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Evolution of Loan-to-Value policies in Belgium and their potential impact on default rates.

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Daytime schedule

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1. Help for the code : It helps me to correct some error I had in my R code

2. Generation of graphs : It generates some graphs with the data I gave to have cleaner graphs than it was in Excel.

After using ChatGPT, the author(s) diligently reviewed and edited the content produced by the tool. We take full responsibility for the final content presented in this thesis.

By signing this declaration, we affirm that the content of this master's thesis reflects our original work, augmented by the responsible use of AI.

6th August 2024

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Contents

1 Executive summary

This study assesses the impact of loan-to-value (LTV) policies on mortgage default rates in Belgium. First, it compares housing affordability in Belgium with that of economically similar countries such as France, Denmark, Finland, Sweden, Canada and Israel. We will see that Belgium is in the middle of the pack when it comes to housing affordability, with a theoretical time to obtain a mortgage of 2.88 years.

The analysis focuses on policy changes in 2016 and 2020 in Belgium. The results show that policy adjustments in 2016 and 2020 had no significant effect on mortgage default rates. Statistical tests, including equality of variance tests, Student's t-tests and Diff-in-Diff models, indicate that policy changes had no significant impact on default rates in Belgium compared to France.

These results raise questions about the effectiveness of LTV policies as a tool of financial regulation. Other factors, such as general economic conditions and income levels, appear to play a more decisive role in the financial stability of borrowers.

2 Introduction

The loan-to-value (LTV) ratio is an important financial indicator used by banks to evaluate the risk associated with granting a mortgage loan. This is the ratio of the amount of the loan to the appraised value of the property to be financed, hence the preponderant variable in lending decisions. This ratio would therefore be used as the basis for determining a maximum loan amount that the bank could lend, based on the value of the property and contribution required from the borrower.

It is normally held by many that owning a house is what pulls them out from abject poverty. Further research shows that possession of a home promotes economic solidity as well as households' asset accumulation. Policies favoring access to shelter are important for both banks and governments since it matters for citizens' welfare. However, offering 100% loan to property value brings about significant defaults risks which can threaten financial stability. The perfect LTV rate is thus subjective; let us ask what should be the point at which it should be set between housing affordability and financial risk management? This creates huge effects on

banks and borrowers through LTV policies. For the bank, high LTV raises default risk and might affect financial stability. It makes it difficult for ownership at a lower LTV on the borrowers' side by increasing the down payment amount. The importance, thus, rests on finding a balance that will give households access to housing while limiting the risks for banks.

Although such policies are of a great importance, there is no comprehensive study on the evolution and impact of LTV policies; therefore, this important dimension of mortgage lending remains relatively unknown. This lack of information concerning LTV led us to the exploration of this subject and trying to understand the implications of this variable and its impact on credit defaulting in Belgium, while trying to also understand what the purpose of changes to the LTV policy over time is.

This paper is going to assess the LTV policy from various dimensions in order to answer this question. First, we compare the LTV regulations in force in Belgium with those of countries at a similar level of GDP or GDP per capita. On this, it will let the research contrast what is being adopted in Belgium with others around the rest of the world, understand their relative position, and consider whether there are any alternative ways of doing things.

Next, we present a diachronic analysis of the LTV policies in Belgium, in which attention is focused on changes generated by different economic crises. This section will use temporal data to establish links between policy changes and economic variables.

In addition, event studies will be carried out to specifically examine the impacts of policy adjustments in 2016 and 2020. By isolating these dates, we will assess the effects of these adjustments on mortgage default rates.

With equality of variance tests, Student's t-tests, and Diff-in-Diff models, we will be able to determine precisely how the change in policy affects Belgium's default rate relative to that of France.

This paper seeks to contribute to the existing body of knowledge pertaining to LTV policies, their effectiveness, and the consequent impact on the rate of mortgage default. By comparing policies in different countries and analyzing specific adjustments in Belgium, we hope to provide valuable information for policymakers, researchers and financial sector professionals. Our main hypothese is that changes in LTV policies directly affect default rates..

In conclusion, our results indicate that LTV policies in Belgium, despite adjustments in 2016 and 2020, did not have the expected significant impact on default rates. This suggests that other factors, such as general economic conditions, may play a more decisive role in the financial stability of borrowers.

3 Literature review

We realize that, though LTV is an important variable, most of the scientific articles take it for granted, and none of them analyze its actual impact on the economy. However, we managed to find a few studies that focused on the different perspectives of this variable, giving us valuable information.

The determinants of LTV ratios are varied and include economic, regulatory and market-specific factors. Zhu, Betzinger and Sebastian (2017) have shown that macroeconomic variables such as interest rates, inflation and economic growth significantly influence LTV policies. In periods of economic stability and growth, lenders may be more inclined to offer higher LTV ratios due to lower perceived risk. Conversely, in periods of economic recession, the risk of default increases, prompting stricter LTV policies.

