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The impact of unemployment and income on delinquency and default in the USA

VERSÃO FINAL APÓS DEFESA

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Resumo

Esta investigação estuda o impacto do desemprego e do rendimento na taxa de delinquência e no incumprimento dos créditos americanos. Para fazer esta análise foram utilizados os empréstimos automóveis, os cartões de crédito, as hipotecas e os empréstimos para estudantes, utilizando dados em painel para o District of Columbia e para os 50 estados dos Estados Unidos da América (EUA). Para a realização deste estudo foram utilizados dados anuais de 2003 a 2018, aplicando um modelo probit, que será comparado com um modelo linear para cada tipo de empréstimo. A inovação deste estudo é a introdução do spread do desemprego para estudar o efeito do desemprego nas taxas de delinquência destes empréstimos. Este estudo encontra evidências empíricas de que o spread do desemprego aumenta a delinquência e o incumprimento dos créditos e o rendimento médio das famílias diminui a delinquência e o incumprimento dos créditos nos EUA. Os resultados demonstram que o sentimento do consumidor faz com que a taxa de delinquência e o incumprimento diminuam e o índice S&P 500 faz com que a taxa de delinquência e o incumprimento diminuam. Para evitar os efeitos da delinquência e do incumprimento na economia, o governo dos EUA deve criar medidas com o intuito de gerar mais empregos, reduzindo assim o desemprego e aumentando o rendimento das famílias.

Palavras-chave

Incumprimento dos empréstimos automóveis; Incumprimento dos cartões de crédito; Incumprimento das hipotecas; Incumprimento dos empréstimos de estudantes; Taxa de delinquência

Resumo Alargado

Os Estados Unidos da América (EUA) são uma das maiores e mais influentes economias do mundo, registando no quarto trimestre de 2019 um Produto Interno Bruto (PIB) de 21,729.124 bilhões de dólares (FRED). Neste estudo pretende-se estudar o efeito do rendimento e do desemprego na delinquência e no incumprimento dos créditos nos EUA e será ainda estudado o efeito de outros fatores, tais como, o sentimento do consumidor e o índice bolsista S&P500. Os EUA foram escolhidos para fazer esta análise, pois é um país em que a dívida dos mutuários, a delinquência e o incumprimento têm vindo a aumentar nos últimos anos. As hipotecas são o tipo de empréstimo que têm as maiores taxas de delinquência nos EUA, seguido dos empréstimos de estudantes, dos empréstimos automóveis e por último dos cartões de crédito (Federal Reserve Bank of New York, Quarterly report on household debt and credit, 2020). Outro dos fatores que motivou esta escolha foi o fato de os EUA serem uma enorme potência económica mundial e, como ocorreu na crise financeira de 2007-2009, um aumento na delinquência e no incumprimento dos créditos dos americanos poderia influenciar as economias de outros países.

O principal objetivo deste estudo é perceber quais os fatores que influenciam a taxa de delinquência e o incumprimento, em particular, o desemprego e o rendimento e qual o seu impacto. As principais perguntas que pretendem ser respondidas neste estudo são: (i) qual será o impacto do desemprego e do rendimento nas taxas de delinquência e no incumprimento? (ii) o aumento do desemprego irá fazer com que a taxa de delinquência e o incumprimento aumentem em todos os casos? (iii) o aumento do rendimento fará com que a taxa de delinquência e o incumprimento diminuam em todos os casos?

Para a realização deste estudo foram utilizados dados em painel para o District of Columbia e para os 50 estados dos Estados Unidos da América (USA), aplicando um modelo probit, que será comparado com um modelo linear para cada tipo de empréstimo. O horizonte temporal é de 2003 a 2018 e foi escolhido de forma a analisar os dados mais recentes, incluindo a crise financeira de 2007-2009. A principal contribuição para a literatura é a utilização do spread do desemprego para representar o desemprego, pois por norma é utilizada a taxa de desemprego em estudos similares.

Na literatura foram encontradas evidências de que alguns dos fatores que têm grande impacto na delinquência e no incumprimento dos vários tipos de créditos são o desemprego, o rendimento, o género, a etnia e o sentimento do consumidor (Woo, 2002; Fuinhas et al., 2019; Wadud et al., 2019;).

A proporção de mutuários com o seu empréstimo vencido há 90 dias ou mais para os empréstimos automóveis (AUTO), os empréstimos dos estudantes (STUDENT), as hipotecas (MORTGAGE) e os cartões de crédito (CREDIT), serão as variáveis dependentes. O rendimento médio por agregado familiar (MHOUSEHOLD) representa o rendimento. O spread do desemprego representa o desvio do desemprego de cada estado em relação à média do desemprego total nos EUA. O spread do desemprego (SUNEM) é calculado pela diferença entre taxa de desemprego de cada estado (UNEM) e taxa de desemprego dos EUA (UNEMUSA), ambas em logaritmos. O sentimento do consumidor (CSENT) e o índice S&P500 (SP500) também serão estudados. O índice S&P500 foi deflacionado, tendo sido utlizado o deflator (DEFLATOR) do PIB. O PIB representa o crescimento económico, neste estudo está designado por GDP, será divido pela população (POP) tornando-se *per capita* (GDPPC). Neste estudo foram ainda utilizadas duas taxas de juro, o St. Louis Fed Financial Stress Index (FEDFUND) e os títulos de longo prazo do governo a dez anos para os EUA (LONGT). Nestas duas variáveis a inflação (INFLATION) teve de ser removida. Por último foi utilizado o saldo médio da dívida por mutuário para os empréstimos dos estudantes (STUDENTD), para as hipotecas (MORTGAGED) e para os cartões de crédito (CREDITD). As fontes de dados são: Federal Reserve Bank of New York and Equifax, US Bureau of Statistics, Federal Reserve Economic Data, World Bank, Yahoo Finance e Surveys of Consumers - University of Michigan.

Os resultados dos testes diagnósticos comprovam que a autocorrelação de primeira ordem, a dependência seccional e a heterocedasticidade estão presentes e não há normalidade multivariada nos resíduos. Os baixos valores de VIF e média VIF provam que a multicolinearidade não é um problema. A regressão de efeitos aleatórios deve ser utilizada nestas estimativas.

Com o intuito de comparar os resultados com os obtidos no modelo anterior foi feita uma análise de robustez, em que foi aplicada a mesma metodologia que a utilizada anteriormente, porém foi utilizada a taxa de desemprego para representar o desemprego.

Os resultados deste estudo demonstram que um aumento no spread do desemprego faz com que a taxa de delinquência e o incumprimento também aumentem. Quanto à taxa de desemprego, nos empréstimos automóveis, nos cartões de crédito e nas hipotecas, o seu aumento tem o mesmo efeito que o spread do desemprego, faz com que a taxa de delinquência e o incumprimento aumentem. Por outro, nos empréstimos de estudantes, a taxa de desemprego tem o efeito contrário, faz com que a taxa de delinquência e o incumprimento diminuam. Quanto ao rendimento médio por agregado familiar, quando este aumenta a taxa de delinquência e o incumprimento diminuem. A partir dos resultados obtidos, confirmamos que um aumento no desemprego faz com que a delinquência e o

incumprimento aumentem e que um aumento no rendimento faz com que a delinquência e o incumprimento diminuam.

De forma a evitar o aumento da taxa de delinquência e o incumprimento dos empréstimos, o governo americano deve criar mais medidas de regulação neste mercado. Por exemplo, pode adotar medidas de modo a controlar os preços das habitações, para que possam continuar a pagar seus empréstimos. Outra das medidas que poderiam ser adotadas é a atribuição de mais bolsas de estudo, reduzindo assim a delinquência nos empréstimos dos estudantes.

Abstract

This investigation focuses on the impact of unemployment and income on delinquency and default rates. Auto loans, credit cards, mortgages and student loans in the United States of America (USA) were used to perform this analysis Panel data covered the District of Columbia and the 50 states of the USA with annual data from 2003 to 2018. A probit model was used and compared with a linear model for each type of loan. The innovation of this study is the introduction of the spread of unemployment variable to study the effect of unemployment on these loans' delinquency rates. This study finds empirical evidence that the spread of unemployment increases delinquency and default on credit, and the median household income decreases the delinquency and default in the USA. The results demonstrate that consumer sentiment impacts negatively on delinquency and default, as does the S&P 500 index. To prevent the effects of delinquency and default on the economy, the US government should promote measures to create more jobs, reducing unemployment and increasing household income.

