
	Transport equipment manufacturing		
Production value of transport equipment manufacturing	Credit to the transport equipment manuf	0.017	0.896
	Investment in machinery and equipment	6.074**	0.014
	Monetary base	25.316***	0.000
	Industrial production of U.S.	9.445***	0.002
	Real interest rate	4.006**	0.045
	ALL	71.233***	0.000
Credit to the transport equipment manufacturing	Production of transport equipment manuf	0.722	0.395
	Investment in machinery and equipment	1.977	0.160
	Monetary base	16.760***	0.000
	Industrial production of U.S.	0.543	0.461
	Real interest rate	0.173	0.677

* = Significance at 10% level, ** = Significance at 5% level, *** = Significance at 1% level

4.2 Results from the ARDL-bounds model

Results obtained through the ARDL-bounds model are shown in tables 8, 9, and 10. In each case included in these tables, bounds test shows a long-run relationship among variables of the model. Moreover, models do not present heteroscedasticity, serial autocorrelation, or stability problems.

The main results are the following:
Total manufacturing sector: 1) The impact of bank credit on production is positive and significant. 2) Investment has a positive and significant effect on manufacturing production. 3) The interest rate has a negative and significant impact on manufacturing production, indicating that real increments in the cost of money negatively affect production. 4) The coefficient of the monetary base is negative and significant. Although this coefficient was expected to be non-significant, the negative sign indicates that monetary policy has no long-run effect on production. 5) When excluding the monetary base, the essential results do not change (see table 9). 6) In the extended model, the coefficient of the bank loan concentration index is negative and non-significant (see table 10).

Food industry: 1) The impact of bank credit on production is positive and significant. 2) Investment has a positive and significant effect on food production. 3) The interest rate has a negative and non-significant impact on production. 4) The coefficient of monetary base is non-significant, indicating that monetary policy has no long-run effect on production. 5) When excluding the monetary base, the essential results do not change (see table 9). 6) In the extended model, the coefficient of the bank loan concentration index is negative and non-significant (see table 10).

Beverage and tobacco industry: 1) The impact of bank credit on production is positive (although small) and significant. 2) Investment has a positive and significant effect on beverage and tobacco production. 3) The interest rate has a positive and significant impact on production, indicating that increments in this variable due to a decline in inflation stimulate economic activity. 4) The coefficient of monetary base is negative and non-significant. 5) When excluding the monetary base, the essential results do not change (see table 9). 6) The only anomalous output is the negative sign of industrial production of the United States, this may be due to a particular dynamic on data the model did not capture. 7) In the extended model, the coefficient of the bank loan concentration index is positive and significant (see table 10).

Paper industry: 1) The impact of bank credit on production is positive and significant. 2) Investment has a positive and significant effect on paper production. 3) The interest rate has a positive and significant impact on production. 4) Industrial production of the United States has a positive and significant impact on production. 5) The coefficient of the monetary base is positive and significant. 6) When excluding the monetary base, the essential results do not change (see table 9). 7) In the extended model, the coefficient of the bank loan concentration index is negative and non-significant (see table 10).

Chemical industry: The impact of bank credit on production is positive but non-significant (in the base and the extended models). Thus, we do not show results for this sub-sector.

Non-metallic mineral-based production: 1) The impact of bank credit on production is positive and significant. 2) Investment has a positive and significant effect on production. 3) The interest rate has a negative and non-significant impact on production. 4) The coefficient of monetary base is positive and significant. 5) When excluding the monetary base, the essential results do not change (see table 9). 6) In the extended model, the coefficient of the bank loan concentration index is negative and non-significant (see table 10).

Primary metal industries: When estimating the base model, the statistics about homoscedasticity, absence of serial autocorrelation, and stability were approved, but the bounds test was not, indicating the absence of cointegration. Thus, we do not show results for this sub-sector.