Other researchers have looked at the impact of LTV ratios on housing affordability and housing market stability. De Graeve, De Jonghe and Vennet (2007) studied these effects and pointed out that higher LTV ratios can increase homeownership rates by reducing the need for upfront capital for borrowers. Nevertheless, they indicated that higher ratios might result in higher rates of default if not properly managed.

LTV policies have been revised time and again in the past with a view to enhancing resilience in financial systems in the face of financial crises. For example, the global financial crisis in 2008 highlighted the dangers of high LTV loans. Against this backdrop, most countries have introduced stringent regulations that reduce the ceiling on LTV ratios. Vincent, with respect to Belgium, notes that such changes are made today with an emphasis on inducing a decline in systemic risk by way of making the lending to real estate much safer for banks and other financial institutions.

LTV policies differ significantly from country to country, in view of specific national economic and regulatory settings. Reusens and Warisse made a comparison, in 2018, across LTV policies in many European countries, which implies that approaches actually differ by way of priorities given at the national level for financial stability versus housing affordability. For example, Sweden and Finland maintain comparatively high LTVs for first-time buyers, while France is seen to have adopted a very conservative approach to contain financial risks.

Examining the determinants of multifamily mortgage default, Archer, Elmer, Harrison and Ling (2002) concluded that LTV policies play a crucial role in managing default risk. Their research underscores the need for a balanced kind of regulation balancing the freedom from financial crisis and access to housing.

Finally, Winters and Van Den Broeck (2016) did an analysis of the evolution of the Belgian mortgage market over the last 25 years and highlighted the role LTV policies have played in steering the real estate market. They found that the prudent practices of Belgian banks, combined with appropriate LTV policies, have contributed to the stability of the Belgian real estate market. However, they also noted that periodic policy adjustments are necessary to respond to economic developments and financial crises.

This work will therefore make it possible to contribute to help to define the real effects of LTV ratio policies and to study the impact on the default rate on real estate loans.

4 Methodology

The loan-to-value ratio is one of the essential financial indicators that the bank will use to measure the degree of risk associated with lending money to someone to buy a house. LTV refers to the relationship between the loan amount and the estimated value of the property to be financed; hence, it is likely to turn out to be the predominant variable in the lending decision. One of the main controversies at the root is, however, the LTV ratio between two camps: the banks, who would like to see a low LTV in order to assure more security on the financial side, and buyers, who want a high LTV to make housing affordable and create an avenue into house ownership for improving financial stability.

Owning a home is often seen as a way out of poverty. Studies show that home ownership promotes economic stability and enables households to build up stable assets and financial security. Andrews, Caldera Sánchez and Johansson (2011) point out that housing markets and structural policies in OECD countries play a key role in promoting access to housing, which is essential for the well-being of citizens.

However, 100% lending introduces a vast element of default risk, which might destabilize the financial system. It is also begging the question of where appropriate thresholds for LTVs ought to lie to reconcile goals of housing affordability with prudent management of financial risk.

Banks would like to maintain the LTV ratio low for financial safety and reducing the risk of default; the buyers, on the other hand, need a higher LTV ratio, which would definitely prove to be useful for housing affordability and financial safety by means of ownership in housing. This duality of issues lies at the heart of LTV policies, which must strike a balance between the security of the financial system and the economic well-being of households.

This problem highlights the critical importance of the LTV ratio threshold and leads us to question the real impact of LTV ratio changes on mortgage default probability, as one of the main arguments put forward by banks is that higher LTV ratios increase default risk.

we are going to compare the LTVs between countries as an aim to work out the case of Belgium to compare it with others in order to have a more general viewpoint of the position of Belgium in the world.

To answer our research question, we first need to collect data. This data collection phase has been the most complicated part of our work, due to the very small amount of information available. We were nevertheless able to collect some from the National Bank of Belgium and the Banque de France.

Next comes the question of statistical testing. The first idea would have been to run linear regressions, but by comparing the data, we can see that the variability of the LTV ratio is extremely low, so this method is not relevant.

The second idea was to create an event study model. This model would show the impact of an event, in this case the modification of LTV policies in 2016 and 2020, on the probability of contract default. However, an event study would tend to capture other effects which, for us, would be undesirable.

So we are going to use our data as a treatment group, and for this we will use a Difference-in-Differences model with the default rate in Belgium as the treatment group and the default rate in France as the control group.

We have to first ensure the data are relevant and correspond to the assumptions of the model. For checking stationarity we used the Augmented Dickey-Fuller test, for homoscedasticity, the Breusch-Pagan test; for autocorrelation, the Durbin-Watson test; and for normality, the Shapiro-Wilk test.

