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Macroeconomic and financial determinants of mortgage delinquency in Mexico

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Abstract

This paper analyses the impact of a set of macroeconomic and financial variables on the delinquency behavior in mortgage lending granted by Mexico's six most important banks. Based on times series analysis tools and a quantile regression model, the probability distributions of the delinquency rates of each of these banks are analyzed. The evidence shows that inflation, interest rate, exchange rate, volume of international reserves, stock market index, and the number of private sector workers benefiting from social security, influence the behavior of delinquency. There are some differences in the effects of these variables on the delinquency of the six banks covered in this study, most likely due to differences in portfolio composition and strategies for the origin of credit. Knowing the importance of these variables in relation to the delinquency of mortgage portfolios can be useful to improve decisions regarding the generation and management of mortgage credits, as well as for the design and implementation of macroeconomic, financial, and fiscal policies that enhance resilience of the banking sector.

Keywords: Mexico's mortgage delinquency, delinquency indexes, mortgage macroeconomic impacts, overdue debt, cointegration, quantile regression.
JEL classification: E44, G10, G19, G21, G51.

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Determinantes macroeconómicos y financieros de la morosidad hipotecaria en México

Resumen

Este trabajo analiza el impacto de un conjunto de variables macroeconómicas y financieras sobre el comportamiento de la morosidad en los créditos hipotecarios otorgados por los seis bancos más importantes de México. La evidencia muestra que la inflación, la tasa de interés, el tipo de cambio, el volumen de las reservas internacionales, el índice bursátil y el número de trabajadores del sector privado que se benefician de la seguridad social, influyen en el comportamiento de la morosidad. Hay algunas diferencias en los efectos de estas variables sobre la morosidad de los seis bancos cubiertos en este estudio, probablemente debido a diferencias en la composición de la cartera y las estrategias para el origen del crédito. Conocer la importancia de estas variables en relación con la morosidad de las carteras hipotecarias puede ser de utilidad para mejorar las decisiones en materia de generación y gestión de créditos hipotecarios, así como para el diseño e implementación de políticas macroeconómicas, financieras y fiscales que mejoren la resiliencia del sector bancario.

Palabras clave: morosidad hipotecaria en México, índices de morosidad, impactos macroeconómicos hipotecarios, deuda vencida, cointegración, regresión cuantílica.
Clasificación JEL: E44, G10, G19, G21, G51.

1. Introduction

In the wake of the subprime crisis and currently the COVID-19 crisis, concern about mortgage delinquency has grown significantly due to the continued volatility and downturn of housing prices and consequent negative impacts on both lenders and borrowers, as well as on the economy in general. Access to mortgage lending today and in a global context for the economy of a nation represents equity opportunities for people, along with improved individual and social well-being. Home s one of the most important assets for families, largely acquired through credits granted by banking institutions and public institutions.

Mortgage lending, in conjunction with the construction sector and the housing market, are important drivers of economic growth. In Mexico, as in the rest of Latin American countries, this type of credit has grown markedly in recent decades, mainly in the urban centers due to an expansion of the middle class, along with increased financial inclusion and a competitive response from the banking sector. However, responding to the state of the economy, prices and their volatility in the housing sector are set in the markets and their changes affect banking institutions, family groups holding mortgagers, and finally the country's economy leading to severe economic crises. The causes of non-payment depend on both microeconomic and macroeconomic factors. Both factors bear upon the behavior and ability of borrowers to pay, or, where appropriate, weak credit practices of financial institutions. However, market consensus is also a response to macroeconomic and financial factors; thus, it is also possible to identify, for each institution, the impact of key variables reflected in the trends of its default mortgage portfolios. This is the central concern of our investigation for the case of Mexico.

Households in the absence of liquidity to meet their payments may lose their homes, collateral for banks of the credit granted. In fact, financial crisis might lead to "predatory" practices from banks (Rosen 2008). However, credit guaranties may be insufficient for the bank to recover the amounts granted; the embargo on mortgaged housing might not find a favorable market for the sale of seized properties. In extreme cases, banks almost converted into brokers must turn to real estate intermediaries losing income from commissions, legal costs, and low price of seized properties put up for sale. For lenders, this problem might be minimized in full-recourse countries; under this type of regulation debtors can be prosecuted until their arrears are fully cleared up, even using other personal assets.

Moreover, if delinquency takes place in a context of widespread crises, the need may arise to resort to large bailouts to the banking sector. Direct rescue programs to mortgagees have been exceptionally applied; some recent programs allow delayed payments to avoid massive home foreclosures. In this process, uncertainties in a particular housing economy and market may lead to situations where the value of mortgaged property is much less than the debtor's credit balance; that is, the contractual amounts to be paid are exaggeratedly greater than the value of the property. In this case, the number of family groups that stop paying grows and the amount of bad loans jumps-up.

Recent history reveals global economic scenarios that have led to the arrears in mortgage portfolios and negative debtor behavior, increasing

sharply the stock of non-performing loans (NPL) in the banking sector. In turn, this affects the level of private investment, limits the scope of bank credit to households, and small and large corporations hindering economic performance and development in many countries (Radu, 2021; Kepli *et al*., 2021: Tolo and Virén, 2021). Furthermore, during the 2007-2008 subprime crisis, the US., housing market was affected by the mortgage credit crisis, which not only affected that country, but also subsequently shifted a credit clutter to the global economy (Hull & White, 2008).

However, banking and family groups are not isolated actors in the development of mortgage lending and the evolution of the overdue portfolio. The behavior of these two groups is the product of changes in the economy that modify the ability to pay and the sentiment of both debtors and lenders. These changes result, above all, from the product of economic and financial policies aimed at maintaining stability, as well as responding to turbulences and avoiding crises.

Since the financial and economic sectors are deeply interrelated, it is possible to identify key variables that affect changes in the overdue banking portfolio. That is, we propose that it is possible to measure the sensitivity of delinquency to key variables in the economy. Because mortgage lending is a long-term contract, its evolution and delinquency have also a long-term impact on the growth of the economy because the decisions of mortgagers are intertemporal. It is therefore imperative to identify variables that affect the risk of the arrears or non-compliance by accredited parties. This is precisely the objective and contribution of this work. Regarding developed countries there is ample evidence that macro variables including exchange rates, interest rates and employment affect mortgage payment levels leading to increased defaults during booms and busts periods (Agnello and Schuknech 2011; Lambertino et al (2013); Ghosh (2015); Kroot and Giouvris (2016); Larsen (2018), Kupčinskas and Paškevičius (2020). This work bridges the gap concerning research on this issue for the case of developing countries, first by reviewing the extant literature, and second by examining the relationship between macroeconomic variables and non-performing loans in Mexico.

It should be noted that, in Mexico, the housing sector has performed irregularly in recent years. In 2018, this sector's contribution to Gross Domestic Product (GDP) was 5.90% (INEGI, 2019).[1] However, this participation has decreased. Since 2019 growth of the real estate sector suffered a contraction of 5.0% and by 2020, due to the impact of the COVID-19 pandemic, an additional fall of

[1] Please see the listing of acronyms at the end or the paper.