Keywords

Auto loan default; Credit card default; Mortgage default; Student loan default; The delinquency rate.

Index

Figures List

Tables List

Acronyms List

USA	United States of America
GDP	Gross Domestic Product
VIF	Variance Inflation Factor
OLS	Ordinary Least Squares

1. Introduction

It is important to study the factors that influence delinquency and credit default in the United States of America (USA), as American families' debt has been increasing in recent years. If credit delinquency and default increase too, this can cause problems in the U.S. economy. In March 2019, total household debt was $ 13.67 trillion, an increase of $ 124 billion over the fourth quarter of 2018, and general household debt is now 22.5 % above 2013 values (Federal Reserve Bank of New York, Quarterly report on household debt and credit, 2019).

At the end of March 2019, 4.6% of outstanding debt was in delinquency. The delinquency for credit card balances has been rising since 2017, while the delinquency for auto loan balances has been increasing since 2012 and for student loans, delinquency transition rates remain high. In the first quarter of 2019, mortgage delinquencies improved compared to 2018, because just 1.0% of mortgage balances were 90 or more days delinquent (Federal Reserve Bank of New York, Quarterly report on household debt and credit, 2019).

This paper focuses on the USA, because as can be seen from the above, it is a country in which borrower debt is growing, and delinquency has also increased in recent years. Another factor motivating the choice of this country is that the USA is a major economic power. As happened in the financial crisis of 2007-2009, an increase in Americans' credit delinquency could have a contagion effect on other countries' economies (Kim et al., 2015).

A loan becomes delinquent when the borrower fails to pay an instalment. This investigation will consider delinquency with 90 days or more in arrears, considered serious delinquency. Default is a consequence of delinquency, and as a rule, U.S. federal loans are only considered default after 270 days without any payment being made, as presented in the Code of Federal Regulations of United States of America.

The main objective of this study is to understand the factors influencing delinquency and default, in particular, unemployment and income. It is also intended to analyse the impact of these factors on delinquency and default. The main questions to be answered in this study are: (i) what is the impact of unemployment and income on delinquency and default? (ii) will increased unemployment always increase delinquency and default? (iii) will increased income always cause delinquency and default to decrease?

Car loan, credit card, mortgage and student loan delinquency will be used, and to achieve the objective of this study, a probit model will be used, which will be compared with a linear model. The results suggest that the spread of unemployment causes delinquency and default to increase in all cases, and median household income has the opposite effect. The main

contribution to the literature is the use of the spread of unemployment variable to represent unemployment, as other studies of this kind generally use the unemployment rate (Fuinhas et al., 2019).

This investigation is organised in seven sections. Section 2 presents the literature review. Section 3 presents the methodology used, divided into three subsections, data, method, and diagnostic tests. Section 4 shows the results and Section 5 presents the robustness analysis. In Section 6, the results are discussed. Finally, Section 7 concludes.

2. Literature Review

Loan defaults arise in situations where a borrower fails the stipulated deadline, often due to unexpected shocks, such as job loss, divorce, mourning, health problems and increased interest on loans (Wadud et al., 2019).

Student Loans

Many factors can determine the likelihood of students going into default, such as ethnicity, gender, graduation, and success (Herr and Burt, 2005).

Regarding gender, it is known that male students are more likely to default, and age is also an essential factor because older students are more likely to default. When it comes to ethnicity, Caucasian students are less likely to default than those of other races (Woo, 2002). It should be noted that people who have already defaulted once are more likely to do so again and are also more likely than those who have never defaulted (Woo, 2002).

The hours the student spends studying can determine their future success. For example, if students have good grades and graduate, the probability of getting a job with a higher salary increase, so the probability of default decreases. On the other hand, less time spent studying increases the likelihood of default. Students who leave university without graduating are more likely to be unable to repay the student loan and default (Steiner and Teszler, 2003).

There is some evidence that debt affects young people's academic decisions, indicating their preference for better-paid jobs. Students who know it will be difficult to pay off their student loans choose areas they know will pay higher wages, such as engineering or technology (Schemeiser et al., 2016). Young people are also more averse to holding debt and having credit constraints (Rothstein and Rouse, 2011).

The three factors that seem to help students to repay their loans during financial crises are higher earnings, low unemployment rates and richer families (Looney and Yanellis, 2015). Students whose parents have higher education, i.e., parents who have attended university, are less likely to default than those who are the first in their family to attend university (Choy and Li, 2006). Students who have debt in addition to a student loan, for example, credit card debt, prefer to pay off the credit card debt first, which makes student loan default occur more quickly (Pinto and Mansfield, 2006).

The type of institution from which the student graduates can also be a determining factor of the probability of default. If this is a for-profit institution, the amount of the loan is higher, so the delinquency rate is also higher (Deming et al., 2012). However, it does not

depend only on the institution attended, but on the amount borrowed. The higher the amount, the higher the delinquency rate (Choy and Li, 2006).

If the government subsidises tuition fees, the number of students needing to borrow decreases. Consequently, delinquency rates also decrease (Ionescu and Simpson, 2016). When people are optimistic about the future, they invest in education and to be able to study at university, and they probably need a loan. If the future does not go as expected, they might default. Consumer sentiment can, therefore, increase delinquency rates (Fuinhas et al., 2019).

Auto Loans

For most Americans, automobiles are the most important asset after their homes, so auto loans are an essential part of banks' portfolios (Aizcorbe et al., 2003).

One of the most important factors leading to an increase in the delinquency rate is the length of the auto loan because loans for five or more years are more likely to default (Wu et al., 2018). In auto loans, gender is also an important factor in women's delinquency rates being much lower than men's. This disparity is mainly due to women being risk-averse (Borghans et al., 2009).

Younger people usually also default more easily because they are less likely to have financial stability. Married people have lower delinquency rates, which may be because they must take more responsibility. Education is also a major factor, because the more education the borrower has, the lower the delinquency rate (Duan et al., 2018).

The unemployment rate significantly affects car loan delinquency rates, because when unemployment increases, the probability of default rises too. It can be concluded that the increase or decrease in delinquency rates may be caused by shocks in household liquidity (Erik Heitfield and Tarun Sabarwal, 2004).

Vehicle purchases by Americans have an asymmetrical relationship with current and future economic expectations. When adverse economic events are predicted, car sales fall, but they do not increase when a favourable economic situation is predicted (Baghestani, 2019). Consumer pessimism, caused by economic or other reasons, can lead to a slowdown in economic growth (Matsusaka and Sbordone, 1995). Consumer sentiment is a determining factor of delinquency rates for auto loans, as increased current confidence tends to reduce auto loan default rates but increased expected consumer sentiment raises these rates. (Wadud, 2019).

Credit Cards

Nowadays, credit cards are a vital payment method and a way of obtaining credit in the U.S. (Chakravorti and To, 2007). Access to credit is an important means of consumption, and in an economy with rational agents, more access to credit improves welfare (Aiyagari, 1994).

Borrowers' characteristics are determinants of the probability of going into default. Debtors who are self-employed or unemployed are more able to manage their expenses, so are more able to avoid delinquency. Employees are used to a stable income, so get into difficulties more easily when suffering some shock in their income (Leow and Crook, 2014).

Income is an important determinant of the probability of delinquency. As income increases, the probability of default decreases. The opposite situation also occurs, as when income decreases, the probability of default increases (Kim et al., 2018). The probability of credit card default is affected by fluctuations in income and not by the amount of the income itself (Li et al., 2019).

Concerning credit cards, as with other types of loans, women are less likely, and young people more likely, to become delinquent. In developed regions, when economic changes occur, such as changes in inflation, the probability of default also increases (Li et al., 2019). The likelihood of incurring delinquency is significantly affected by the unemployment rate. When unemployment rises, the delinquency rate also increases due to the reduced ability to pay off credit cards (Agarwal and Liu, 2003; Bellotti and Crook, 2013; Kim et al., 2018).

In recent years, the number of credit cards and online transactions has increased. This increase can result from credit cards being easy to use and practical. In this case, consumer sentiment has a significant, positive effect on credit card delinquency rates, with consumer optimism in the U.S. raising credit card default (Wadud et al., 2019).