After these tests, our models satisfies all hypotheses except the stationarity test for the 2016 model. To reduce the stationarity of our data, we first performed a logarithmic transformation on our data to stabilize the variance and make the differences proportional, but this was not enough. We then differentiated the data to eliminate any trends that might prevent stationarity, but this did not work either. In the end, we used the logarithmic function and triple differentiation to obtain our lowest p-value for the stationarity of our data.

Now that our hypotheses have been tested, we can run our classic Diff-in-Diff model to answer our research question.

Given that our model evaluates the probability of default, our variable is bounded between 0 and 1, so it makes sense to adapt our model a little to make it more reliable. We will then perform a logit adjustment on our model to make the results more accurate.

5 LTV worldwide and housing affordability

5.1 Comparison of different LTV ratio regulations

This section aims to compare the different maximum LTV ratios in each selected country and to relate these maximum LTV data to average wages, house prices and average house size to establish a theoretical housing affordability ratio. The selected countries have similar GDP, GDP per capita, or real estate market characteristics to to Belgium. The goal is to determine Belgium's position in terms of housing affordability in comparison with other countries with similar characteristics and be able to have a more global perspective. This analysis is grounded in data collected up to the end of 2023 and sourced from Worldometer (2024).

5.1.1 Selection of countries for comparison

5.1.2 In Europe

In Europe, comparisons will be made with Sweden, Denmark, Finland, and France. Sweden's GDP per capita is similar to Belgium's, facilitating direct comparisons. Finansinspektionen's 2023 report on the Swedish mortgage market reveals that while rising interest rates are impacting households, the majority of new mortgagors have good financial margins. Sweden's structured LTV policies make it a relevant case study for understanding these trends.

Denmark, with its GDP per capita similar to Belgium's and dynamic real estate market, offers another interesting comparison.

Finland's strong economic stability with several stricts rules for LTV ratio will enable us to make some comparison with the Belgian model.

France is included due to its general economic and cultural similarities with Belgium.

5.1.3 Outside Europe

Outside Europe, the analysis includes Israel and Canada. Israel's GDP is very close to Belgium's, making it a significant factor in the analysis. More, the size of this country is similar to that of Belgium which make their situation comparable.

Canada, despite its large size, has the GDP per capita closest to Belgium's outside Europe. Its distinct real estate market and specific LTV policies provide a different perspective on housing affordability in a North American context.

5.2 Average real estate prices and average salaries

To properly analyze LTV policies, it is important to know the property prices and average wage in each selected country. All prices have been standardized in EUR for non-Euro countries thanks to the OECD Data (n.d) about the Purchasing Power Parities (PPP).

Country	Property price (EUR/m^2)	Average wage (EUR/Month)	Source property	Source wage
Belgium	3014.00	3489.00	SD Worx, 2023	Immoweb, 2024
Sweden	3148.00	3600.00	SCB, 2023	Nomades, 2024
Denmark	3104.00	6100.00	Averagesalarysurvey,	Statista, 2023
Finland	2300.00	4018.00	Statistic Finland, 2024	Infofinland.fi, 2024
France	3074.00	3183.00	Insee, 2024	Seloger, 2024
Israel	5701.00	3284.78	Globes, 2024	Wrobel, 2023
Canada	2419.11	4246.16	Salaryaftertax, 2024	Properstar, 2023

Table 1: Comparison of property prices and average salaries

5.3 LTV policy in each country

Understanding different LTV policies helps us grasp how different countries function. This information is a key indicator of financial stability in the real estate sector and directly affects housing affordability and debt levels. We will go through the different LTV policies that each country has adopted to understand the effects of these policies on the respective real estate markets.

5.3.1 Belgium

Since 2020, the maximum LTV rate in Belgium has been brought down to 90% (National Bank of Belgium, 2019). The policy helps the country achieve financial stability and maintain hyper-housing affordability with a flexible approach. This, in turn, encourages new takers to realize improved financial stability by entering the employment category.

5.3.2 Sweden

Since 2010, the Swedish government has enforced an LTV ceiling of 85%, with the policy promoting low household indebtedness despite rapidly rising property prices and related risks. There are other amortization requirements of 2% per annum for loans over 70% LTV and 1% per annum for loans between 50% and 70% LTV. During the COVID-19 crisis, the government has suspended the annual amortization requirements to offer support for the homeowners and to keep the market attractive for new entrants as well (Finansinspektionen, 2023).

5.3.3 Denmark

The country maintains a different LTV policy for different types of property, with the maximum rate for principal residences being 80% and for open-end loans, which can change to 75%. For secondary residences, the rate is between 50% and 65%. The rate for commercial property follows a similar pattern. However, the

LTV level can increase with the availability of financial guarantees like possession of substantial pay-slips or clean financial history (FinansDanmark, n.d).