13% was expected. Similarly, the overdue mortgage portfolio increased 10.7% in 2019 versus 5.3% in 2018, albeit primarily due to new mortgages (INEGI, 2020; BBVA, 2020). In line with these negative trends, the balance of the overdue mortgage portfolio amounting to 2.3% in 2019 has increased to 5.9% by October 2020. Bank administrators consider it within manageable levels. Yet, this has been possible due to regulatory facilities granted to banks extending payment deadlines and allowing to restructure credit from their customers with declining payments. Yet, recovery of the housing sector could take from two to three years (BBVA, 2020).

Originally, CNBV and SHCP set out the policies to support clients with mortgage loans in effect as of February 28th, 2020: Partial or total deferral of capital and/or interest payments for up to four months, with the possibility of extending it to an additional two months, relative to the entire amount payable including accessories. Balances may be frozen at no interest charge. This allows such appropriations not to be considered by credit institutions as an overdue portfolio and therefore reserves do not need to be created. Additionally, Banxico cut the reference rate three times from 7.25% at the beginning of the year until reaching 5.5% on May 14th. Banxico also implemented measures to increment liquidity, reestablish trading conditions, and to impulse credit activity. Simultaneously, the government enforced fiscal and public spending measures to offset the negative impact on the population's health and on economic activity (Banxico, 2020).

Considering the analyses and conditions previously identified, this research seeks to contribute by increasing analysis capabilities about the causes of mortgage credit defaults, complementing the internal tools available to banks for decision-making and better management of mortgage loans. Our hypothesis indicates that key economic and financial variables are relevant to explain the sensitivity of mortgage portfolio delinquency. It is important to emphasize that for monetary and economic policy authorities, knowing the impact of economic and financial variables on mortgage lending delinquency becomes valuable information for adjusting monetary and fiscal policies to strengthen the resilience of the banking sector; for regulatory authorities, this information would be an advanced indicator to avoid bank runs, a systemic risk of the sector which could lead to a collapse of the economy.

First, we apply the Pesaran and Shin ADRL model (1998) to test cointegration, then we employ a quantile regression model to study the impact of economic and financial variables about ten deciles of the delinquency index of six of the most important Mexican banks: Banorte, BBVA, Citibanamex,

HSBC, Santander, and Scotiabank. The study period covers December 2008 to June 2020. The mortgage portfolio of these institutions comprises 96% of Mexico's mortgage portfolio, largely reflecting thinness and concentration of the banking sector in Mexico (CNBV, 2020). Currently, 50 commercial banks operate in Mexico and three are in the process of starting operations; in addition, the country has six development banks and about one hundred representations of foreign institutions (ABM, 2020).

The structure of this paper is as follows. Section 2 is devoted to review relevant literature on empirical evidence about the importance of economic and financial variables regarding default risk of mortgage portfolios, particularly for the case of developing economies. Section 3 describes the data and methodology used for the empirical analysis. Section 4 presents the empirical evidence, and section 5 offers a discussion of the results and the conclusions.

2. Literature review

The literature on the delinquency of mortgage lending, in terms of its depth and scope, is of recent development, encouraged by the impacts of the subprime crisis and now by the COVID-19 pandemic health crisis. Delinquency involves a delay in payments of an obligation or debt incurred by a natural or moral person and is instituted by the proportion between the overdue portfolio to the total portfolio.

Essentially, there are two prevailing theories of mortgager default: strategic default which occurs when debt is too high relative to the value of the house, due to adverse life events, in such a way that the monthly payment is too high relative to available resources (Ganong and Noel, 2020). Under that framework of analysis multiple models have been developed to determine the causes of default and consequent growth of bank's mortgage portfolios. Most of these studies are microeconomic in nature; this approach includes studies on the behavior of individuals and households, often supported by demographic, administrative and legal surveys, and data and on financial education (Campbell, 2013; Chan *et al*., 2013; Scott and Pressman, 2015; Lin *et al.*, 2015; McCabe, 2018; Zhang, 2019; Kurowski, 2021). Research approaches apply both descriptive methodologies and diverse econometric models. Some studies focused on behavioral studies have been often supported by surveys and demographic data, or else experimental

studies (Bocian *et al*. 2008; Gerardi *et al*. 2010; Pavan and Barreda-Tarrazona; 2020; Waldron, 2020; Kim *et al*., 2021). Alternative models have highlighted the measurement of the probability of bankruptcy (Campbell and Cocco, 2015; Kroot and Giorvis, 2016; Mocetti and Viviano, 2017; Lee and Mayock, 2019; Sumita *et al*., 2021; Kellner *et al.* 2022).

Another set of research addresses the issue of delinquency by examining public policies on housing and credit, highlighting the norms of construction, guidelines on urban growth, regularization, state intervention (Chan *et al*., 2015; Stanga, 2020). Also, much emphasis is placed on liquidity, often suggesting, with sophisticated models, government intervention with fiscal and monetary policies, basically low interest rates, subsidies, and in critical cases the capitalization and bailouts of banking institutions which due to large defaults are on the brink of bankruptcy, in "technical bankruptcy" (Demyanyk, and Hasan, 2010; Donnelly and Embrechts, 2010; Smith, 2017). These studies focus on individual decision making and do not include macroeconomic variables.

Concerning the responsibility of individuals and family groups, "consumers," empirical evidence about delinquency is growing, including for the so-called emerging economies. Our review of previous studies emphasizes the role of macroeconomic variables in mortgage delinquency. Among recent studies dealing with developed countries, relevant to our study, must be mentioned those by Campbell and Cocco (2015), Larsen (2018), Kupčinskas and Paškevičius (2020), Karadima and Louri (2021), and Fallanca *et al.* (2021).

Campbell and Cocco (2015) propose a dynamic model on accredited decisions about how much to consume and how much to pay, making prepayments or not paying in each period. They apply a dynamic model of a family that inhabits a home with a mortgage, and that in each period must decide how much to consume and whether to exercise, options to default, prepay, or rent the loan. The explanatory variables used are income, labor, house prices, and both inflation and interest rates, matching the US., experience of declining house prices and low interest rates before the subprime crisis.

Larsen (2018) Examines a Norwegian high-resolution housing transaction data set, to determine the link between the US. monetary policy reversal and the housing market upswing in the fall of 2008. His empirical evidence confirms the existence of a clear-cut house price index turn-around soon after the monetary policy reversal was initiated. The evidence suggests that the monetary policy reversal played a significant role in the housing market recovery.

Kupčinskas and Paškevičius (2020) study the relationship between house loans, interest rates, unemployment, and house rent prices in Germany, France, Spain, and Italy for the period 2003 to 2018, using monthly data. The authors tests cointegration and causality relations between house loans and macro variables employing a vector error correction model and Granger causality methods. Their results affirm a long-term cointegrating relationship between the real house loans and interest rates, unemployment and house rent prices for France, Spain, and Italy, but not for Germany. On average the equilibrium in house loan development is reached from 4 to 8 years, suggesting the presence of long-term equilibrium, albeit the variables reach it in a rather long time.