When interest rates increase, the probability of default also increases, with higher charges on credit cards. The amount owed affects delinquency rates, as the higher the amount, the greater the likelihood of default. The number of credit cards is an important factor; the more credit cards used, the higher the delinquency rates (Wadud et al., 2019).

Mortgages

Mortgages are an important part of banks' financial assets. Although banks can secure mortgage pools, the financial crisis in 2007-2009 demonstrated that the increase in mortgage delinquencies could destabilise the entire financial system (Campbell, 2012).

First, it was thought that the main factors leading to mortgage default were interest rates and house values (Black and Scholes, 1973). It was then realised that other factors

influenced mortgage default, such as divorce, job loss or accident, which are called trigger effects (Vandell, 1991). Trigger events, such as unemployment, illness and divorce, are unforeseen and temporary or permanent events, likely to change borrowers' current and future income and make it difficult to pay off a mortgage (Danis and Pennington-Cross, 2008).

Strategic default happens when the borrower has negative housing equity due to the market value of their home being less than the value of their mortgage at the time of deciding to move to another house (Foote et al., 2008). Negative equity is often due to a decrease in house prices. When borrowers have negative equity, and another trigger factor arises, for example, job loss, this is called a double trigger effect and the probability of default increases substantially (Gerardi et al., 2013). The probability of strategic default also increases when the borrower knows someone who has already done the same (Bhutta et al., 2010; Guiso et al., 2013). When a trigger effect occurs, a borrower with positive equity can sell the house and pay off the mortgage (Foote et al., 2008).

Black people and Hispanics have significantly higher delinquency rates than white people, which can be due to the prevalence of high-risk mortgage characteristics such as prepayment penalties, loans with payment resets, and loans with terms over 30 years (Li and Mayock, 2019). Neighbourhoods with a more significant number of black people are more likely to default (Green and Furstenberg, 1975).

When the number of mortgage delinquencies increases in one state, other U.S. states will probably be affected by contagion, due to increasing unemployment in all states (Ji et al., 2019). The most critical trigger event in mortgage default is job loss (Gerardi et al., 2013). The regional unemployment rate has more effect on mortgage default because it affects families' income at that time and probably in the future (Böheim and Taylor, 2000).

Household income is an important factor in the likelihood of default because families with higher incomes and a more expensive home are less likely to default. When families have had financial problems in the past and gone into default, the probability of defaulting again is higher than in families that have never defaulted (Böheim and Taylor, 2000). Income volatility also has a significant effect on the probability of delinquency (Diaz-Serrano, 2005).

Families with low financial literacy find it difficult to handle some macroeconomic shocks, such as job loss (Klapper et al., 2013). These families are more likely to default than financially literate ones, because in addition to not knowing how to deal with macroeconomic shocks, they may have false expectations (Gerardi et al., 2013). Women

generally perform better with bank loans than men and have lower delinquency rates (Chen et al., 2019).

Consumer sentiment reduces mortgage default at present, but too much optimism about the future may cause more mortgage default (Wadud et al., 2019). Families borrow more when they have better expectations for the future, but they may not be prepared for shocks. Usually, the interest families pay on a credit card, and auto loans are higher than that paid on a mortgage. Hence, over-optimistic families think it will be easy to repay this loan (Laufer, 2018).

Income, the unemployment rate, consumer sentiment and being a woman are the factors influencing delinquency rates of the four types of loans studied. Ethnicity fundamentally affects the likelihood of mortgage and student loan default. Strategic default usually happens only in relation to mortgages. The debtor's age is a factor influencing student loans and auto loans.

Figure 1 shows some factors present in the literature that cause an increase in car loan delinquency and car loan default.

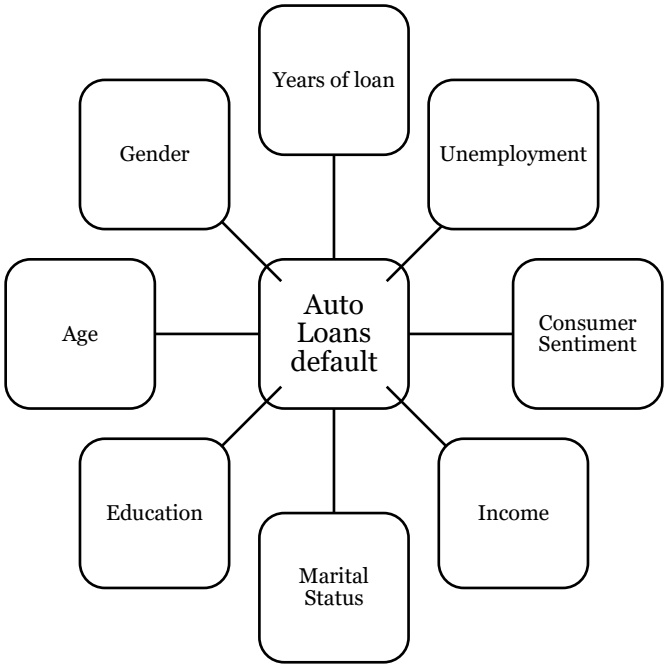

Figure 1. Some factors that cause auto loan default

Figure 2 represents some factors taken from the literature that cause an increase in credit card delinquency and default.

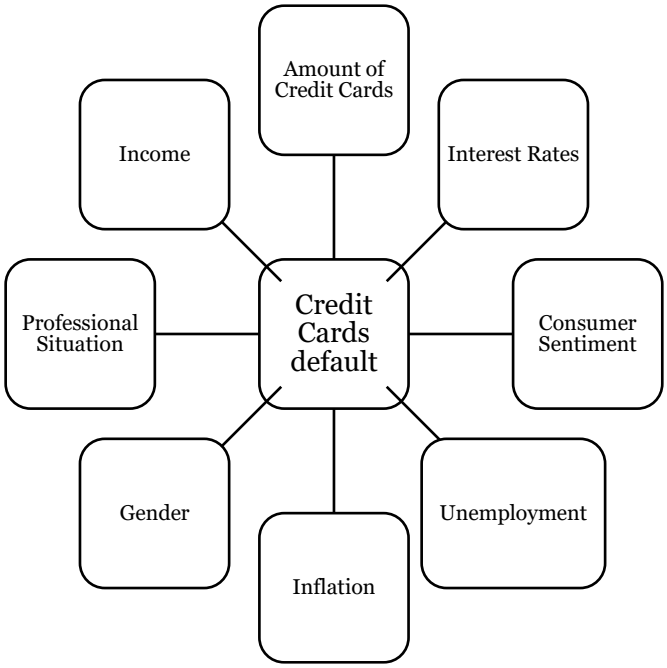

Figure 2. Some factors that cause credit card default

Figure 3 shows some factors found in the literature that increase mortgage delinquency and cause mortgage default.

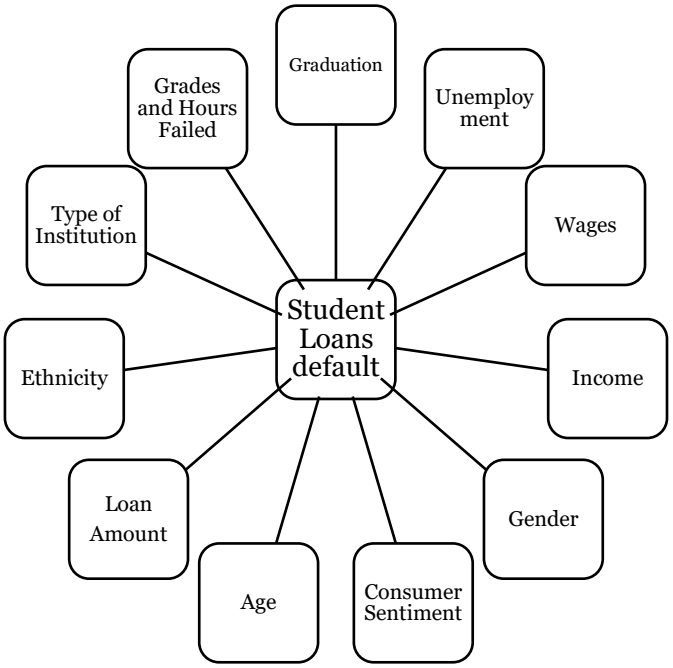

Figure 3. Some factors that cause student loan default

Figure 4 shows some factors present in the literature that can increase student loan delinquency and cause student loan default.