5.3.4 Finland

In Finland, the LTV ceiling summed up for all new mortgages is 85%, with a 95% LTV ceiling in the beginning for the first-time buyer group (Helsinki Times, 2018). This policy helps the young buyer groups and helps them enter the real estate markets and achieve financial stability very soon.

5.3.5 France

In France, banks generally provide not more than 80% where exceptions are made at 85% to contain the financial risk and reduce the possibility of a bubble in the property market (Stat Info, 2024). The government maintains a conservative policy balancing housing access and stability of the financial markets.

5.3.6 Israel

Israel's government policy concerning LTV specifies 75% for first-time homebuyers, making it easier to acquire a property quickly with less reliance on credit. The existing homeowners' LTV rate stands at 50% focusing on first-time homebuyers and curbing real estate speculation. For foreign residents, these 50% have the possibility to be increased at 50 - 70 % LTV to the maximum rate (Asden Israel, 2022).

5.3.7 Canada

There is no LTV ceiling in Canada, and loans greater than 80% LTV attract mortgage insurance from entities such as the Canada Mortgage and Housing Corporation to cushion lenders against a default. This insurance makes access to property faster, with a lower personal contribution. Mortgage refinancing attracts a maximum LTV of 80%. There is a stress test to ensure that there is a repayment of

loans at an increased interest rate. In addition to that, the banks are more strict with the foreign investors and they allow them a maximum LTV of 80% in the absence of the CMHC insurance (CMHC SCHL, 2024).

5.3.8 Summary of ratio in each country

Here is a table summarizing the different LTV ratios in each country.

Country	Maximal LTV ratio
Belgium	90%
Sweden	85%
Denmark	80%
Finland	95%
France	85%
Israel	75%
Canada	100%

Table 2: LTV ratio in each country

5.4 Analysis of housing accessibility

This section evaluates housing affordability in different countries to see if the policies align with their performance. By using average wages and property prices from Table 1, we can calculate a theoretical housing affordability ratio, representing the time needed to acquire one square meter of land expressed in years. To compute this ratio, we will use these computations :

$$(Propertyprices/Averagewage)/12 = Year/m^2 \tag{1}$$

Country	Property prices (EUR/m^2)	Average wage (EUR/Month)	Time for 1m^2 (years)
Belgium	3014.00	3489.00	0.072
Sweden	3148.00	3600.00	0.073
Denmark	3104.00	6100.00	0.042
Finland	2300.00	4018.00	0.048
France	3074.00	3183.00	0.080
Israel	5701.00	3284.78	0.145
Canada	2419.11	4246.16	0.047

Table 3: Comparing housing affordability in different countries

We can distinguish three different groups by these results. The first one is with Denmark, Finland and Canada which are the country with the smallest time to buy a square meter of land with about half a month. After, we have the second group with Belgium, Sweden and France with nearly a month to buy a square meter. Finally, we have Israel where the population have to save 1.5 month of salary to buy a square meter of land.

Our final objective is to calculate the time required to save the necessary amount for a mortgage loan based on average salaries. So now, we can add the information of the average size for a house in each country.

Country	House size (m^2)	Source
Belgium	120	shrinkthatfootprint, 2024
Sweden	83	shrinkthatfootprint, 2024
Denmark	137	shrinkthatfootprint, 2024
Finland	82	shrinkthatfootprint, 2024
France	112	shrinkthatfootprint, 2024
Israel	115	La jaune et la rouge, 2024
Canada	181	shrinkthatfootprint, 2024

Table 4: Average size for home in each country

5.5 Time needed to obtain a loan in each country

Based on the previous data, we can construct the table 16 in the appendix which explain how all the expenses are divided in all the different country computed as follow :

$$Propertyprice \times Housesize \times (1 - MaximalLTVratio) \tag{2}$$

To make this more understandable, we can create the following table, which will add a time ratio for obtaining a loan.

Country	Average wage	Money to bring	Time for 1m^2	Time for loan
Belgium	3489.00	36,168.00	0.072	0.86
Sweden	3600.00	39,192.60	0.073	0.91
Denmark	6100.00	85,049.60	0.042	1.16
Finland	4018.00	9,430.00	0.0048	0.2
France	3183.00	51,643.20	0.080	1.35
Israel	3284.78	163,903.75	0.145	4.16
Canada	4246.16	0.00	0.047	0.00

Table 5: Time required to obtain a loan in different countries, expressed in years

Belgium occupies an intermediate position compared to the other countries studied, with an average of 0.86 years to obtain a mortgage loan. This period is longer than in Finland (0.2 year) and Canada, where it is possible to obtain the entire loan on credit. It is important to note that in Canada, loans exceeding 80% LTV require mortgage insurance, adding further costs.