Transportation equipment manufacturing:[4] 1) The impact of bank credit on production is positive and significant. 2) Investment has a positive and significant effect on production, as we expect on a sub-sector based on high technology. 3) In the base model, the interest rate has a positive and non-significant impact on production. When excluding the monetary base, this coefficient turned out to be significant (see table 4). 4) In the base model, industrial production of the United States has a negative and non-significant impact on production. When excluding the monetary base, this coefficient has a positive and significant impact on production (see table 9), as we can expect in a sub-sector involved in the North American automotive production chain. 5) The coefficient of monetary base is negative and non-significant. 6) In the extended model, the coefficient of the bank loan concentration index is negative and non-significant (see table 10).

In summary, our result for the whole sector (coefficient value = 0.54) is substantially greater than those obtained by other works concerning Mexico (using the economy's total GDP instead one sector). For instance, Venegas et al. (2009) obtained 0.08, Tinoco-Zermeño et al. (2014) obtained 0.26, and Cisneros-Zepeda (2022) obtained 0.10. This last author

[4] This sub-sector did not include the observation corresponding to March 2020 because the Covid-19 pandemic negatively impacted production.

found that bank credit denotes a change after the financial crisis of 2008, as it stooped having positive effects on economic growth. Our results reject that conclusion for the manufacturing sector. Bijlsma et al. (2018) reviewed 68 cross-country studies that use credit to the private sector relative to GDP as a proxy for financial development. They found that the logarithmic models on average predict an increase in GDP growth of 0.13 percentage points.

Table 8
Long-run coefficients from the basic model

Variable	*Total of sector*	*Food industry*	*Beverage and tobacco industry*	*Paper industry*	*Non-metallic mineral-based prod.*	*Transportation equipment manufacturing*
Lag structure	(1,0,2,1,1)	(2,0,3,0,1)	(3,2,0,0,4,4)	(1,2,4,1,4,0)	(1,2,1,1,0)	(2,0,3,0,4)
Adjustment coefficient	-0.2770*** (0.0515)	-0.2183*** (0.0562)	-0.3378*** (0.0690)	-0.3469*** (0.0625)	-0.5664*** (0.0764)	-0.4680*** (0.0541)
Bank credit	**0.5401****** (0.1521)	**0.2602****** (0.0878)	**0.0762***** (0.0331)	**0.1995****** (0.0357)	**0.1638****** (0.0376)	**0.1794***** (0.0696)
Investment in machinery and equipment	0.5213*** (0.0845)	0.6729*** (0.1575)	0.3947*** (0.1315)	0.3098*** (0.0862)	0.1264*** (0.0426)	0.6722*** (0.1248)
Monetary base	-0.4702*** (0.1721)	-0.1687 (0.1477)	-0.1527 (0.3275	0.2888*** (0.0877)	0.7137*** (0.0431)	-0.4058 (0.3940)
Real interest rate	-0.0161** (0.0076)	-0.0062 (0.0085)	0.0196** (0.0095)	0.0129*** (0.0034)	-0.0027 (0.0037)	0.0088 (0.0095)
Industrial production of the U.S.	-	-	-1.5090*** (0.5535)	0.2709* (0.1566)	-	-0.5685 (0.6007)
Dummy of structural break	0.0206** (0.0079)	-0.0151** (0.0064)	0.0243** (0.0122)	-0.0259*** (0.0082)	0.0314*** (0.0103)	0.0045*** (0.0012)
Constant	2.7896*** (1.0022)	1.6354** (0.7665)	5.3935** (2.2983)	0.4024 (0.3358)	-1.3506*** (0.3773)	6.6524** (3.0388)
Statistics						
No. of observations	126	126	129	129	129	128
R-square	0.4454	0.3558	0.4243	0.4438	0.3807	0.6300
Adjusted R-square	0.3865	0.2810	0.3177	0.3528	0.3238	0.5805
Bounds (F)	8.732***	7.243***	5.515***	6.018***	11.935***	17.562***
Bounds (t)	-5.379**	-3.879*	-4.893***	-5.547***	-7.412***	-8.648***
Breusch-Pagan/Cook-Weisberg *Chi-square* *Probability*	1.53 0.2156	1.14 0.2855	2.99 0.0837	1.28 0.2574	1.72 0.1895	0.07 0.7915
Breusch-Godfrey (lag 1) *Chi-square* *Probability*	0.624 0.4296	0.159 0.6905	0.102 0.7499	1.881 0.1702	1.578 0.2091	0.593 0.4412
Breusch-Godfrey (lag 2) *Chi-square* *Probability*	4.121 0.1274	1.526 0.4664	0.258 0.8792	2.033 0.3619	1.661 0.4358	0.652 0.7218
Breusch-Godfrey (lag 3) *Chi-square* *Probability*	4.241 0.2336	1.529 0.6755	0.304 0.9593	2.633 0.4517	1.728 0.6307	0.708 0.8712
Breusch-Godfrey (lag 4) *Chi-square* *Probability*	5.305 0.2574	4.240 0.3745	5.888 0.2076	4.420 0.3521	4.225 0.3764	0.960 0.9158
Sbcusum *Statistic* *Critical value (5%)*	0.3953 0.9479	0.3711 0.9479	0.5165 0.9479	0.3522 0.9479	0.4132 0.9479	0.9073 0.9479