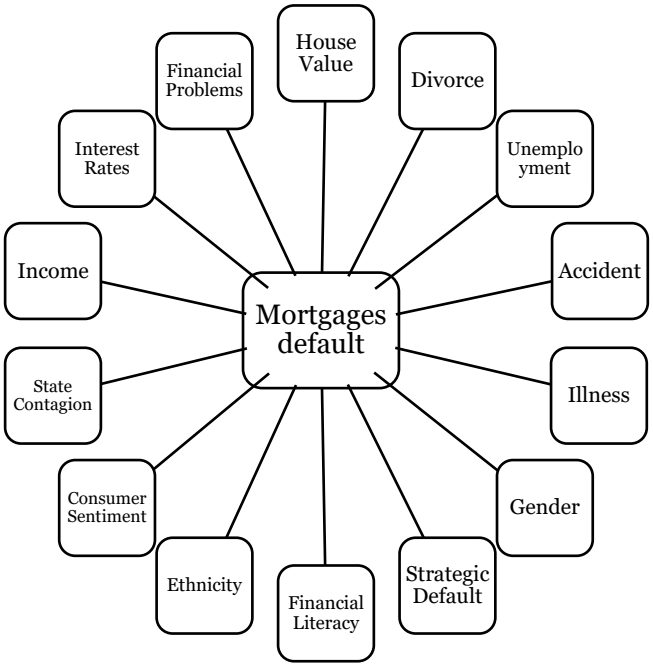

Figure 4. Some factors that cause mortgage default

3. Methodology

This section is divided into three subsections. The first presents the variables, data sources and descriptive statistics used in this investigation. The second presents the models used, and the last section provides the diagnostic tests of the variables.

3.1. Data

This investigation used panel data for the District of Columbia, a federal district in the USA, and for the 50 states, namely: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming. Annual data from 2003 to 2018 was used. The time horizon was chosen due to data availability. The USA was chosen due to being one of the biggest economies in the world and has occurred with the subprime crisis in 2007-2009; it can influence other economies when suffering a shock. What also motivated the choice of the USA was the fact that delinquency is increasing in this country and they have more data available. Table 1 describes the variables.

Table 1. Variables Description

Variable	Definition	Source
AUTO	Percentage of auto debt balance ninety or more days delinquent	Federal Reserve Bank of New York and Equifax
CREDIT	Percentage of credit card debt balance ninety or more days delinquent	Federal Reserve Bank of New York and Equifax
MORTGAGE	Percentage of mortgage debt balance ninety or more days delinquent	Federal Reserve Bank of New York and Equifax
STUDENT	Percentage of student loan debt balance ninety or more days delinquent and in default	Federal Reserve Bank of New York and Equifax
GDP	Real total gross domestic product in millions of dollars	Federal Reserve Economic Data
CREDITD	Credit card debt balance per capita	Federal Reserve Bank of New York and Equifax
MORTGAGED	Mortgage debt balance per capita	Federal Reserve Bank of New York and Equifax
STUDENTD	Student loan debt balance per capita	Federal Reserve Bank of New York and Equifax
UNEM	The unemployment rate in percentage, annual by state	U.S. Bureau of Statistics
MHOUSEHOLD	Real median household income in U.S. dollars by state	Federal Reserve Economic Data
FEDFUND	St. Louis Fed Financial Stress Index, annual	Federal Reserve Economic Data
DEFLATOR	GDP deflator	World Bank
INFLATION	Inflation at consumer prices, annual, in percentage	World Bank
SP500	S&P500 Index	Yahoo Finance
LONGT	Long-term government bond yields (10-year) for the United States in percentage, annual	Federal Reserve Economic Data
CSENT	The index of Consumer Sentiment, annual	Surveys of Consumers- University of Michigan
UNEMUSA	Unemployment rate in percentage, annual in the USA	Federal Reserve Economic Data
POP	Resident population in thousands	Federal Reserve Economic Data

To study car loan default, the dependent variable was the proportion of borrowers with ninety or more days owing (AUTO). To study credit card default, the dependent variable was the proportion of borrowers with ninety or more days owing (CREDIT). To study mortgage default, the dependent variable was the proportion of borrowers with ninety or more days owing (MORTGAGE). Lastly, to study student loan default, the dependent variable was the proportion of borrowers with ninety or more days owing, including defaults (STUDENT). These variables were retrieved from the Federal Reserve Bank of New York and Equifax, and all the variables were created from 5% of the USA population, except the variable referring to student loans which is only based on 1% of the U.S. population.

The unemployment rate by state (UNEM) was retrieved from the U.S. Bureau of Statistics and real median household income by state (MHOUSEHOLD) was retrieved from Federal Reserve Economic Data. The US unemployment rate (UNEMUSA) was retrieved from Federal Reserve Economic Data and was used to calculate the spread of unemployment (SUNEM), which is the difference between the state unemployment rate and the USA unemployment rate, both in logarithms. The spread of unemployment represents the deviation of unemployment in each state in relation to unemployment in the USA.

The Consumer Sentiment (CSENT) index for the USA, retrieved from Surveys of Consumers - University of Michigan, will be used to represent consumer sentiment. The S&P500 variable (SP500), retrieved from Yahoo Finance, is an index that tracks the stocks of the 500 biggest companies listed on the New York Stock Exchange and represents the financial markets. This variable will be deflated by the Gross Domestic Product (GDP) deflator (DEFLATOR), which was retrieved from the World Bank. The Gross Domestic Product (GDP) for each state represents economic growth. This variable will be divided by the population (POP), to become per capita (GDPPC).

The St. Louis Fed Financial Stress Index (FEDFUND) for the USA, retrieved from the Federal Reserve Economic Data, represents financial stress. The long-term government bond yields for ten years (LONGT), retrieved from Federal Reserve Economic Data, is a ten-year interest rate. For the variables of FEDFUND and LONGT, inflation (INFLATION), retrieved from the World Bank, will be removed.

The average credit card debt balance per borrower (CREDITD) will be used to study credit card default. Average mortgage debt balance per borrower (MORTGAGED) will be used to study mortgage default. Average student debt balance per borrower (STUDENTD) will be used to study student loan default. These variables were all retrieved from the Federal Reserve Bank of New York and Equifax, and all variables were created from 5% of the U.S. population, except the variable referring to student loans which is only from 1% of the U.S. population. All the variables will be transformed into natural logarithms (variables with the prefix "L"), except the dependent variables, FEDFUND and LONGT.

Table 2 reveals the characteristics of the series through descriptive statistics.