It is important to notice that these figures are theoretical, assuming 100% wage savings. Next, we consider the theoretical cost of living in each country. The information concerning the amount of money dedicated for credit in the different country were found on Statbel (2023), OECD (n.d.), Statista (2023), Finland Today (2020), RadioCanada (n.d.) and on Ministère de la Transition écologique et

de la Cohésion des territoires (2022).

Country	Average wage	Budget for credit	Home savings (EUR/Month)	Time for loan (Years)
Belgium	3489.00	30%	1046.70	2.88
Sweden	3600.00	45%	1620.00	2.02
Denmark	6100.00	15%	915.00	7.75
Finland	4018.00	20%	803.60	1.37
France	3183.00	18%	572.94	7.5
Israel	3284.78	25%	821.2	16.63
Canada	4246.16	31%	1316.30	0.00

Table 6: Budget allocate to housing and time for a loan

When factoring in the cost of living, certain trends change, such as Denmark's and France's because their citizens allocates 15% and 18% of their budget to housing. Belgium has an average housing affordability compared to other countries with similar economies, with an average theoretical time of 2.88 years to obtain a loan. Finland, is the fastest country of this comparison with 1.37 years on average. Canada's results are influenced by additional insurance costs for loans exceeding 80% LTV.

5.6 Conclusion

Looking at the case of Belgium, although the Loan-to-Value (LTV) ratio is among the highest compared to other countries, at 90% of the amount lent by the bank, the time taken to obtain a loan remains in the middle range, amounting to 2.88 years of savings. It's also interesting to note that some countries, like Canada, have entirely different LTV systems. In Canada, the limit is set at 80%, with compulsory insurance if first-time buyers wish to borrow more.

6 The Belgium case

Now that we have a more general view of Belgium in the world, our aim is to determine the evolution of the LTV ratio in Belgium and then try to determine whether variations in policy have had an impact on the number of credit defaults.

6.1 Evolution of the LTV ratio in Belgium

Before 2005: Prudent practices

Before 2005, Belgian banks adopted a cautious approach to mortgage lending, limiting interest charges to a reasonable percentage of borrowers' disposable income. This prudence was aimed at avoiding excessive risk and maintaining the stability of the real estate market. Although there was no precise LTV policy, the percentage hovered around 80%, except in special cases (Zachary, 2009).

2005: Introduction of MICPD (Mortgage interest, capital allowances and insurance premiums)

In 2005, Belgium introduced MICPD, a policy designed to stimulate home ownership by allowing borrowers to deduct mortgage interest and capital from their taxes. This initiative encouraged home ownership, but also contributed to price inflation for certain types of housing (Vangeel, Defau, & De Moor, 2020).

After 2007: stable LTV

Despite an increase in the amounts borrowed, the average LTV ratio has remained stable at around 80%, with no upper limit. This stability reflects the continuity of prudent practices, even after the financial crisis of 2008. Banks have tried to maintain a balance between access to credit and risk management (Zachary, 2009).

2008: The global financial Crisis

The 2008 global financial crisis highlighted the risks associated with high LTV loans. Belgian authorities reassessed regulatory frameworks to ensure financial system stability (Vincent 2012).

2009-2015: Awareness-raising without strict measures

During this period, Belgium raised market players' awareness of the financial risks associated with mortgages without implementing strict regulatory measures concerning LTV (Vangeel, Defau, & De Moor, 2020).

2016: Recommendations by the NBB

In 2016, the NBB recommended limiting mortgage loans to an LTV ratio of 80%, encouraging borrowers to make a personal contribution of at least 20%. This recommendation aimed to balance housing affordability and financial stability (Banque Nationale de Belgique, 2019).

2020: Reinforcement of macroprudential measures

In 2020, Belgium strengthened its macroprudential measures, modifying limits for new loans with a maximum LTV of 90% and introducing capital cushions for high-risk loans. These measures aimed to reduce systemic risk (Banque Nationale de Belgique, 2019).

2021 and beyond: Adjustments and monitoring

Belgium continues to monitor the real estate market and adjust its LTV policies according to economic conditions and risks, maintaining financial stability while facilitating housing access (Vangeel, Defau, & De Moor, 2020).