Notes: Standard errors in parentheses. Significance at *10%, **5%, ***1% levels.

Table 9
Long-run coefficients from the basic model, excluding the monetary base

Variable	*Total of sector*	*Food industry*	*Beverage and tobacco industry*	*Paper industry*	*Non-metallic mineral-based prod.*	*Transportation equipment manufacturing*
Lag structure	(2,0,6,6)	(2,0,3,1)	(3,2,0,4,4)	(1,2,4,4,0)	(3,3,1,0)	(2,0,3,0,4)
Adjustment coefficient	-0.2126*** (0.0403)	-0.1536*** (0.0388)	-0.3355*** (0.0686)	-0.2628*** (0.0580)	-0.1684*** (0.0489)	-0.3497*** (0.0490)
Bank credit	**0.5411*** **(0.0894)	**0.3877***** (0.0768)	**0.0718**** (0.0317)	**0.3069***** (0.0256)	**0.2095*** (0.1159)	**0.4160***** (0.0406)
Investment in machinery and equipment	0.4671*** (0.0778)	0.9156*** (0.1387)	0.3541*** (0.0946)	0.5389*** (0.0806)	0.2862* (0.1543)	0.7145*** (0.1275)
Real interest rate	-0.0055 (0.0085)	-0.0018 (0.0110)	0.0216** (0.0086)	0.0091** (0.0046)	-0.0070 (0.0150)	0.0207** (0.0100)
Industrial production of the U.S.	-	-	-1.2986*** (0.3125)	0.0733 (0.2100)	-	1.2415*** (0.4482)
Dummy of structural break	0.0122** (0.0059)	-0.0150** (0.0063)	0.0209** (0.0098)	-0.0273*** (00.84)	0.0259*** (0.0083)	0.0256* (0.0130)
Constant	0.8728*** (0.2672)	0.4520* (0.2679)	4.4374*** (1.0253)	1.0523*** (0.2716)	0.9908** (0.3961)	-0.5241 (0.6766)
Statistics						
No. of observations	126	126	129	129	129	126
R-square	0.4668	0.3400	0.4232	0.3942	0.2740	0.5773
Adjusted R-square	0.3771	0.2763	0.3226	0.3077	0.2191	0.5239
Bounds (F)	8.460***	8.478***	6.623***	5.014**	3.857*	15.736***
Bounds (t)	-5.264***	-3.957**	-4.890***	-4.528**	-3.439*	-7.130***
Breusch-Pagan/Cook-Weisberg *Chi-square* *Probability*	6.33 0.0919	0.95 0.3299	2.59 0.1074	0.58 0.4453	1.45 0.2278	1.04 0.3081
Breusch-Godfrey (lag 1) *Chi-square* *Probability*	1.695 0.1929	0.244 0.6216	0.136 0.7127	1.373 0.2414	0.315 0.5745	2.228 0.1356
Breusch-Godfrey (lag 2) *Chi-square* *Probability*	4.836 0.1091	0.729 0.6945	0.258 0.8791	1.396 0.4977	0.321 0.8518	2.272 0.3211
Breusch-Godfrey (lag 3) *Chi-square* *Probability*	5.232 0.1556	0.869 0.8328	0.263 0.9668	1.838 0.6067	1.079 0.7821	3.002 0.3913
Breusch-Godfrey (lag 4) *Chi-square* *Probability*	7.622 0.1065	4.603 0.3306	5.491 0.2406	3.963 0.4111	3.029 0.5530	3.426 0.4893
Sbcusum *Statistic* *Critical value (5%)*	0.3216 0.9479	0.3985 0.9479	0.4778 0.9479	0.5394 0.9479	0.6447 0.9479	0.9131 0.9479

Notes: Standard errors in parentheses. Significance at *10%, **5%, ***1% levels.