Although not directly dealing with macroeconomic determinants of mortgage delinquency, it is worth mentioning recent research by Karadima and Louri (2021). Due to problems derived from the sovereign debt crisis and delays in formulating a close-Knit policy response, Greek banks faced serious problems which led to substantial increases in non-performing loans. Employing aggregate data for the period 2003Q1-2020Q2 and the autoregressive distributed lag (ARDL) bounds testing approach, Karadima and Louiri find that non-performing loans are determined mostly by factors related to macroeconomic conditions, rather than by bank-related factors. Government debt, which exerts a significant and positive long-term impact on non-performing loans regardless of some short-term dynamics that provide a temporary relief. The fiscal balance is also found to exert a negative long-term effect, justifying the pursuit for surpluses post-crisis.

Finally, Fallanca *et. al*. (2021) examine the relationship between non-performing loans and major macroeconomic indicators, using a wide variety of methodologies, sometimes with different results. They advance an empirical test employing dynamic conditional correlation models, with constant and time-varying parameters. Fallanca *et. al*., apply these models to quarterly delinquency rates and a set of 8 US., macroeconomic variables: Real GDP, unemployment, inflation, money supply, house price index, S&P 500, T-bills 3 months, and real Effective Exchange rate for the period 1985-2019. Results show that the correlation is often negligible in this period except during periods of economic crises, in particular the early 1990 crisis and the subprime mortgage crisis.

Research on mortgages and nonperforming loans is limited but a growing area in developing countries. Akin to the interest of this work, their research stresses the relationship between macroeconomic and financial variables

with mortgage delinquency. Representative works of Africa, Middle East, and Asia include those by Njienga (2016), Nyabakora *et al.* (2020), Qwader (2019; Upadhyaya *et al.* (2017); Kepli *et al.* (2021), Ahmed *et al.* (2021), Ayberk and Önder (2022) and Ristic (2021) for a transition economy. For the Latin American countries are those advanced by Vallacorba and Delgado (2007), Fajardo Moreno (2016), Scheib and Chavaría (2019), Conto López *et al*. (2019), and Avanzini *et al.* (2020).

In Africa, due to an increase in non-performing loans, Njienga (2016) examines the relationship between select macroeconomic variables and the delinquency rate in Kenya's commercial banking during the period 2006-2013. The macroeconomic variables studied are inflation rate, credit interest rate, exchange rate from the US dollar to Kenya's shilling, and public debt as a percentage of Gross Domestic Product (GDP). The loan delinquency rate was represented by net non-performing loans as a percentage of gross loans for the period 2006-2013. Public debt was the only independent variable that had a positive relationship with the default rate of default loans. According to the empirical evidence, inflation, the interest rate on loans and the exchange rate were negatively correlated with the dependent variable. By means of p-values, it is established that the interest rate on loans and the exchange rate were significant, while inflation and public debt were not significant in the regression model.

Following this line of research, Nyabakora *et al.* (2020) explore the impact of key macroeconomic variables on nonperforming loans for the Tanzanian banking sector for the period 2013 to 2019. Variables comprise Gross Domestic Product growth rate, money supply rates, inflation rate, exchange rate, and interest rate. The authors presume that commercial banks must be protected from unknown harmful factors, including those affecting nonperforming loans. Nyabakora et al. apply panel data regressions and correlation analysis. Their evidence reports a positive impact of interest rate and exchange rate on nonperforming loans. Nonetheless, the results provide evidence of a negative impact of gross domestic product growth rates, the rate of money supply, and inflation rates on nonperforming loans.

Similarly, for the case of Jordan, Qwader (2019) examine the impact of macroeconomic variables such as GDP, unemployment rate, interest rates, remittances of workers abroad and external grants on non-performing loans of Jordanian banks. Empirical tests apply an autoregressive distributed-lagged model (ARDL). The study confirms the presence of a long-term equilibrium relationship between the variables under analysis. It was also found

that there is an inverse relationship with a significant effect on the long and short term for both external grants, GDP, and interest rates on non-performing loans in Jordanian banks. Additionally, no impact on the long and short run was found for both remittances of workers abroad and the rate of unemployment on non-performing loans in Jordanian banks. The study recommends the Jordanian government to adopt policies and programs aiming at the reduction of the cost of borrowing to diminish nonperforming loans, to promote the development of local investments and explore new international markets to attract Jordanian labor.

Upadhyaya *et al.* (2017) investigate the trends in non-performing loans (NPL) in Indian banks and main macroeconomic factors that may be causing a surge in the level delinquency loans. Empirical tests are carried out using correlation analysis along with pairwise Granger causality tests followed by panel regression. The evidence indicates that GDP growth, change in exchange rate and global volatility have major effects on the NPL level of the Indian banking sector levels of non-performing loans.

Kepli *et al.* (2021) examine the determinants of non-performing loans in the Malaysian banking system. Employing annual data from 1988 to 2018. The work appraises both the short and long-run dynamics of several macroeconomic variables impacts using an Auto-Regressive Distribution Lag (ARDL) cointegration approach. The empirical evidence demonstrates mixed results. In the long-run, exchange rate is positive and significantly related to nonperforming loans, while industrial production and money supply are negative and significant. Additionally, inflation does not have significant effect on NPLs in Malaysia. The findings of this study are useful in assisting the banking institutions and policy makers to design macro and fiscal policies.

Lastly, it is worth mentioning the case of a transition economy. In Servia, after financial liberalization during the last two decades of the XX century, banks extended credit in more relaxed terms which increased non-performing loans. Using data for the period 2010-2019, Ristic *et, al.* (2021) examine non-performing loans trends in Servia to identify the determinants of credit risk. Applying a vector autoregressive model, the evidence confirms that macroeconomic and bank-specific factors affect the level of non-performing loans. These factors are GDP, inflation, employment, return to total assets, cost efficiency, capital adequacy ratio, and income diversification.

Turning to Latin America, Vallcorba and Delgado (2007) study the determinants of the delinquency of Uruguay's private banks during the period 1989-2006; although they do not specifically assess the case of

mortgage defaults, they determine the existence of delinquency cointegration relationships with a set of macroeconomic variables. Variables included as explanatory factors are annual and quarterly variation in total loans in dollars to private national residents granted by private banking; percentage of such guaranteed credits; year-on-year real change in GDP; average dollar interest rate charged by private banking; unemployment rate or occupancy rate; or year-on-year variation in dollars in the average wage index; and finally, year-on-year real depreciation rate.

The evidence obtained indicates the presence of an equilibrium relationship between delinquency, change in wages in dollars and higher interest rates result in greater long-term default. This conclusion underscores the relevance of credit exchange risk in economies with dollarized banking systems. This was and remains the case for Mexico and several Latin American countries because the sale of real estate and real estate is often quoted in dollars.

In another Latin American study, Fajardo Moreno (2016) points out that the modality of the consumer portfolio that exists in Colombia shows a procyclical pattern that should be considered in the formulation of policies for proper risk management. Unfavorable growth processes lead to higher levels of non-compliance with household pay-per-view; the ability to pay decreases. The study uses multivariate time series methodologies for aggregated data and panel data for a sample obtained from Colombia's leading credit bureau, CIFINI. The results indicate that inflation and the interest rate are significant in predicting the performance of the quality of the consumer portfolio; however, unemployment shows low explanatory power.