6.2 Graphs of LTV in Belgium

Below is a graph showing the evolution of the actual and maximum LTV ratio in Belgium:

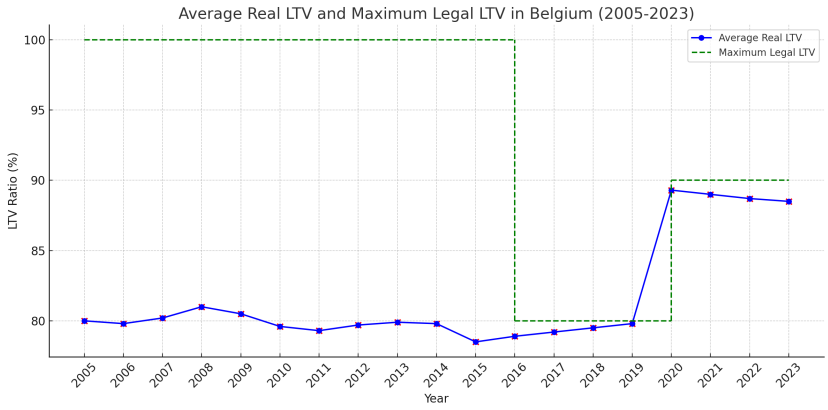

Figure 1: Loan-To-Value ratio in Belgium

We can therefore see that, even if before 2016 it was possible in some cases to borrow even 100% of the sum, real LTV rates are nevertheless stagnating around the 80% level. The graph shows a staircase shape with two distinct levels: the first at the bottom of the staircase, at around 80%, and the second after 2020, at around 90%.

In order to determine the real effects of the 2016 and 2020 policy changes, it is ideal to carry out statistical tests to obtain reliable results.

The first idea was therefore to run linear regressions to establish the significance of the change. However, given the shape of the graph, linear regressions are not relevant. In 2016, the policy set a maximum at a rate already close to the effective average LTV, which does not allow us to obtain satisfactory results for regressions because the variation is too small.

We will therefore use the statistical method of Difference-in-Differences. This in-

volves comparing two groups: a treatment group, which is affected by the policy change, and a control group, which is not. By observing the differences in outcomes before and after the policy change in the two groups, this method isolates the effect of the policy change by controlling for other factors. In other words, the Difference-in-Differences method helps to assess the causal impact of an intervention by comparing changes in outcomes between the treatment and control groups. In our case, the treatment group will be Belgium and our control group will be France.

France was selected on the basis of its economic similarity to Belgium. Before we start with the statistical tests, we can take a look at how the LTV ratio has evolved in France.

6.3 Evolution of the LTV ratio in France

2000-2007: Period of economic growth

From 2000 to 2007, France experienced significant economic growth and rising real estate prices. During this period, banks adopted more flexible lending practices to stimulate the real estate market. The Loan-to-Value (LTV) ratio frequently reached 80-90%, with some cases even going up to 100%. This approach aimed to enhance housing affordability and boost market activity (IGEDD, 2024; Rocket Mortgage, 2024).

2008-2012: Financial crisis response

The global financial crisis of 2008 led to increased scrutiny and stricter lending regulations in France. The financial authorities imposed more stringent LTV limits, reducing the maximum LTV ratio to around 80%. This measure aimed to mitigate risk and ensure the stability of the financial system during a period of economic uncertainty (IGEDD, 2024; Uswitch, 2024).

2013-2019: Economic recovery and stabilization

Following the financial crisis, the French economy began to recover gradually. During this time, the LTV ratio remained stable at around 80-85%, reflecting a cautious yet supportive approach to mortgage lending. Some banks offered LTV ratios up to 90% for borrowers with strong credit profiles (Expatica, 2024).

2020-2024: Impact of COVID-19 and post-pandemic adaptation

The COVID-19 pandemic introduced new economic challenges and uncertainties. In response, French banks demonstrated flexibility in lending practices to support borrowers during the crisis. The LTV ratio during this period generally fluctuated between 80% and 85%, with occasional adjustments to accommodate economic recovery efforts post-pandemic (Banque de France, 2024; IGEDD, 2024).

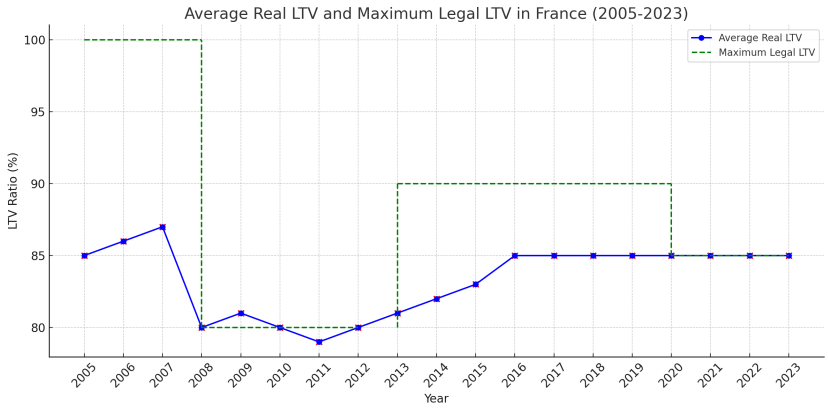

Figure 2: Evolution of LTV ratio in France

7 Results analysis

7.1 Checking assumptions of the model

Before running our statistical tests, we need to verify that the assumptions made by our model are held true, such as stationarity, homoscedasticity, absence of autocorrelation, and normality of residuals.