Table 10
Long-run coefficients from the extended model

Variable	*Total of sector*	*Food industry*	*Beverage and tobacco industry*	*Paper industry*	*Non-metallic mineral-based prod.*	*Transportation equipment manufacturing*
Lag structure	(1,02,1,2,0)	(1,0,0,2,3,0)	(2,2,0,4,4,1)	(4,1,0,0,4,0,1)	(1,2,1,1,1,4)	(2,0,2,0,4,0)
Adjustment coefficient	-0.1858*** (0.0469)	-0.1654*** (0.0405)	-0.4282*** (0.0686)	-0.2760*** (0.0639)	-0.5716*** (0.0809)	-0.2665*** (0.0596)
Bank credit	**0.6579***** (0.2052)	**0.2862**** (0.1149)	**0.0373*** (0.0222)	**0.2165***** (0.0421)	**0.1808***** (0.0413)	**0.3933***** (0.0672)
Investment in machinery and equipment	0.5844*** (0.2142)	0.6139*** (0.1950)	0.2617*** (0.0900)	0.0941 (0.0944)	0.1605* (0.0857)	0.8385*** (0.2592)
Monetary base	-0.1219 (0.2150)	0.0688 (0.1463)	-	0.3698*** (0.0896)	0.6605*** (0.0642)	
Real interest rate	-0.009 (0.0117)	-0.0100 (0.0089)	0.0143** (0.0062)	0.0136*** (0.0043)	-0.0038 (0.0045)	0.0143 (0.0117)
Industrial production of the U.S.			-1.0143*** (0.3393)			1.2436* (0.7024)
Index of bank loan concentration	-0.1010 (0.2147)	-0.0524 (0.2120)	0.3486** (0.1553)	-0.1686 0.1367	-0.0627 (0.0865)	-0.4737 (0.4126)
Dummy of structural break			0.0033*** (0.0005)		0.0336*** (0.0108)	
Constant	0.8564 (0.5616)	0.6587 (0.4855)	4.1988*** (1.2641	1.0977 (0.6915)	-0.8522 (0.6375)	0.5207 1.6745
Statistics						
No. of observations	115	116	116	116	116	115
R-square	0.3698	0.2811	0.5057	0.4406	0.4415	0.4296
Adjusted R-square	0.3025	0.2050	0.4079	0.3502	0.3513	0.3562
Bounds (F)	4.494**	4.711**	7.650***	4.241**	8.809***	3.875*
Bounds (t)	-3.958*	-4.081*	-6.243***	-4.317*	-7.066***	-4.465**
Breusch-Pagan/Cook-Weisberg *Chi-square* *Probability*	2.05 0.1526	1.22 0.2690	0.01 0.9193	1.74 0.1870	4.51 0.0337	0.37 0.5406
Breusch-Godfrey (lag 1) *Chi-square* *Probability*	0.301 0.5835	0.472 0.4923	1.188 0.2757	2.458 0.1169	0.732 0.3291	1.659 0.1977
Breusch-Godfrey (lag 2) *Chi-square* *Probability*	1.783 0.4101	0.525 0.7693	1.766 0.4872	2.526 0.2827	1.179 0.5547	1.987 0.3703
Breusch-Godfrey (lag 3) *Chi-square* *Probability*	2.060 0.5601	2.726 0.4538	2.435 0.4872	3.448 0.3276	1.589 0.6618	2.293 0.5139
Breusch-Godfrey (lag 4) *Chi-square* *Probability*	3.692 0.4493	6.027 0.1971	4.283 0.3690	3.618 0.4602	4.318 0.3647	2.337 0.6741
Sbcusum *Statistic* *Critical value (5%)*	0.7236 0.9479	0.6097 0.9479	0.6020 0.9479	0.3735 0.9479	0.3676 0.9479	0.4771 0.9479

Notes: Standard errors in parentheses. Significance at *10%, **5%, ***1% levels.