In addition, Conto López *et, al.* (2019) examine the determinants of the overdue portfolio index in the Colombian banking sector using a model with long-term panel data. They analyze by lines of credit (housing, commercial, consumption and microcredit). Their hypothesis indicates that both the macroeconomic variables as well as changing behavior of banks influence the overdue portfolio and that this effect varies depending on the line of credit. Empirical evidence allows them to conclude that it is possible to explain Colombia's overdue portfolio index, mainly by macroeconomic variables such as the representative exchange rate of the Colombian market, the real interest rate, and by bank-specific variables such as the supply ratio and solvency. In addition, they show that the effects vary depending on the line of credit; the housing credit line is the least responsive to changes in micro and macroeconomic variables, whereas the trade line shows the greatest influence of these variables.

At a regional level in Mexico, recognizing that mortgage contracts depend on house prices, Scheib and Chavaría (2019) discuss what macroeconomic factors affect housing prices in Mexico´s Northern state of Nuevo León. It is worth noting that Cañon *et, al.* (2022) have shown that the bank loans granted to Mexican firms have higher interest rate, 11% above the mean rate, when the lender bank has market power. The differential on interest rates is greater when the borrowers are small in size and when they are located in Mexico´s Central and Southern regions.

These macroeconomic factors included in Schieb and Chavarria (2019) study include inflation, interest rate on Federation Treasury certificates, gross domestic product, and peso parity against the dollar; the analysis period covers from 2007 to 2018. They select a longitudinal probabilistic model in which they perform a multivariate regression analysis. The main results indicate there is a positive relationship between the various economic factors that influence the price of homes in the state of Nuevo León. This study is also consistent with Ayberk and Önder (2022) findings who find that Turkish banks increase their mortgage allocation lending following up movements in the houses prices, during the period 2007Q4-2015Q2. Our study does not only confirm findings for other developing countries, but also confirming previous related research from developed countries.

In a recent sophisticated study, Avanzini *et, al*. (2020) examine the individual and systemic determinants on mortgage delinquency assuming that Chile is a full-recourse economy. They consider mortgage defaults to be a rare event compared to meeting payments for the total amount of mortgages; this approach allows them to capture a broad, intentionally biased sample set, *i.e*., endogenously stratified sampling and examining the contribution of idiosyncratic and systemic determinants, as well as their interactions. To this end, they adapt and expand Geanakoplos and Zame's (2014) model of mortgage default for non-full-endorsement economies, adding a non-pecuniary cost for non-compliance to consider the potential expected loss of utility against the existence of full-recourse. Their evidence indicates that household financial conditions and their interactions with systemic determinants represent an important part of the cross-cutting likelihood of mortgage default. However, systemic determinants do not highlight fundamentals of the economy - macroeconomic variables; the authors emphasize house prices and the pay-to-value ratio of housing.

To complete this literature review, it is worth highlighting three recent related papers by Mosso Martínez and López-Herrera (2019; 2020a, 2020b).

They examine the role of key macroeconomic variables in the mortgage stock portfolio. As a frame of reference, they include advances and extensive literature on portfolio theory, particularly on multivariate models developed to measure risk, specifically systematic risk, of financial assets. In their 2019 and 2020a papers the authors examine the long-term equilibrium relationship between delinquency and the deterioration securitized mortgages in Mexico. The evidence indicates how long ahead it is possible to anticipate the deterioration in the occurrence of default and the deterioration of the portfolio of securitized mortgages itself. An ARDL model is used to explain the deterioration of that portfolio based on the variables of the original set, including the effect of the existence of a long-term relationship as shown by the Pesaran and Shin (1998) cointegration test. The existence of a long-term relationship between delinquency and the deterioration of the stock market mortgage portfolio is identified, the empirical evidence shows that changes in delinquency in a previous month produce increases deterioration. The behavior can be explained by changes that are generated in delinquency; a possible explanation has its origins in the systematic risk factors that affect delinquency.

Likewise, in their 2020b paper, Mosso-Martínez and López-Herrera point to economic and financial variables that contribute to the explanation of systematic risk of the securitized mortgage portfolio. They select key risk factors, after a thorough review of the literature: housing price index, 28-Day Mexican treasury certificates rate, national consumer price index, unemployment rate, monetary base, global economic activity index, exchange rate, average oil export price, Mexican Stock Exchange Price Index, international reserves, merchandise trade balance, average US. one moth Treasury Certificate. Their econometric evidence shows that economic openness and international money market conditions are risk factors that can affect delinquency. Evidence was also found signaling that the postulated variables are relevant to explain delinquency of the portfolio studied.

3. Econometric methodology and expected variables impact

Our econometric methodology first employs the Pesaran and Shin ADRL model (1998). It is a versatile model allowing to test cointegration including the case of a combination of I(1) and I(0) variables. It can be specified as follows.

$$y_t = c_0 + c_1 t + \sum_{i=1}^{p} \phi_i y_{t-i} + \sum_{j=0}^{q} \boldsymbol{x}_{t-j} \beta_j + u_t \quad (1)$$

The ARDL ($p,q,...q$) can reparametrized as the conditional error correction or long run form:

$$\Delta y_t = c_0 + c_1 t - \alpha(y_{t-1} - \theta^T \mathcal{X}_{t-1}) + \sum_{i=1}^{p-1} \varphi_i^T \Delta y_{t-i} + \sum_{j=0}^{q-1} \Delta \mathcal{X}_{t-j} \psi_j + u_t \quad (2)$$

$where, \alpha = 1 - \sum_{i=1}^{p} \phi_i$ is the speed-of adjustment parameter and $\theta = \frac{\sum_{j=0}^{q} \beta_j}{\alpha}$ is the vector containing the long-run parameters. Equation (2) can be reparametrized as the error correction model (ECM):

$$\Delta y_t = c_0 + c_1 t - \alpha(y_{t-1} - \theta^T \mathcal{X}_{t-1}) + \sum_{i=1}^{p-1} \varphi_i^T \Delta y_{t-i} + \gamma^T \Delta \mathcal{X}_t + \sum_{j=1}^{q-1} \Delta \mathcal{X}_{t-j} \psi_j + u_t. \quad (3)$$

This study also makes use of quantile regression analysis. Quantile regressions focus on estimating and inferring on conditional quantile functions. It provides procedures to estimate not only the conditional mean function, but also the full range of the quantile function and it can be employed when linearity, assumed in standard linear regression, is not present. In short, quantile regression results offer robust estimates due to its ability to provide a more complete analysis of stochastic relationships between random variables. Defining the th-ésimo conditional quantile, $0<\tau<1$, of y given x como

$$Q_y(\tau|x) = min\{\eta|\mathbb{P}(y \leq \eta|x) \geq \tau\}. \quad (4)$$

Assuming the linear relationship $Q_y(\tau \mid x)=x^T \beta(\tau)$, being x^T a matrix of observable variables covarying with y and $\beta(\tau)$ a vector of parameters, using quantile regression, can be estimated $Q_y(\tau \mid x)$ by specifying.

$$\begin{aligned} y &= x^T \beta(\tau) + \xi(\tau) \\ Q_\xi(\tau|x) &= 0 \end{aligned} \quad (5)$$

In vector y one can accommodate the observed values of the delinquency index of a bank's mortgage portfolio, while matrix x considers the observations of the explanatory variables of this model. $\beta(\tau)$, the vector of parameters to be estimated depends on the quantile τ, just like the stochastic error, $\xi(\tau)$, for which there is no hypothesis about their probability distribution.