Table 2: Descriptive statistics

Variable		Mean	Stad.Dev.	Min	Max	Observations
AUTO	overall	.0321797	.0142536	.0083	.0939	N = 816
	between		.0107266	.0162509	.0604698	n = 51
	within		.0094986	.00322	.07422	T = 16
LUNEM	overall	.0563031	.019216	.0239606	.1280267	N = 816
	between		.0104704	.0315862	.0743287	n = 51
	within		.0161753	.0211017	.1127942	T = 16
SUNEM	overall	-1.731277	.2628097	-2.225415	-1.295002	N = 816
	between		.0104704	-1.755994	-1.713251	n = 51
	within		.2626049	-2.200698	-1.306427	T = 16
LMHOUSEHOLD	overall	10.98577	.1574319	10.4607	11.36611	N = 816
	between		.1479688	10.6566	11.26162	n = 51
	within		.0573846	10.78987	11.23124	T = 16
CREDIT	overall	8.57551	2.405206	3.61	22.35	N = 816
	between		1.64457	5.382607	13.51229	n = 51
	within		1.769232	4.717829	17.41322	T = 16
LCREDIT	overall	7.988544	.1782439	7.408531	8.486734	N = 816
	between		.156307	7.576007	8.357406	n = 51
	within		.0882535	7.778106	8.30317	T = 16
MORTGAGE	overall	2.684789	2.486294	.3	20.74	N = 816
	between		1.239097	.8964816	7.826934	n = 51
	within		2.162072	-4.452146	15.59785	T = 16
LMORTGAGED	overall	10.26032	.3694912	9.13777	11.15768	N = 816
	between		.3465804	9.523476	10.9213	n = 51
	within		.1364425	9.732617	10.6431	T = 16
STUDENT	overall	9.153063	2.989368	3.13	18.36	N = 816
	between		1.8551	6.180089	13.1449	n = 51
	within		2.357597	1.669145	15.06558	T = 16
LSTUDENTD	overall	8.021654	.5252841	6.507277	9.497022	N = 816
	between		.2118916	7.625614	9.00231	n = 51
	within		.4815098	6.636654	8.750639	T = 16
FEDFUND	overall	-.3913259	.8766446	-1.348205	1.878667	N = 816
	between		0	-.3913259	-.3913259	n = 51
	within		.8766446	-1.348205	1.878667	T = 16
LONGT	overall	.0106416	.0099892	-.0037101	.0361221	N = 816
	between		0	.0106416	.0106416	n = 51
	within		.0099892	-.0037101	.0361221	T = 16
LINFLATION	overall	.020851	.0108917	-.0035618	.0376724	N = 816
	between		0	.020851	.020851	n = 51
	within		.0108917	-.0035618	.0376724	T = 16
LSP500	overall	2.690151	.2483272	2.261315	3.171503	N = 816
	between		0	2.690151	2.690151	n = 51
	within		.2483272	2.261315	3.171503	T = 16
LCSENT	overall	4.413669	.136764	4.154184	4.589041	N = 816
	between		0	4.413669	4.413669	n = 51
	within		.136764	4.154184	4.589041	T = 16
LUNEMUSA	overall	.0601538	.0168511	.0381785	.0917432	N = 816
	between		0	.0601538	.0601538	n = 51
	within		.0168511	.0381785	.0917432	T = 16
LGDPPC	overall	3.919985	.2557052	3.464963	5.21478	N = 816
	between		.2525668	3.510167	5.17004	n = 51
	within		.0526232	3.640604	4.195904	T = 16

The Stata command xtsum was used to obtain the results.

Figure 5 represents the evolution of delinquency in auto loans, credit cards, mortgages and student loans from 2003 to 2018 in the 50 U.S. states and District of Columbia.

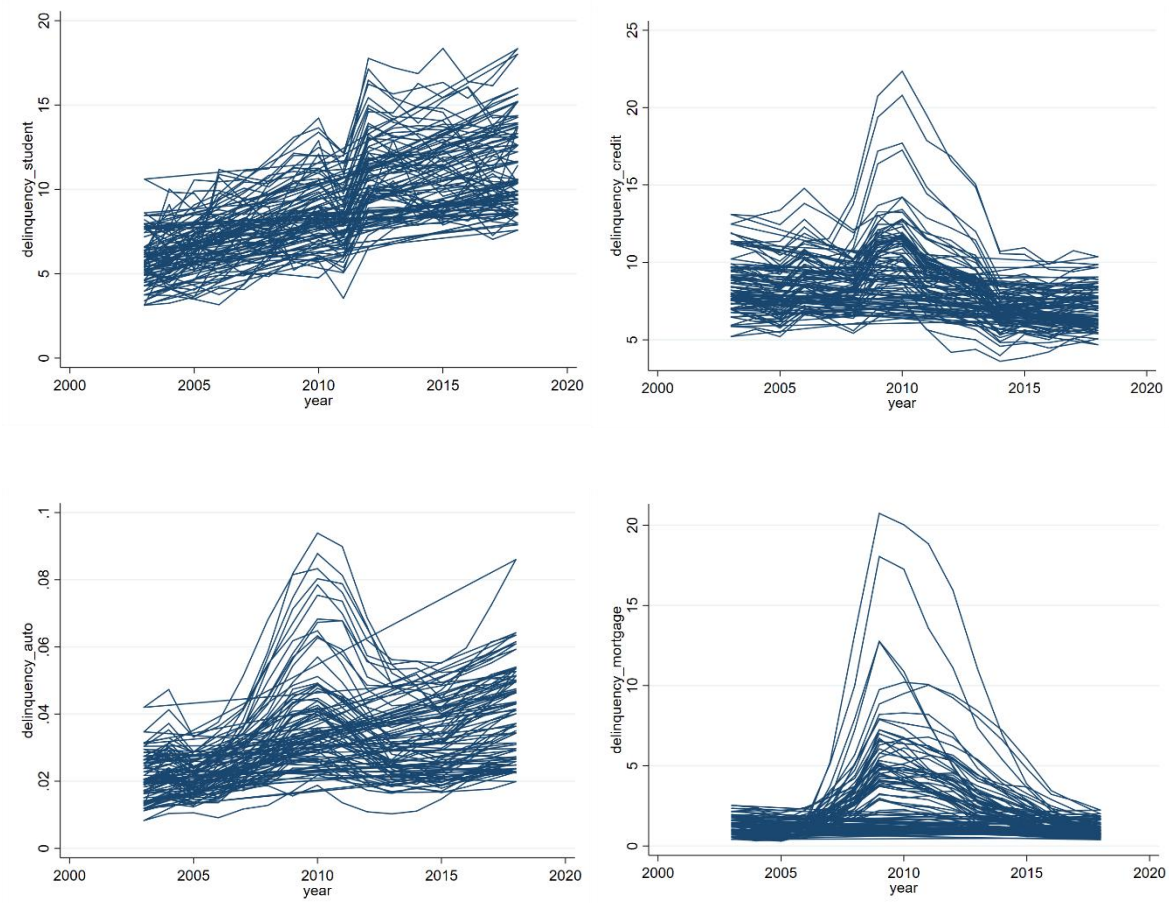

Figure 5. Evolution of credit delinquency from 2003 to 2018 in the District of Columbia and the 50 US states

As observed, delinquency increased in all types of credit during the 2007-2009 financial crisis. Student loans and auto loans show the greatest increase in delinquency in recent years. As for credit cards, since the financial crisis, delinquency has remained stable in most states. Student loan delinquency had increased exponentially since 2003, except after 2010, when there was a general decrease, which may be due to implementing measures to support the payment of student loan instalments during the Obama administration.

Concerning mortgages, the decrease in delinquency after the financial crisis is quite noticeable, presenting much lower values in recent years. Auto loan delinquency has been increasing in all American states since 2003.

3.2. Method

To study delinquency and default, auto loans, credit cards, mortgages and student loans will be used. The dependent variables used in this investigation are between 0 and 1, so a probit model will be used, as is most common in this type of study because it is a type of regression where the dependent variable has values between two values (Diaz-Serrano, 2005). A model will incorporate the four types of credit studied, and for each of them, a linear and probit model will be made. The probit model will be compared with the linear model in each case. A robustness analysis will compare the results of this model, where the unemployment rate will be used instead of the spread of unemployment. The STATA 15.0 was used to perform these econometric analyses. The equations described below represent the estimation of the probit model for each type of credit.

The probit model to study car loan default is represented by the following equation (1):

$$\begin{aligned} \text{AUTO}= \beta_{0it} + \beta_{1i}SUNEM + \beta_{2i}LMHOUSEHOLD + \beta_{3i}LINFLATION + \\ \beta_{4i}LONGT + \beta_{5i}LGDPPC + \beta_{61}LCSENT + v_i + \varepsilon_{it} \end{aligned} \quad (1)$$

The probit model to study credit card default is represented by the following equation (2):

$$\begin{aligned} \text{CREDIT}= \beta_{0it} + \beta_{1it}SUNEM + \beta_{2it}LMHUSEHOLD + \beta_{3it}LCREDITD + \\ \beta_{4it}LONGT + \beta_{5it}LSP500 + \beta_{6it}LCSENT + v_i + \varepsilon_{it} \end{aligned} \quad (2)$$

The probit model to study mortgage default is represented by the following equation (3):

$$\begin{aligned} \text{MORTGAGE}= \beta_{0it} + \beta_{1it}SUNEM + \beta_{2it}LMHOUSEHOLD + \beta_{3it}LMORTGAGED + \\ \beta_{4it}LONGT + \beta_{5it}LCSENT + v_i + \varepsilon_{it} \end{aligned} \quad (3)$$

The probit model to study student loan default is represented by the following equation (4):

$$\begin{aligned} \text{STUDENT}= \beta_{0it} + \beta_{1it}SUNEM + \beta_{2it}LMHOUSEHOLD + \beta_{3it}LCSENT + \\ \beta_{4it}FEDFUND + \beta_{5it}LINFLATION + v_i + \varepsilon_{it} \end{aligned} \quad (4)$$

3.3. Diagnostic Tests

Table 3 presents the Doornik-Hansen test (2008), the Wooldridge test (2010), the Breusch-Pagan test (1979) and the Pesaran test (2004) for the four types of credit. The Doornik-Hansen test was performed to check the multivariate normality of residuals and the Wooldridge test to check the presence of the first-order autocorrelation. The Breusch-Pagan test checks the presence of heteroscedasticity, and the Pesaran test was performed to check the presence of cross-sectional dependence. The results of these tests demonstrate that heteroscedasticity, first-order autocorrelation, and cross-sectional dependence are present in all types of credit and that there is no multivariate normality in the residuals.