First, we will start with stationarity. After running the Augmented Dickey-Fuller test, we noticed that our data were not stationary. We therefore transformed our data using a logarithmic transformation of our data to stabilize the variance, but this was not enough, so we performed a triple differentiation to reduce the p-value of our model as much as possible. These transformations made our 2020 model stationary, but our 2016 model still not. We must therefore be cautious when interpreting the results of the 2016 model.

We can continue with the Breusch-Pagan test for homoscedasticity and note that our results do not reject the null hypothesis that assumes homoscedasticity, so our results are relevant in this respect.

Now, relative to autocorrelation with the Durbin-Watson test, our results indicate that there might be some autocorrelation in the 2016 data, but that the results for 2020 do not allow rejecting the hypothesis of no autocorrelation.

We can continue with the last hypothesis, which is the normality of the residuals with the Shapiro-Wilk test, and we note that we cannot reject the null hypothesis of this model which says that the residuals are normally distributed.

7.2 Tests for equality of variances

Levene's test is used to verify the homogeneity of variances between two or more groups. It tests the null hypothesis that the variances of the groups are equal. The

formula for Levene's test is as follows:

$$W = \frac{(N-k)}{(k-1)} \frac{\sum_{i=1}^{k} N_i (Z_{i.} - Z_{..})^2}{\sum_{i=1}^{k} \sum_{j=1}^{N_i} (Z_{ij} - Z_{i.})^2}$$

Where :

- N is the total number of observations,
- k is the number of groups,
- N_i is the number of observations in group i,
- $Z_{ij} = |Y_{ij} - \bar{Y}_i|$ is the absolute value of the deviation of observation Y_{ij} from the group mean $\bar{Y}_i$,
- $Z_{i.}$ is the mean of Z_{ij} for group i,
- $Z_{..}$ is the overall mean of Z_{ij}.

The Levene's test uses the statistic W which follows a Fisher-Snedecor F-distribution.

Homogeneity of variances is an important prerequisite for parametric tests. If variances are unequal, this can bias the results of mean comparison tests. By checking the equality of variances, we ensure that the parametric tests we use are appropriate and reliable.

Year	Df	F value	Pr(>F)
2016	1	1.6036	0.2235
2020	1	1.2354	0.2828

Table 7: Levene's test results

Here are our results for the Levene test. These results show that the variances of the default rates before and after the policy changes in 2016 and 2020 are not significantly different ($p > 0.05$). This indicates that the variances are homogeneous, allowing us to use Student's t-test to compare the means.

7.3 Comparing means with Student's t-test

Student's t-test is used to compare the means of two independent samples. It tests the null hypothesis that the means of the two samples are equal. The formula for Student's t-test is as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where :

- $\bar{X}_1$ and $\bar{X}_2$ are the means of the two samples,
- n_1 and n_2 are the sizes of the two samples,
- s_p is the pooled estimate of the standard deviation of the two samples, calculated as follows:

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

where s_1^2 and s_2^2 are the variances of the two samples.

By comparing the mean default rates before and after the policy changes, we can determine whether these changes had a significant effect. This helps us understand the impact of the policies on default rates.

Year	t value	df	p value	Mean (Before)	Mean (After)
2016	0.5377	16	0.5982	1073757.5	885021.3
2020	0.795	16	0.4382	983613.7	808964.9

Table 8: Results of the Student's t-tests for comparing the means before and after policy changes in 2016 and 2020

The results of Student's t-tests show that the differences in default rate means before and after the policy changes in 2016 and 2020 are not statistically significant ($p > 0.05$). This indicates that the policy changes had no significant impact on

default rates.

For 2016, the p-value is 0.5982, well above the 0.05 significance level. This indicates that the difference between the defect rate averages before and after 2016 is not significant. The average before 2016 is 1,073,757.5, while the average after 2016 is 885,021.3.

For the year 2020, the p-value is 0.4382, which is also well above the 0.05 significance level. This indicates that the difference between the average defect rates before and after 2020 is not significant. The pre-2020 mean is 983,613.7, while the post-2020 mean is 808,964.9.

7.4 Difference-in-Differences model

The Difference-in-Differences (Diff-in-Diff) method is used to estimate the effect of a treatment or intervention by comparing changes in outcomes over time between a treated group and a control group. This method allows for controlling the effects of unobserved variables that are constant over time.

We choose to use this model for our study of the impact of LTV policies on the credit default rate in Belgium, using France as a control group. This decision is based on several academic studies demonstrating the relevance and effectiveness of this method in similar contexts.

For example, Zhou et al (2016) used the Diff-in-Diff method to compare the efficacy of medical treatments with unbalanced groups. Their study shows that this method is particularly useful for analyzing the effects of an intervention in contexts where treatment and control groups may have significant initial differences.