To estimate $\beta(\tau)$ the following optimization problem is solved.

$$\beta(\tau) = \underset{\beta \in \mathbb{R}}{arg\,min}\ \frac{1}{n}\left\{\sum_{y_i \geq x_i^T} \tau \left|y_i - x_i^T \beta\right| + \sum_{y_i < x_i^T} (1-\tau)\left|y_i - x_i^T \beta\right|\right\}. \quad (6)$$

The explanatory variables forming x and considered in the analysis presented in the following section are the National Consumer Price Index

(INPC), the rate of Treasury Certificates (Cetes) at 28 days, the peso-dollar exchange rate, the price of the Mexican petroleum mixture (Petroleum), the international reserves in Banxico's possession, the Mexican Stock Exchange's Price Index (IPC), and the number of affiliates of the Mexican Social Security Institute (AIMSS).

Concerning their expected signs, inflation undermines the purchasing power of accredited individuals, thus a positive sign could be expected: the higher inflation is, the lower purchasing power is making it difficult to pay mortgage loans; however, inflation also raises the cost of housing rent and the value of homes, which would make it more desirable to cover the hypotheca's payment to avoid losing the house. Interest rate movements can make it difficult to pay variable rate credits; the expected sign is positive. The exchange rate can be considered an indicator of the strength of macroeconomic fundamentals and, therefore, confidence in the evolution of the economy, hence the expected sign is negative.

Oil price behavior may indicate expectations of economic performance at the global level; the expected sign is positive if expectations are favorable, negative otherwise. International reserves are the result of the balance of accounts with the rest of the world, the expected sign is negative. In addition, this acquis is an important part of the income of many families helping them finance their spending, activating the economy. The stock market indicator shows local economic expectations, a negative expected sign when prices grow. Finally, the number of IMSS members indicates the level of employment in the private sector, as such their expected sign is negative; but being considered an indicator of the economic cycle, it was necessary to expect a positive sign given the recessive and low-economic performance context during the decade analyzed, which include six months of the COVID-19 crisis.

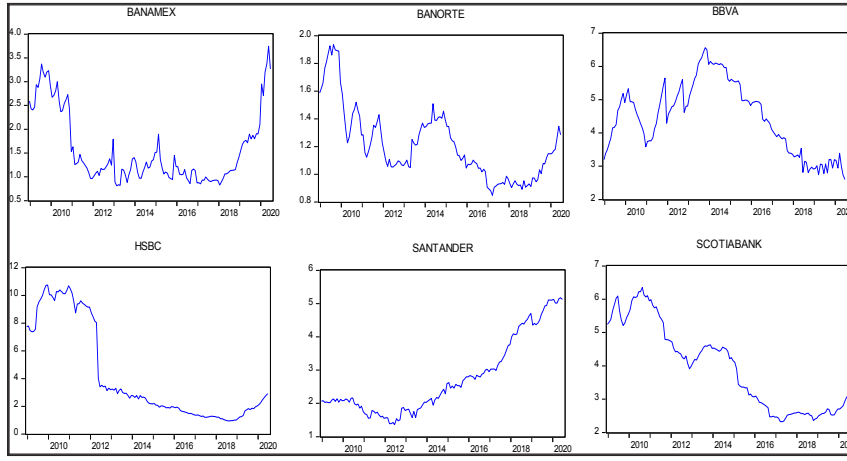
The delinquency indexes[2] of Banorte, BBVA, Citibanamex, HSBC, Santander and Scotiabank were obtained from the public information portfolio of the National Banking and Securities Commission (www.gob.mx/cnbv) on a monthly basis from December 2008 to June 2020. Mexico´s housing data is available only since 2013. Similarly, due to some data discontinuities our study ends June 2020. At the end of the first half of 2020, the six banks analyzed accounted for 92.76% of the origination of mortgage credit, for the period under analysis. Of the value of the total mortgage portfolio ($831 807 million

[2] The delinquency index is estimated based in the relationship between the value of the mortgage portfolio in default to the value of total mortgage portfolio granted by the bank.

pesos, mdp), Banorte awarded loans of $169 078 mdp. (20.33%), Citibanamex $86 409 mdp. (10.39%), BBVA $233 005 mdp. (28 01%), HSBC $61 530 mdp. (7.40%), Santander $87 539 mdp. (10.52%) and Scotiabank $133 990 mdp. (16.11%); other banks and credit institutions extended mortgage loans by $60 255 mdp. (7.24%). Compared to the beginning, at the end of the period analyzed there were notable changes in the mortgages market share of the six banks covered by this study: Banorte, HSBC and Scotiabank lost, respectively, 26%, 68% and 47% of their share, while BBVA, Citibanamex and Santander observed a growth of their respective share of 6%, 24% and 143% (CNBV, 2020).

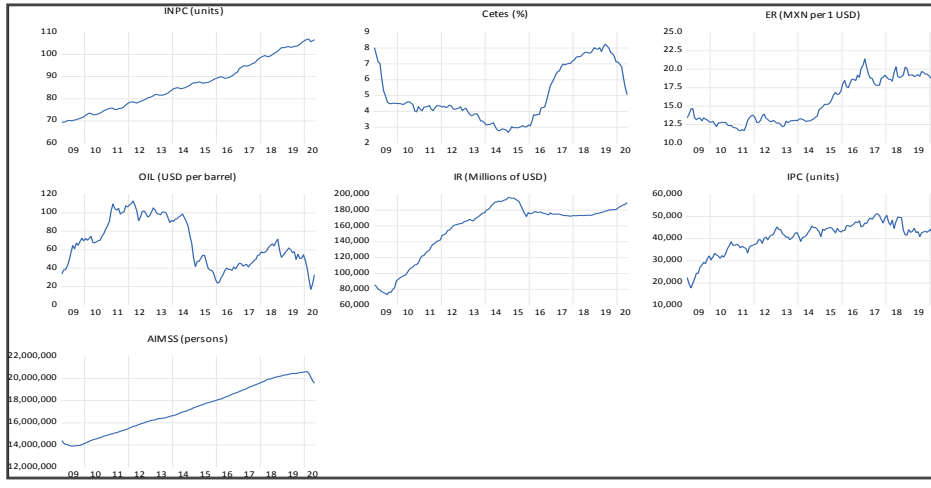
The National Consumer Price Index (INPC) was obtained from INEGI; the yield rate of the Federation 28-Day Treasury Certificates (Cetes), the peso-dollar exchange rate (ER), international reserves and the Price and Quote Index of the Mexican Stock Exchange (IPC) were obtained from Banxico statitics; oil prices (OIL) from the Ministry of Energy (www.gob.mx/sener) and the number of members of the Mexican Institute of Social Security (AIMSS) from the Observatory of Economic Cycles of Mexico (OCEM): https://ocemciceuaemex.wixsite.com/ocemciceuaemex).