Table 3. Doornik-Hansen, Wooldridge, Breusch-Pagan and Pesaran tests

	Doornik-Hansen test	**Wooldridge test**	**Breusch-Pagan test**	**Pesaran test**
Auto Loans	333.841***	262.867***	66.97***	95.97***
Credit Cards	107.222***	116.942***	83.23***	91.12***
Mortgages	2756.806***	36.977***	72.09***	87.89***
Student Loans	247.738***	373.997***	4.11**	111.20***

Notes: H_0 of Doornik-Hansen test: multivariate normality; H_0 of Wooldridge test: no first order autocorrelation; H_0 of Breaus-Pagan test: Constant variance; H_0 of Pesaran test: cross sectional independence; *** denotes statistical significance at the 1% level. To compute these tests, the Stata commands *mvtest*, *xtserial, estat hettest* and *xtcd,* respectively, were used.

Table 4 reveals the VIF and mean VIF statistics. The VIF statistics were used to test for the presence of multicollinearity. The lower VIF and mean VIF values prove that multicollinearity is not a problem in these estimations (all values are below the benchmark of 10).

Table 4. VIF and Mean VIF statistics

	VIF			
Variables	**Auto Loans**	**Credit Cards**	**Mortgages**	**Student Loans**
LMHOUSEHOLD	1.69	2.99	3.22	1.09
SUNEM	1.10	1.26	1.28	1.09
LGDPPC	1.57			
LONGT	1.54	1.41	1.01	
LINFLATION	1.54			1.03
LCSENT	1.07	2.46	1.36	1.86
LSP500		2.83		
LCREDITD		2.81		
LMORTGAGED			3.08	
FEDFUND				1.80
Mean VIF	1.42	2.29	1.99	1.37

Note: The Stata command *vif* was used.

Table 5 shows the Breusch-Pagan Lagrangian multiplier test (1980). This test was performed to decide between a random-effects regression and a Pooled Ordinary Least

Squares (OLS) regression. The result demonstrates that a random effects regression should be used in these estimations.

Table 5. Random effects *vs* Pooled OLS

	Random effects vs Pooled OLS
Auto Loans	1467.39***
Credit Cards	1374.51***
Mortgages	601.92***
Student Loans	415.34***

Notes: Ho Breusch-Pagan Lagrangian multiplier test: variances across entities is zero; *** denotes statistical significance at the 1% level. The Stata command *xttseto* was used.

The equations described below represent the random effects regression for each type of credit.

The random-effects regression to study car loan default is represented by the following equation (5):

$$\text{AUTO}= \beta_0 + \beta_{1it}SUNEM + \beta_{2it}LMHOUSEHOLD + \beta_{3it}LINFLATION + \beta_{4it}LONGT + \beta_{5it}LGDPPC + \beta_{61t}LCSENT + \alpha_i + \mu_{it} \quad (5)$$

The random-effects regression to study credit card default is represented by the following equation (6):

$$\text{CREDIT}= \beta_0 + \beta_{1it}SUNEM + \beta_{2it}LMHUSEHOLD + \beta_{3it}LCREDITD + \beta_{3it}LONGT + \beta_{4it}LSP500 + \beta_{5it}LCSENT + \alpha_i + \mu_{it} \quad (6)$$

The random effects regression to study mortgage default is represented by the following equation (7):

$$\text{MORTGAGE}= \beta_0 + \beta_{1it}SUNEM + \beta_{2it}LMHOUSEHOLD + \beta_{3it}LMORTGAGED + \beta_{4it}LONGT + \beta_{5it}LCSENT + \alpha_i + \mu_{it} \quad (7)$$

The random-effects regression to study student loan default is represented by the following equation (8):

$$\text{STUDENT}= \beta_0 + \beta_{1it}SUNEM + \beta_{2it}LMHOUSEHOLD + \beta_{3it}LCSENT + \beta_{4it}FEDFUND + \beta_{5it}LINFLATION + \alpha_i + \mu_{it} \quad (8)$$

4. Results

Table 6 reveals the results of the estimation of random effects linear models and probit models with bootstrapped standard errors.

Table 6. Estimation results of random effects linear models and probit models with bootstrapped standard errors.

	Auto Loans			Credit Cards			Mortgages			Student Loans		
	Linear Model	Probit Model		Linear Model	Probit Model		Linear Model	Probit Model		Linear Model	Probit Model	
Variables	**Estimate**	**Estimate**	**Margins**	**Estimate**	**Estimate**	**Margins**	**Estimate**	**Estimate**	**Margins**	**Estimate**	**Estimate**	**Margins**
LMHOUSEHOLD	0.1011	0.4149**	0.1356**	-0.1398***	-0.5316***	-0.1679***	-0.2411***	-1.5079***	-0.2602***	-0.0218	0.6366*	0.2321*
SUNEM	4.5829***	12.5928***	4.1140***	2.9788***	7.9480***	2.5111***	3.1601***	10.4399***	1.8015***	2.4074***	5.7126**	2.0828**
LGDPPC	-0.0342	-0.0856509	-0.0279									
LONGT	-4.6937***	-14.8153***	-4.8401***	1.1833***	2.8117***	0.8883***	1.3305***	5.3755***	0.9276***			
LINFLATION	-5.6359***	-17.4615***	-5.7046***							-5.1844***	-13.8961***	-5.0664***
LCSENT	-0.3795***	-1.1176***	-0.3651 ***	-0.2343***	-0.6007***	-0.1898***	-0.4756***	-2.0651***	-0.3564***	-0.3639***	-1.1186***	-0.4078***
LSP500				-0.1577***	-0.5453***	-0.1723***						
LCREDITD				0.0877***	0.3060***	0.0967 ***						
LMORTGAGED							0.1586***	1.0999***	0.1898***			
FEDFUND										-0.1175***	-0.3267***	-0.1191***
CONSTANT	1.1626**	0.6802833		2.5571***	6.8588***		3.2353***	13.0441***		2.3125**	-2.1987	
Diagnostic Statistics												
N	816	816		816	816		816	816		816	816	
R^2	0.2732			0.4885			0.5013			0.3519		
Wald test	251.57***	376.58***		908.10***	1059.17***		334.47***	671.85***		953.74***	958.28***	

Notes: ***, ** and * denote statistical significance at the 1% , 5% and 10% levels, respectively; To estimate the models, the Stata commands *xtreg*, *xtprobit* and *bootstrap* were used, respectively.

The bootstrapped standard errors are used to control the phenomena found in diagnostic tests, such as cross-sectional dependence and heteroscedasticity.

As the dependent variable is between 0 and 1, linear models may not provide a rigorous perception of the impacts of some independent variables on the dependent variable. The margins give us the variation in the percentage of the variables used in the dependent variable.

In the auto loans model, in the linear model, the spread of unemployment is statistically significant. It has a positive impact on delinquency, but the median household income is not significant. The long-term government bond yields for ten years, inflation and consumer sentiment are significant and have a negative impact on delinquency. The constant is significant and has a positive impact, while GDP is not significant. In the probit model, the spread of unemployment and median household income are significant and also have a positive impact. The long-term government bond yields for ten years, inflation and consumer sentiment are statistically significant and have a negative impact. GDP and the constant are not significant.

When comparing the margins of the probit model of auto loans and the linear model, the coefficients are remarkably close. However, the significances change, as is the case of median household income.