Conclusions

This paper presents evidence of a positive and significant impact of bank credit on manufacturing production in Mexico. This positive effect was observed for the entire sector (coefficient value = 0.54) and for almost all analyzed sub-sectors: i) food industry (0.26), ii) beverage and tobacco industry (0.07), iii) paper industry (0.19), iv) non-metallic mineral-based products (0.16), and vi) transportation equipment manufacturing (0.41).

Regarding the rest of the explicative variables, the investment in machinery and equipment was significant in all estimated models. The real interest rate also was significant in 3 out of 6 models. Industrial production of the United States only became significant in 2 of the 6 models, mainly due to weak exogeneity and Granger causality problems. The monetary base only turned out to be significant in 2 of the 6 models, which is expected because, generally, monetary policy does not yield a long-run effect on economic activity. The bank loan concentration index was negative and non-significant in almost all models, showing that loan concentration has not negatively affected manufacturing production.

As mentioned at the end of section 4.2, our results are different from those found in previous case studies of Mexico. What would be the explanation for such differences? In the first place, our study focuses on the manufacturing sector, which according to the theory is a sector more sensitive to the impact of gross fixed investment, and a relevant part of the credit granted to manufacturing companies is allocated to this type of investment. Second, our analysis period is different from previous studies and does not include periods of economic crisis, which represents a less general case. Third, our study period is one of low inflation and, according to Tinoco-Zermeño et al. (2014), inflation has negatively impacted Mexican GDP by affecting bank credit in the private sector; consequently, our results are not affected in this way.

On the other hand, our results are different from those obtained for other countries, mainly for developed economies. For example, the study by Bijlsma et al. (2018) indicated at the end of section 4.2 shows that our coefficients are higher than the average of many other countries. In developed countries an inverted U effect has been found, indicating a threshold value above which bank credit (as a percentage of GDP) has decreasing effects on economic growth. This threshold may be about 96 percent (Ho and Saadaoui, 2022) or even 135 percent (Lay, 2020), but in Mexico, as discussed in the introduction, banks grant credit to the private sector equivalent to less than 30 percent of the Mexican GDP. In other words, there is still plenty of room for bank credit to generate positive effects on economic growth.

These results are relevant because they indicate that bank credit has had a relevant repercussion on the production of manufacturing industries during non-crisis times. Our results suggest that special credit programs be designed (or extended) specifically for the manufacturing sector, particularly for the following industries: food, beverage, paper, non-metallic mineral-based products, and transportation equipment manufacturing. These represent close to 80 percent of the manufacturing production, equivalent to 12-13 percent of the total GDP of the Mexican economy. The strategic sector-specific credit has proven to be effective in other countries (i.e, Thampy and Tiwary, 2021). The credit granted to these sub-sectors may generate a greater stimulus for economic growth. Bank credit given towards productive activity is a developmental tool that has not been employed with enough intensity or clarity in the Mexican economy. The results shown in this research indicate a viable path for progress.

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Appendix A: Definition and source of data

Table A.1
Definition and source of data used in the econometric analysis

Concept	*Source*
Production value – Total of the manufacturing sector and the 7 sub-sectors analyzed	INEGI: Encuesta Mensual de la Industria Manufacturera, Bases 2008 y 2013.
Credit from commercial banking (total portfolio) – Total of the manufacturing sector and the 7 sub-sectors analyzed	Banco de México: Sistema de Información Económica, Banca Comercial, Crédito por la principal actividad del acreditado.
Index of investment in machinery and equipment	INEGI: Indicadores económicos de coyuntura, Inversión fija bruta, Base 2013, Maquinaria y equipo.