Figure 1 shows the evolution of monthly mortgage delinquency indexes between december 2008 and june 2020 for the six banks. At the end of 2010 the default in mortgage activity for Citibanamex, HSBC and Scotiabank maintain a declining trend, a condition that prevails except for Citibanamex, which presents a sharp increase beginning 2017. Banorte maintains a mortgage a declining credit delinquency rate, but with some increasing variations between 2013 and 2015. These changes can be attributed to the global recession brought about by the subprime mortgage crisis generated in the United States. A similar condition prevails for BBVA. However, since 2013, this institution 2013 shows a declining trend. Finally, Santander maintains since 2012 a rising trend in its delinquency rate of its non-performing loans.



Source: own elaboration using information from CNBV.

Figure 1
Delinquency indexes of mortgage portfolios (percent)



Source: own elaboration using data from INEGI, Banxico, SE and OCEM.

Figure 2
Macroeconomic and financial variables

Figure 2 shows the behavior of the seven economic and financial variables used in the econometric analyses as independent variables. Monthly data includes december 2008 to june 2020. The number of AIMSS, INPC, stock

market indicator and exchange rate show and increasing trend, but at the end of the sample there is a drop in the case of the first two variables: The exchange rate shows some low decreasing trend till 2013; ever since starts an increasing trend till 2016 which is flowed by a short declining trend and a relatively sharp rise in 2020, reflecting and impact of the COVID-19 crisis.

International reserves also show a significant growth until 2014. Following a two-year declining trend, growth is resumed till the end of the period under analysis. The interest rate shows a noticeable declining trend from the beginning period, reaching minimum levels in 2014. Until 2019 a growing trend follows in 2019 and in 2020 a fall in the interest rate takes place due to monetary policies enforced to mitigate de pandemic impacts. Finally, oil prices show a significant hike until 2014 which is followed by some recovery and finally a declining trend since 2018.

4. Empirical evidence

4.1. Time series analysis

According to the ADF unit root tests (table 1), practically all of series analyzed can be considered non-stationariy I(1) variables when tested in logs (except the Cetes interest rate, expressed in percentual terms) and stationary I(0) when the tests are carried out for the first differences of the logs. Nevertheless, in none of the test specifications does the log of the consumer price index (INPC) reject the null hypothesis of non-stationarity, which could be attributed to a structural change in the series, as suggested by the Lee and Strazicich (2003) test shown at the bottom of the same table 1. When considered the first differences of the consumer price index logs, the null hypothesis of unit root with a structural change is rejected when considering a break in the intercept (crash model) or when is considered a break occurring in both the intercept and the trend (break model). In short, for practical issues, we can assume that all the series levels can be considered as I(0) variables and their first differences as I(1).

Table 1
Unit root tests

ADF-H0: unit root	C	C&T	NC&NT
At Levels	t-Statistic	t -Statistic	t -Statistic
Banamex	-1.1216	-0.0012	-0.7088
Banorte	-1.6884	-2.4324	-1.549
BBVA	-0.5694	-1.9171	-0.6926
HSBC	-1.2031	0.7295	-1.408
Santander	0.3759	-2.0946	1.6677
Scotiabank	-1.746	-1.1491	-1.3284
INPC	-0.1036	-2.5643	2.3298
Cetes	-1.8157	-0.8947	-0.4846
ER	0.192	-2.8288	1.2738
Oil	-1.8347	-2.9368	-0.2101
IR	-5.2934***	-3.8467**	2.0865
IPC	-2.9681**	-1.9976	0.9572
AIMSS	-2.6157*	3.0229	2.5126
First Differences	*t*-Statistic	*t* -Statistic	*t* -Statistic
ΔBanamex	-7.4273***	-8.0477***	-7.4553***
ΔBanorte	-10.2022***	-10.2774***	-10.2266***
ΔBBVA	-5.2131***	-5.5555***	-5.211***
ΔHSBC	-9.5851***	-9.7329***	-9.5559***
ΔSantander	-5.6645***	-5.9049***	-5.3836***
ΔScotiabank	-3.3129**	-3.4619	-3.1386**
ΔINPC	-2.4405	-2.4195	-0.6273
ΔCetes	-3.2882**	-2.5508	-3.3051***
ΔER	-9.4685***	-9.6684***	-9.369***
ΔOil	-7.0617***	-7.1786***	-7.0974***
ΔIR	-3.6282***	-5.0522***	-2.8853***
ΔIPC	-11.1914***	-6.4267***	-11.1048***
ΔAIMSS	-4.3551	-4.7328***	-2.2852***

Lee and Strazicich unit root tests H_0: Unit root with break

Crash model			Break model	
Variable	Break date	τ-min	Break date	τ-min
INPC	2016:10	-2.0261	2016:11	-3.6522
ΔINPC	2016:01	-8.0894***	2015:01	-9.0211***

All variables are in logs, except by the Cetes that is in percentual terms
ADF = Augmented Dickey-Fuller unit root test
C = Constant, C&T = Constant and Trend, NC&NT = No constant, nor Trend
***, ** & * denotes, respectively the 1%, 5% & 10% significance level

The ARDL bound tests shown in table 2 reports evidence of cointegration for almost all the banks' delinquency index and the assumed explanatory economic and financial variables. BBVA is the only exception since the evidence of cointegration is almost no significant.

Table 2
ARDL Bound tests

H_0: **No levels relationship (no cointegration)**							
Equation	**Model specification**	**Statistic**	**NC&NT**	**RC&NT**	**uRC&NT**	**uRC&RT**	**uRC&uRT**
Banamex	Long run form	*F*	5.0952***	4.4924***	4.8915***	4.8581***	4.6060**
		t	-5.3744***		-5.0346**		-5.4422**
	ECM	*F*	5.0952***	4.4924***	4.8915***	4.8581***	4.6060**
		t	-6.5636***		-6.4325***		-6.2433***
Banorte	Long run form	*F*	4.5958***	5.5478***	4.6207***	6.3740***	7.0452***
		t	-3.3086		-3.5316		-4.3527
	ECM	*F*	4.5958***	5.5478***	4.6207***	6.3740***	7.0452***
		t	-6.2365***		-6.2492***		-7.7132***
BBVA	Long run form	*F*	1.9823	2.8325	3.1811*	2.8324	2.6210
		t	-2.8384		-2.9404		-2.9664
	ECM	*F*	1.9823	2.8325	3.1811*	2.8324	2.6210
		t	-4.0968*		-5.1910***		-4.7129*
HSBC	Long run form	*F*	4.3166***	3.8312**	4.1459**	3.8665**	3.9301**
		t	-1.6918		-1.5720		-1.9574
	ECM	*F*	4.3166***	3.8312**	4.1459**	3.8665**	3.9301**
		t	-6.0326***		-5.9133***		-5.7585***
Santander	Long run form	*F*	2.3565	2.6693	2.6172	2.4519	2.5211
		t	-3.6608		-3.9868		-3.9397
	ECM	*F*	2.3565	2.6693	2.6172	2.4519	2.5211
		t	-4.4628**		-4.6993**		-4.6131**
Scotiabank	Long run form	*F*	3.5474**	3.3393**	3.7566**	3.3734*	3.7491*
		t	-3.8090		-3.6411		-3.6932
	ECM	*F*	3.5474**	3.3393**	3.7566**	3.3734*	3.7491*
		t	-5.4791***		-5.6359***		-5.6315***