In the linear model for credit cards, the spread of unemployment is statistically significant. It has a positive impact on delinquency, while median household income is significant and has a negative impact. The average credit card debt balance per borrower, and long-term government bond yields for ten years are both statistically significant and have a positive impact on the dependent variable. Consumer sentiment and SP500 are both statistically significant and have a negative impact. The constant is significant and has a positive impact. The spread of unemployment, average credit card debt balance per borrower and long-term government bond yields for ten years are statistically significant. They have a positive impact on the probit model. Median household income, consumer sentiment and SP500 are significant and have a negative impact on delinquency. The constant is statistically significant and has a negative effect.

In the case of credit cards, if we compare the Probit margins with the linear model, the coefficients are close, and the significance levels are the same.

In the linear model for mortgages, the spread of unemployment is statistically significant. It has a positive impact, while median household income is significant and has a negative effect on delinquency. Average mortgage debt balance per borrower, and long-term government bond yields for ten years are both significant and have a positive impact on the dependent variable. Consumer sentiment is significant and has a negative effect on delinquency, while the

constant is significant and has a positive effect. The spread of unemployment is significant and has a positive impact on the probit model, and median household income is significant and has a negative impact. Average mortgage debt balance per borrower, and long-term government bond yields for ten years are both statistically significant. They have a positive effect on delinquency, as happened in the linear model. Consumer sentiment is significant and has a negative impact, while the constant is significant and has a positive impact on the dependent variable.

In mortgages, if we compare the margins of the probit model and the linear model, the significance levels are the same, and the coefficients are close, except for the spread of unemployment. The value of the spread of unemployment in the linear model is higher than the value of the Probit margins.

In the linear model of student loans, the spread of unemployment is significant and has a positive impact, but the median household income is not statistically significant. Consumer sentiment, FEDFUND and inflation are significant and have a negative impact on delinquency. The constant is significant and has a negative effect. In the probit model, the spread of unemployment and median household income are both statistically significant and have a positive impact on delinquency. Consumer sentiment, FEDFUND and inflation are significant and have a negative effect on the dependent variable, as in the linear model. In this model, the constant is not statistically significant.

When comparing the margins of the probit model of student loans and the linear model, the coefficients are close, and the significance levels change, as is the case of median household income and spread of unemployment.

5. Robustness

A robustness analysis will be made to compare the effect of unemployment and income on credit delinquency and default. The same methodology was applied, using the unemployment rate, instead of using the spread of unemployment. The unemployment rate is used in this model because it is generally used in the literature to measure the effect of unemployment on credit delinquency and default (Fuinhas et al., 2019).

For mortgages, the probit estimator was unable to converge, so it was not possible to estimate. To be able to do so, two years were removed from the time horizon. In this estimation, the period is from 2005 to 2018.

The results of the diagnostic tests of this model prove that first-order autocorrelation and cross-sectional dependence are present in all types of credit, and there is no multivariate normality in the residuals. Heteroskedasticity is present in all types of credit, except in student loans (see Table A1). The lower VIF and mean VIF values prove that multicollinearity is not a problem in these estimations, and a random effects regression should be used (see Table A2 and Table A3). Table 7 reveals the results of estimating the random effects linear models and probit models with bootstrapped standard errors.

Table 7. Estimation results of random effects linear models and probit models with bootstrapped standard errors.

	Auto Loans			Credit Cards			Mortgages			Student Loans		
	Linear Model	Probit Model		Linear Model	Probit Model		Linear Model	Probit Model		Linear Model	Probit Model	
Variables	**Estimate**	**Estimate**	**Margins**	**Estimate**	**Estimate**	**Margins**	**Estimate**	**Estimate**	**Margins**	**Estimate**	**Estimate**	**Margins**
LMHOUSEHOLD	0.1752**	0.7005***	0.2300***	-0.1423***	-0.4302***	-0.1350***	-0.0840**	-0.6137***	-0.1041***	-0.3167***	-0.5216**	-0.1861**
LUNEM	2.9731***	7.8938***	2.5921***	3.6268***	10.0782***	3.1633***	3.9077***	15.2660***	2.5894 ***	-0.8894**	-1.9180*	-0.6845*
LGDPPC	-0.0298	-0.0958	-0.0315									
LONGT	-4.3763***	-13.8936***	-4.5622***	0.4117**	0.4015	0.1260	0.3518**	0.7508	0.1274			
LINFLATION	-3.8359***	-12.6354***	-4.1490***							-2.1702***	-4.9325***	-1.7602***
LCSENT	-0.0826**	-0.3264***	-0.1072***	0.0709**	0.2577**	0.0809**	-0.1269***	-0.7364***	-0.1249***			
LSP500				-0.1005***	-0.3884***	-0.1219***						
LCREDITD				0.3449***	1.0676***	0.3351***						
LMORTGAGED							0.1711***	1.3829***	0.2345***			
FEDFUND										-0.0320***	-0.0695***	-0.0248***
LSTUDEND										0.2215***	0.6445***	0.2300***
CONSTANT	-1.2051	-6.5076**		-1.1793	-5.1197**		-0.3793	-6.5033***		2.1799**	0.4269	
Diagnostic Statistics												
N	816	816		816	816		714	714		816	816	
R^2	0.1841			0.4273			0.5510			0.4157		
Wald test	233.29***	354.72***		585.01***	727.61***		246.02***	531.24***		939.20***	919.31***	

Notes: ***, ** and * denote statistical significance at 1% , 5% and 10%, respectively; To estimate the models the Stata commands *xtreg*, *xtprobit* and *bootstrap* were used, respectively.

In auto loans in both models, the unemployment rate and median household income are significant and have a positive impact on delinquency. At the same time, consumer sentiment, inflation and long-term government bond yields for ten years are significant and have a negative impact on delinquency and default. GDP per capita is not statistically significant, and the constant is significant only in the probit model.

Comparing the probit margins and linear model of auto loans, the significance levels of median household income and consumer sentiment increase, and the rest remain the same. The coefficients of the two models are close.

In the linear model for credit cards, the unemployment rate is statistically significant, having a positive impact on delinquency. At the same time, median household income is significant and has a negative impact on delinquency. Average credit card debt balance per borrower, consumer sentiment and the long-term government bond yields for ten years are both significant and have a positive impact on delinquency. The SP500 is statistically significant and has a negative effect on delinquency, and the constant is not significant in this model. In the probit model, the unemployment rate is statistically significant and has a positive effect on the dependent variable. However, median household income is significant and has a negative effect on delinquency. Average credit card debt balance per borrower and consumer sentiment are both significant and have a positive impact on delinquency. The SP500 and constant are both statistically significant and have a negative impact, and the long-term government bond yields for ten years are not significant.

If we compare the probit margins of credit cards and the linear model, the coefficients are close, and the significance levels are the same in both models, except for the long-term government bond yields for ten years. That has an in the margins of the probit model is not significant, and its coefficient has decreased compared to the linear model.

In the linear model of mortgages, the unemployment rate is statistically significant. It has a positive impact, while median household income is significant and has a negative impact on delinquency. The average mortgage debt balance per borrower, and long-term government bond yields for ten years are both statistically significant and have a positive effect on delinquency. Consumer sentiment is statistically significant and negative, although the constant is not significant. In the probit model, the unemployment rate is statistically significant and has a positive impact on delinquency. At the same time, the median household income is significant and has a negative impact. The average mortgage debt balance per borrower is significant and has a positive impact, while consumer sentiment and the constant are significant and have a negative impact on delinquency. The long-term government bond yields for ten years are not significant.

When comparing the probit margins and linear model of mortgages, the significance levels are the same, except in the long-term government bond yields for ten years, which is not significant, and the unemployment rate changes the level. The probit margin coefficients of mortgages in the robustness analysis have bigger discrepancies than those of the linear model. However, in the main model of this study, the probit margin coefficients of mortgages have values very close to those found in the linear model.

In both models of student loans, the unemployment rate and median household income are both statistically significant and have a negative impact on delinquency. Average student debt balance per borrower is statistically significant and has a positive effect on delinquency. Inflation and FEDFUND are both significant and have a negative effect on the dependent variable. In the linear model, the constant is statistically significant and has a positive effect on delinquency and in the probit model, it is not significant.