Index of industrial production of United States	Federal Reserve Economic Data, Federal Reserve Bank of St. Louis.
Monetary base	Banco de México: Sistema de Información Económica, Agregados monetarios y activos financieros internos.
28-day equilibrium interbank interest rate (real interest rate)	Own elaboration based on data from Banco de México: Sistema de Información Económica, Tasas de interés representativas.
Internal exchange rate index in pesos per dollar (real exchange rate)	Banco de México: Sistema de Información Económica, Tipos de cambio y resultados históricos de las subastas.
Index of bank loan concentration	Own elaboration based on data from Comisión Nacional Bancaria y de Valores: Portafolio de información, Boletines estadísticos.
Basel III dummy variable	Own elaboration. It assumes a value of 1 from January 2013 to December 2019. Otherwise, it assumes a value of 0.
Financial Reform dummy variable	Own elaboration. It assumes a value of 1 from January 2014 to December 2019. Otherwise, it assumes a value of 0.

Appendix B: Time series graphs

Figure B.1

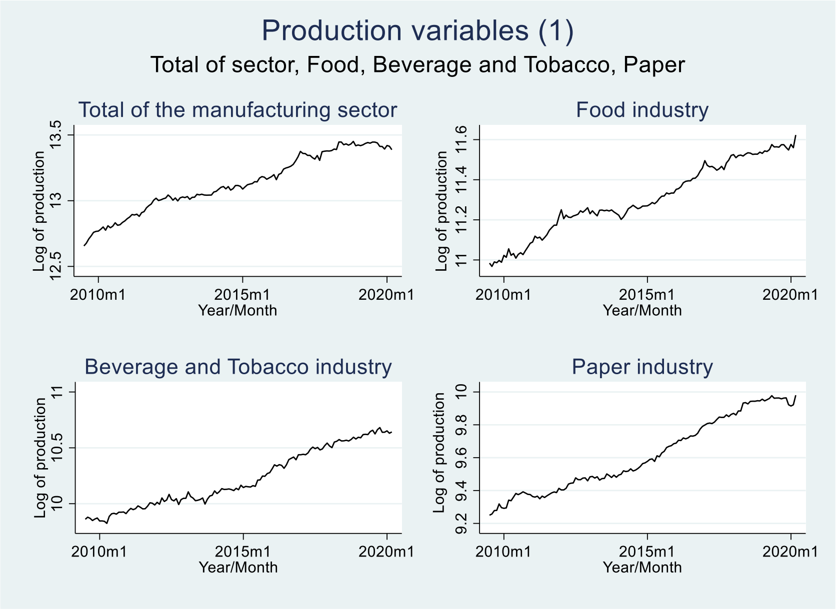


Figure B.2

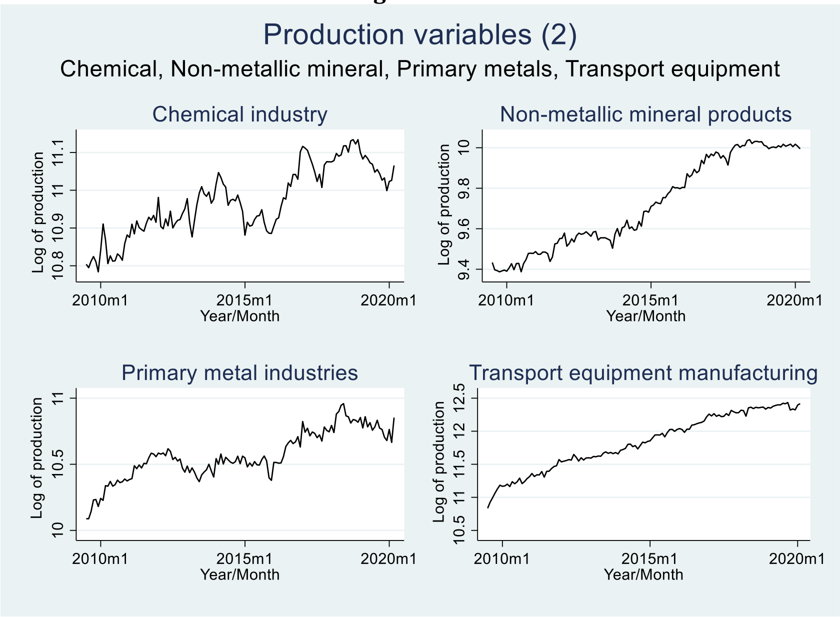


Figure B.3

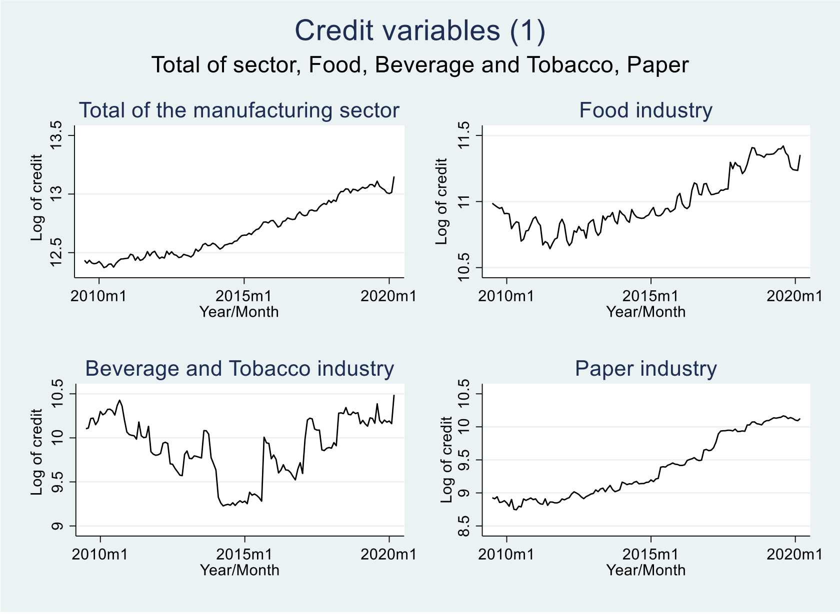


Figure B.4

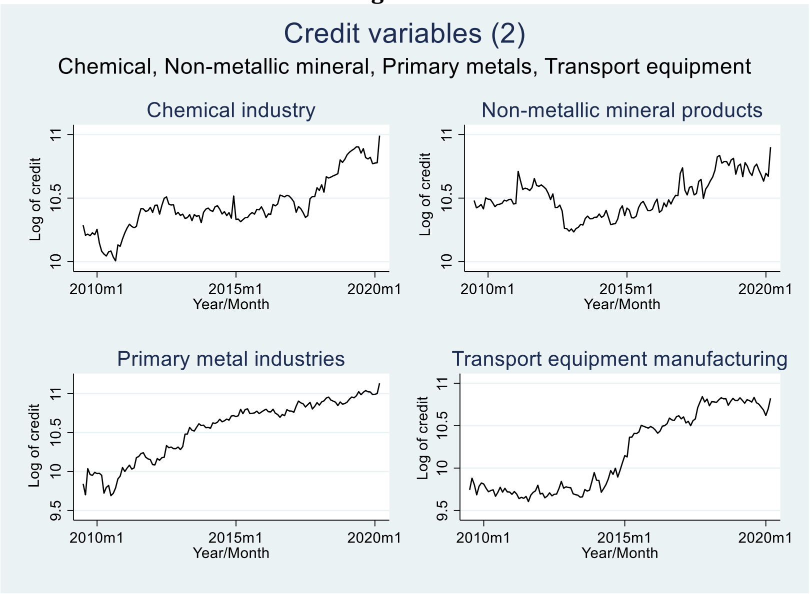
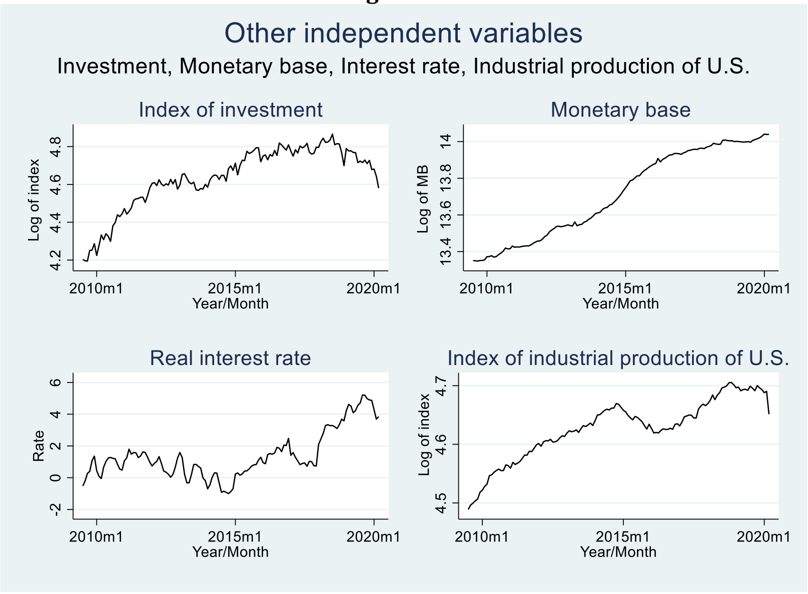