NC&NT = no constant nor trend, RC&NT = restricted constant without trend, uRC&NT = unrestricted constantwithout trend, uRC&RT = unrestricted constant and restricted trend, uRC&uRT = unrestricted constant and unrestricted trend
***, ** & * denotes, respectively the 1%, 5% & 10% significance level

4.2 Quantile regression analysis

Table 3 summarizes the impact of the selected economic and financial variables on the morosity of mortgage loans. Inflation affects the different levels of delinquency of banks' portfolios, mostly with a positive sign as expected, except for HSBC. This confirms that delinquency increases when the economy's prices rise along the cost of living making it difficult for accredited people to honor their commitment to the bank. However, it is appropriate to consider that the estimated relationship between the delinquency of BBVA's mortgage portfolio and prices shows the opposite sign, although it is only significant (at 1% inclusive) for the first three deciles and with a declining impact as the amounts considered rise.

It can be also observed that the impact of the interest rate on the level of delinquency is important. Only in the case of HSBC no significant evidence was found. It is worth noting that the sign of the corresponding coefficients is negative, only by displaying the opposite sign when it is not significant. This result suggests that interest rate increases could have served as incentives to meet the payment of the mortgage debit in the case of contracted loans at variable rates given the higher cost that default could entail. Rate hikes could increase the amount of default interest to be paid, as well as the amount of other associated penalties.

The exchange rate was not significant for any of the delinquency levels of BBVA and HSBC portfolios. In all other cases some evidence of their significance was found, always with a negative sign. It seems that the behavior of oil prices has almost no effect on banks' delinquencies; hence, if these prices are indicative of expectations of the growth of the world economy and a significant source of public revenue, credit portfolios seem to have a kind of immunity to their fluctuations. On the other hand, international reserves are not significant for the delinquencies of HSBC and Scotiabank. However, in the cases of Banamex, Banorte and Santander this variable shows great importance, always with a negative sign. This outcome might be suggesting that the higher level of activity with relative price stability that they might be inducing is reflected in a purchasing power that allows accredited people to face paying their mortgages. Nonetheless, it is noted that it only affects some BBVA delinquencies (the three highest quantiles) and positive signs and coefficients of increasing magnitude as the level of delinquency increases.

Table 3
Quantile regression estimates of default

Bank	Quantil	Constant	INPC	Cetes	Exchange rate	Oil	Reserves	IPC	AIMSS
Banamex	10%	58.289	8.090	-0.124***	-0.455	-0.025	-1.872***	-0.964***	-3.583
	20%	90.308***	11.124***	-0.104***	-1.023**	-0.190	-1.724***	-0.959***	-6.293***
	30%	70.491***	10.973***	-0.142***	-1.440***	-0.152	-2.027***	-1.111***	-4.675**
	40%	65.991**	11.027***	-0.149***	-1.530***	-0.163	-1.985***	-1.280***	- 4.319**
	50%	88.241***	11.464***	-0.123***	-1.269***	-0.203**	-1.568***	-1.371***	-6.051***
	60%	96.282***	11.836***	-0.114***	-1.249***	-0.226**	-1.577***	-1.197***	-6.735***
	70%	117.777***	11.348***	-0.028	-1.233**	-0.342	-0.927***	-1.103	-8.416**
	80%	138.709***	12.084***	0.004	-1.112**	-0.379	-0.940***	-0.534	-10.239***
	90%	160.796***	13.468***	0.023	-1.510**	-0.637***	-0.773**	-0.020	-12.254**
Banorte	10%	-16.294	-0.282	-0.075	-0.307	0.040	-0.399	-0.824***	1.930
	20%	-5.441	0.833	-0.094**	-0.234	0.096	-0.485	-0.881***	1.060
	30%	-12.231	1.093**	-0.119***	-0.468**	0.078	-0.777***	-0.847***	1.639**
	40%	-10.855	1.305**	-0.122***	-0.535**	0.075	-0.840***	-0.816***	1.539**
	50%	-11.172	1.225**	-0.102***	-0.803***	-0.029	-0.745***	-0.823***	1.580**
	60%	-2.699	1.715***	-0.097***	-0.695***	-0.007	-0.667***	-0.831***	0.867
	70%	-1.556	1.750***	-0.096***	-0.7336***	-0.012	-0.643***	-0.796***	0.757
	80%	-1.354	2.048***	-0.109***	-0.821***	-0.018	-0.778***	-0.801***	0.787
	90%	3.787	1.839***	-0.091***	-0.784***	-0.009	-0.554***	-0.866***	0.403
BBVA	10%	-53.71017	-4.404***	-0.080	-0.315	0.035	0.674	-0.448	4.351
	20%	-67.50849***	-4.563***	-0.122**	-0.287	0.152	0.262	-0.640**	5.620***
	30%	-46.90739**	-3.320***	-0.114***	-0.207	0.124	0.023	-0.267	3.980**
	40%	-25.08984	-2.040	-0.101***	-0.315	0.060	0.129	-0.104	2.181
	50%	-18.2834	-1.728	-0.100***	-0.258	0.069	0.109	-0.022	1.639
	60%	12.16516	-0.357	-0.088***	0.103	0.082	0.305	0.079	-0.824
	70%	15.17827	-0.059	-0.090***	0.107	0.085**	0.338**	0.037	-1.082
	80%	21.99394	0.381	-0.085***	0.066	0.067	0.353**	0.117	-1.660
	90%	15.75658	-0.311	-0.066***	-0.127	0.056	0.354**	0.252***	-1.156
HSBC	10%	123.4205**	3.034	-0.036	0.059	0.002	-0.562	0.156	-7.865
	20%	173.977**	6.455	-0.013	0.056	-0.054	-0.403	0.326	-12.028**
	30%	206.5587***	8.102***	0.001	0.317	-0.115	-0.162	0.304	-14.612***
	40%	204.8094***	8.756***	-0.009	0.143	-0.098	-0.137	-0.150	-14.381***
	50%	192.034***	8.325***	-0.015	-0.071	-0.083	-0.197	-0.397	-13.263***
	60%	187.0848***	8.578***	-0.026	-0.058	-0.004	-0.374	-0.763	-12.689***
	70%	243.7443***	11.875***	-0.022	0.779	0.285	-0.370	-0.733	-17.190***
	80%	246.9694***	12.066***	0.008	0.354	0.315	0.309	-0.923	-17.742***
	90%	255.4695***	12.817***	0.015	-0.111	0.273	0.594	-0.933	-18.562***