In student loans, if we compare the probit margins and linear model, significance levels decrease in the Probit margins of the unemployment rate and median household income. The coefficients are remarkably close.

6. Discussion

When there is a shock in the U.S. economy, it is likely to spread to the rest of the world, so it is important to study the impact of unemployment and income on the delinquency and default rate in this country, to prevent this phenomenon. In this investigation, some factors influencing delinquency and default are studied through auto loans, credit cards, mortgages and student loans.

The increase in the spread of unemployment makes the delinquency and default rate rise in the four types of credit, so we can conclude that the spread of unemployment increases the probability of delinquency and default. The spread of unemployment has this effect on delinquency because when borrowers become unemployed, they will have more difficulty in continuing to pay credit instalments. Our results reveal that increased unemployment increases delinquency and default, so the unemployment rate and spread of unemployment are good predictors of credit delinquency and default.

In auto loans, credit cards and mortgages increased unemployment raises the delinquency rate, which agrees with the results in the literature because if borrowers lose their job, they will probably not be able to pay off their credit (Erik Heitfield and Tarun Sabarwal, 2004; Bellotti and Crook, 2013; Gerardi et al., 2013). In student loans, an increase in the unemployment rate decreases the delinquency rate. This may be because, in periods of rising unemployment, the majority of people who lose their jobs are usually less qualified, which means that those who are more qualified occupy their jobs, albeit with a lower salary. The most qualified people are those who have student loans, so if they have a job, they can continue to pay their loan instalments, reducing delinquency and default (Mincer, 1991).

An increase in the spread of unemployment causes delinquency and default to increase in all cases studied. In contrast, an increase in the unemployment rate in the case of student loans causes delinquency and default to decrease.

In credit cards, mortgages and student loans, an increase in median household income decreases the delinquency rate, because if borrowers have more income, they will be able to pay back their loans more easily, corroborating the results found in the literature (Böheim and Taylor, 2000; Schemeiser et al., 2016; Kim et al., 2018). In auto loans, an increase in median household income raises the delinquency rate, because if borrowers have higher income, they will probably buy a more expensive car and probably with a loan for more years. Hence, the more expensive the car and the longer the loan, the higher the likelihood of going into delinquency (Wu et al., 2018). Nevertheless, it can be concluded that an increase in median

household income causes the delinquency and default rate to decrease, so like unemployment, income can be considered a good predictor of delinquency and default on loans.

In all types of credit, except in credit cards estimation with the spread of unemployment, the increase in consumer sentiment causes the delinquency and default rate to decrease, as this period has been one of major economic crisis. Borrowers are more pessimistic about the future, which makes them more careful when requesting loans, thus leading to a decrease in the delinquency rate (Boef and Kellstedt, 2004). In credit cards estimation with the spread of unemployment, increased consumer sentiment raises the delinquency and default rate because when borrowers have high expectations, this could lead them to borrow more than they can pay in the future (Wadud et al., 2019).

This investigation uses two interest rates, the long-term government bond yields for ten years for auto loans, credit cards and mortgages, and FEDFUND for student loans. In credit cards and mortgages, an increase in the interest rate raises the delinquency and default rate, because it increases the charges on credit (Wadud et al., 2019). In auto loans and student loans, an increase in the interest rate lowers the delinquency and default rate, which may be because these interest rates tend to increase during periods of economic growth when wages are higher. Unemployment is low, and so delinquency and default decreases (Aydin et al., 2016).

The inflation rate is used in auto loans and student loans. When this rises, delinquency and default decrease. As in the case of interest rates, the same effect occurs with inflation, which usually increases during periods of economic growth, causing a reduction in delinquency and default (Rizvi and Khan, 2015).

The S&P 500 index is only used in the credit card models, and when the index increases, delinquency and default decrease. This effect on delinquency occurs because when the index is increasing, it means that companies listed on this index had increased profits. This can represent a time of economic growth or recovery, so if the economy is growing, there will be less credit delinquency (Ghosh, 2015).

The average debt balance per borrower is used in credit cards, mortgages and student loans. When this increase, the delinquency and default rates rise because increased debt makes it more difficult for borrowers to repay their loan, increasing the likelihood of delinquency and default (Kelly and McCann, 2016).

The results show that unemployment and income significantly affect credit delinquency and default, and this must be controlled because when a shock occurs, they can cause a decrease or increase of delinquency and default. An exponential increase in delinquency and default requires attention because it can have severe consequences for the U.S. economy and consequently, for others worldwide.

Regarding other factors studied in this investigation, such as consumer sentiment, the inflation rate, average debt balance per borrower, interest rates and the S&P 500 index, the results show that they affect the probability of delinquency and can also lead to problems of delinquency and default.

7. Conclusion

This investigation analyses the impacts of unemployment and income on the delinquency rate and credit default in the USA. An analysis of delinquency in auto loans, credit cards, mortgages and student loans was performed. Data from the 50 states of the USA and the federal state of Columbia were used from 2003 to 2018. The spread of unemployment variable was used to represent unemployment, which is the deviation of unemployment of each state in relation to the unemployment of the USA. Median household income was used to represent income. A probit model was used and compared with a linear model to perform the econometric analysis of this study. The probit model was the estimator chosen since the delinquency values for all four types of loans studied were between 0 and 1.

The results of this study demonstrate that an increase in the spread of unemployment causes delinquency and default to increase as well. On the other hand, when median household income increases, delinquency and default decrease. The results obtained confirm that an increase in unemployment increases delinquency and default and that an increase in income decreases delinquency and default. We concluded too that an increase in consumer sentiment causes delinquency and default to decrease and an increase in the S&P 500 index has the same effect. We also find that when average debt balance per borrower increases, delinquency and default rise too.

In order to control borrowers and creditors to prevent increased delinquency and loan default, policy-makers must create more measures to regulate the credit market. For example, they can monitor loans more effectively, verifying that borrowers only borrow on terms that they will be able to repay in the future. More scholarships could also be granted, thus reducing student loan delinquency. Companies can be subsidised to create more jobs, which would decrease unemployment and increase household income.

Finally, other variables should be analysed to determine their impact on delinquency and default, such as illness, divorce, accidents causing disabilities or prolonged illness, corruption, robberies and becoming a widow. Another factor that may have a big impact on delinquency rates and loan default will be the pandemic the world is experiencing in 2020.

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APPENDIX

Table A1. Doornik-Hansen, Wooldridge, Breusch-Pagan and Pesaran tests

	Doornik-Hansen test	Wooldridge test	Breusch-Pagan test	Pesaran test
Auto Loans	333.936***	294.773***	68.33***	93.93***
Credit Cards	115.563***	76.902***	108.48***	60.55***
Mortgages	2735.634***	126.925***	64.45***	51.29***
Student Loans	5.456**	110.731***	2.50	54.94***

Notes: H_0 of Doornik-Hansen test: multivariate normality; H_0 of Wooldridge test: no first order autocorrelation; H_0 of Breaus-Pagan test: Constant variance; H_0 of Pesaran test: cross section independence; *** denotes statistical significance at the 1% level. To compute these tests, the Stata commands *mvtest*, *xtserial, estat hettest* and *xtcd,* respectively, were used.

Table A2. VIF and Mean VIF statistics

	VIF			
Variables	**Auto Loans**	**Credit Cards**	**Mortgages**	**Student Loans**
LMHOUSEHOLD	1.70	2.52	3.39	1.14
LUNEM	1.86	1.69	2.01	1.24
LGDPPC	1.57			
LONGT	1.54	1.42	1.03	
LINFLATION	1.67			1.26
LCSENT	1.60	2.78	1.58	
LSP500		2.83		
LCREDITD		2.41		
LMORTGAGED			3.11	
FEDFUND				1.27
LSTUDENTD				1.44
Mean VIF	1.66	2.28	2.23	1.27

Note: The Stata command *vif* was used.

Table A3. Random effects *vs Pooled* OLS

	Random effects vs Pooled OLS
Auto Loans	1386.51***
Credit Cards	1936.19***
Mortgages	961.50***

Notes: Notes: H_0 Breusch-Pagan Lagrangian multiplier test: variances across entities is zero; *** denotes statistical significance at 1% level. The Stata command *xttseto* was used.