Figure B.5



Appendix C: Weak exogeneity tests

Table C.1
Weak exogeneity tests

Sector or Sub-sector	*Variable*					
	Bank credit	*Investment*	*Monetary base*	*Industrial production of U.S.*	*Real interest rate*	*Real exchange rate*
<u>Total sector</u>						
(Base model)						
Chi-square	0.6315	2.6538	2.6062	6.7342***	3.2665	
Probability	0.4267	0.1032	0.1064	0.0094	0.0707	
(Extended model)						
Chi-square	0.5280	1.5731	2.5924		3.0476	7.6601***
Probability	0.4674	0.2097	0.1073		0.0828	0.0056
<u>Food</u>						
(Base model)						
Chi-square	1.2637	0.6251	2.0284	6.8622***	0.0050	
Probability	0.2609	0.4291	0.1543	0.0088	0.9434	
(Extended model)						
Chi-square	0.5215	1.0715	0.1079		0.0893	2.2158
Probability	0.4726	0.3005	0.7425		0.7649	0.1365
<u>Beverage & Tobacco</u>						
(Base model)						
Chi-square	0.4124	0.0402	3.5917	7.8412***	0.4424	
Probability	0.5207	0.8409	0.0821	0.0008	0.5059	
(Extended model)						
Chi-square	0.8297	2.4782	4.7375		2.4424	2.8329
Probability	0.3623	0.1154	0.0795		0.0859	0.0923
<u>Paper</u>						
(Base model)						
Chi-square	2.6619	1.5676	0.7148	2.2324	2.1061	
Probability	0.1027	0.8409	0.3978	0.1351	0.1467	
(Extended model)						
Chi-square	0.2616	0.5481	1.5284	0.1293	3.0243	6.3971***
Probability	0.6089	0.4590	0.2163	0.7189	0.0820	0.0065
<u>Chemical industry</u>						
(Base model)						
Chi-square	2.2774	1.5391	0.6321	13.9149***	2.6611	
Probability	0.1312	0.2147	0.4265	0.0001	0.1028	
(Extended model)						
Chi-square	0.6499	0.0690	1.8501		4.6411	0.2618
Probability	0.4201	0.7927	0.1737		0.0612	0.6088
<u>Non-metallic mineral-based</u>						
(Base model)	0.1141	0.0238	1.9166	16.7257***	6.3639	
Chi-square	0.7354	0.8773	0.1662	0.0000	0.0516	
Probability						
(Extended model)	0.4054	2.5245	0.5280		2.5756	1.1207
Chi-square	0.5242	0.1120	0.4674		0.1085	0.2897
Probability						
<u>Primary metal industries</u>						
(Base model)	0.3342	3.4385	0.5444	14.2301***	2.1396	
Chi-square	0.5631	0.0639	0.4605	0.0001	0.1435	
Probability						
(Extended model)						
Chi-square	1.0448	0.1225	0.3495		1.6724	1.5295
Probability	0.3066	0.7262	0.5543		0.1959	0.2261
<u>Transport equipment manuf</u>						
(Base model)	1.9440	0.0005	4.0116	2.1279	0.0586	
Chi-square	0.1632	0.9981	0.0586	0.1446	0.8086	
Probability						
(Extended model)						
Chi-square	1.0630	0.1909	3.0116	0.7042	0.1520	0.9206
Probability	0.3025	0.6621	0.0851	0.4013	0.6965	0.3373