Conclusión. Table 3

Bank	Quantil	Constant	INPC	Cetes	Exchange rate	Oil	Reserves	IPC	AIMSS
Santander	10%	-60.70952***	1.602	-0.054***	-0.267	-0.048	-1.353***	-0.288**	4.492**
	20%	-52.71833***	1.820	-0.049**	-0.190	-0.029	-1.220***	-0.260**	3.823**
	30%	-55.92739***	1.952	-0.056**	-0.268	-0.003	-1.254***	-0.313**	4.049**
	40%	-42.06918***	2.665***	-0.048***	-0.215	-0.013	-1.111***	-0.366***	2.950***
	50%	-37.40827***	2.862***	-0.037**	-0.350**	-0.063	-1.074***	-0.276***	2.567***
	60%	-37.06797***	3.216***	-0.048**	-0.379**	-0.044	-1.217***	-0.259***	2.548***
	70%	-39.05029***	2.945***	-0.034**	-0.576***	-0.114**	-1.141***	-0.273**	2.740***
	80%	-32.10795**	3.338***	-0.029	-0.622***	-0.121**	-1.087***	-0.207	2.146**
	90%	-37.16629**	3.308***	-0.038	-0.722***	-0.141**	-1.244***	-0.162	2.567**
Scotiabank	10%	42.73105***	2.399***	-0.041***	-0.726***	0.067	-0.002	-0.625***	-2.618***
	20%	46.81561***	2.515***	-0.029**	-0.779***	0.036	-0.040	-0.509***	-2.926***
	30%	49.08174***	2.572***	-0.025**	-0.810***	0.021	-0.011	-0.449***	-3.128***
	40%	49.74149***	2.483***	-0.022**	-0.756***	0.032	0.007	-0.407***	-3.195***
	50%	54.6369***	2.765***	-0.021	-0.835***	0.006	-0.056	-0.264***	-3.590***
	60%	55.70865***	2.736***	-0.013	-0.903***	-0.022	0.007	-0.271**	-3.671***
	70%	60.27099***	3.067***	-0.010	-0.952***	-0.049	0.010	-0.231**	-4.046***
	80%	56.96652***	3.208***	-0.031	-0.907***	-0.016	-0.210	-0.296	-3.695***
	90%	56.52482***	3.421***	-0.037	-0.911***	0.013	-0.334	-0.289	-3.644***

***, **, * denote, 1%, 5% and 10% of significance levels , respectively
Source: own elaboration based on our estimates.

The behavior of the stock index of the Mexican Stock Exchange does not affect the delinquency of HSBC and very little to BBVA; in all other cases it does, with a negative sign which is consistent with the assumption that favorable economic expectations captured by the stock market indicator are reflected as signs of economic stability and general conditions that favor compliance by mortgage debtors. The number of IMSS members, a proxy variable for formal employment in México, has significant effects on all levels of delinquency of Banamex, HSBC, Santander, and Scotiabank portfolios. The impact is rather small for Banorte and BBVA. Estimated positive and negative signs are observed, suggesting mixed evidence on the assumption that higher levels of employment are associated with increased potential for payment by debtors and, therefore, the negative sign of the relationship results in lower delinquency of the lenders' portfolio.

5. Discussion and conclusions

This article presents the results of the analysis of the delinquency rates of the mortgage portfolios of the six most active banks granting such loans in Mexico. On the time horizon January 2009 to june 2020, it was noted that there is no single pattern in the behavior of these delinquency indicators. Also, during the section analyzed corresponding to 2020 there is not a deeper and widespread increase about impacts analyzed, as would be expected. However, this can be attributed, at least partially, to the financial and fiscal measures implemented by national and local governments to assist both banking institutions and householders with economic and social policies in order to mitigate the economic impacts of the pandemic.

Based on the estimation of quantile regression models, the effects of various economic and financial variables on the probability distributions of these delinquency indicators were analyzed. Although there are some similarities in the effects of the variables analyzed on delinquency, there is a certain degree of heterogeneity in these effects.

The evidence shows that only the price level and the number of workers affiliated with the IMSS have effects on the probability distributions of the default indicator. In the first case, predominated the presence of significant positive-sign ratios, suggesting that inflation may undermine the ability to pay the mortgage commitment, which is an obvious consequence of the loss of purchasing power. The number of private sector workers with social security also shows differentiated effects, i.e., in some cases with a negative sign, consistent with the idea that the higher level of employment implies greater capacity of workers to face the payment of their debts. Job instability and/or low quality of wages and salaries could explain the presence of opposite signs in some of the estimated ratios; impression that is strengthened when considering the ever-increasing price-level behavior and uptrend of the interest rate observed from the beginning of 2015 to the end of 2018.

At the other end is the case of oil prices, which show only very limited effects to influence the increase in delinquency, although it should be noted that most of the coefficients that proved significant shows a negative sign, consistent with the idea that oil prices reflect better conditions for accredited people to honor their commitment to the credit-granting bank.

Heterogeneous delinquency behaviors and signs of positive estimated ratios could be the result of differences in strategies for the granting of mortgage

loans by banks,[3] resulting in a composition of credit portfolios with different sensitivities for the behavioral effects of economic variables. Those lending strategies could be influenced by specific features of each bank, as suggested by Cantú *et al*. (2020). Their research confirms that credit supply by banks in Mexico is a differenced response to shocks depending not only on their market power and the borrowers' features, but also on their levels of capitalization, liquidity, profitability, and origin of their funding.

A relevant implication is that the design of the strategy to integrate the credit portfolio, banks can be covered by the risk of delinquency (as a precondition to total compliance) based on internal decisions. Furthermore, the results shown here suggest that the analysis of economic and financial conditions can be a fundamental complement to credit decisions. Profile considerations and conditions of accredited persons, which may be sensitive to impact on their credit payment capacity, must be duly considered. Indeed, the empirical evidence suggests that identifying the impact of macroeconomic variables on the delinquency of mortgage portfolios must be pondered to make better decisions to generate and manage mortgage credits. Finally, our evidence is also useful for the design and implementation of macroeconomic, financial, and fiscal policies that enhance resilience of the banking sector to prevent economic crisis; the relationship between macroeconomic variables and mortgage default indexes is advance indicator of potential crises.

Future research opened includes comparative mortgage default studies among the Latin America countries, as well as the comparison with other emerging markets countries where residential housing mortgage credit has become an important part of local banking activities.

[3] It is worth noting that mortgage contracts offer several alternatives for the payment's basis: Banorte, BBVA, Citibanamex and Santander in pesos, UDIS and minimum wages; HSBC and Scotiabank only in pesos and UDIS. Interest rates differ competitively, depending on managerial strategies related to specific housing mortgage contract. Investment Units (UDIS) are units of account based on price increases (inflation), used in mortgage deals and a wide gamut of commercial agreements.

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ACRONYMS

ABM = Association of Mexican Banks
Banxico = Mexico´s Central Bank
BBVA = Banco Bilbao Vizcaya Argentaria (Spanish bank operating in Mexico)
GDP = Gross domestic Product
HSBC = Hong Kong Singapore Banking Corportation
IM = Morosity Index
INEGI = National Institute of Statistics and Geographical Information
SHCP = Secretary of finance and Public Credit