In addition, Dimick and Ryan (2014) applied the Diff-in-Diff method to evaluate changes in health policy. They pointed out that this approach is effective in identifying the specific effects of interventions, taking into account temporal trends and variations between groups.

These examples illustrate that the Diff-in-Diff method is well suited to our study of LTV policies and their impact on credit default rates in Belgium. By comparing the differences in default rates before and after policy changes between Belgium and France, we can isolate the specific effect of policy interventions.

The Diff-in-Diff specification is given by the following equation:

$$Y_{it} = \alpha + \beta D_t + \gamma T_i + \delta (D_t \times T_i) + \epsilon_{it}$$

where:

- Y_{it} is the outcome of interest (here, default rates) for individual i at time t,
- D_t is an indicator for the post-treatment period (1 if $t \geq yearofchange, 0$ otherwise),
- T_i is an indicator for the treatment group (1 if i belongs to the treatment group, 0 otherwise),
- $D_t \times T_i$ is the interaction between the treatment and the post-treatment period,
- δ is the coefficient of interest, measuring the effect of the treatment.

The Diff-in-Diff model allows us to estimate the causal effect of policy changes on default rates in Belgium compared to France. By comparing the differences in default rates before and after the policy changes between the two countries, we can isolate the impact of the policies.

Variable	Estimate	Std. Error	t value	Pr($>\|t\|$)
(Intercept)	1600000	109690	14.587	7.36e-10 ***
treatment1	-1052485	155124	-6.785	8.81e-06 ***
policy_change_20161	-298008	116343	-2.561	0.0226 *
DID_2016	218544	164534	1.328	0.2053

Table 9: Coefficients of the Diff-in-Diff model for 2016

Variable	Estimate	Std. Error	t value	Pr($>\|t\|$)
(Intercept)	1436185	38739	37.073	2.23e-15 ***
treatment1	-905142	54786	-16.522	1.41e-10 ***
policy_change_20201	-227432	58109	-3.914	0.00156 **
DID_2020	105566	82178	1.285	0.21978

Table 10: Coefficients of the Diff-in-Diff model for 2020

The results of the Diff-in-Diff models show that policy changes in 2016 and 2020 had no significant effect on default rates in Belgium compared to France.

For the year 2016, the coefficient for the interaction *DID_2016* is not significant (p = 0.2053), indicating that the policy change in 2016 had no significant impact on default rates.

For the year 2020, the coefficient for the *DID_2020* interaction is not significant (p = 0.21978), indicating that the policy change in 2020 had no significant impact on default rates.

7.5 Logit model

Given that our results are probabilities between 0 and 1, it seems appropriate to perform a logit adjustment to our initial model to increase the precision of our model.

Logit regression, also known as logistic regression, is used to model the probability of a binary outcome based on one or more predictor variables. The logit model is defined as follows:

$$\log\left(\frac{P(Y=1)}{P(Y=0)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$$

Where:

- $P(Y=1)$ is the probability that the event (default) occurs,
- β_0 is the intercept,
- $\beta_1, \beta_2, \ldots, \beta_k$ are the coefficients for the predictor variables $X_1, X_2, \ldots, X_k$.

Logit regression is particularly useful when the dependent variable is binary, and enables us to understand the relationship between the predictor variables and the probability of the event occurring. The probabilities predicted by the logit model are always between 0 and 1.

Variable	Estimate	Std. Error	z value	Pr($>\|z\|$)
(Intercept)	0.4816	0.1051	4.582	0.000427 ***
treatment_centered	-2.6816	0.2102	-12.757	4.25e-09 ***
policy_change_2016_centered	-1.1758	0.3453	-3.405	0.004270 **
DID_2016_centered	1.7926	0.6906	2.596	0.15026

Table 11: Logistic regression results for 2016

Variable	Estimate	Std. Error	z value	Pr($>\|z\|$)
(Intercept)	0.42200	0.09775	4.317	0.00071 ***
treatment_centered	-2.57089	0.19551	-13.150	2.87e-09 ***
policy_change_2020_centered	-0.70583	0.19280	-3.661	0.00257 **
DID_2020_centered	0.67434	0.38560	1.749	0.10221

Table 12: Logistic regression results for 2020

The results of these models validate the results we obtained in our initial Diff-in-Diff model, and so we can confirm that the LTV policy changes of 2016 and 2020 have no significant impact on the default rate.

Robust Standard Errors

Robust standard errors are used to correct potential violations of the homoscedasticity assumptions in regression models. They provide more reliable estimates of the standard errors of the coefficients, allowing for more robust significance tests.

Robust standard errors are calculated by adjusting the variance-covariance matrix of the estimated coefficients. The formula for the robust variance-covariance matrix is as follows:

$$\hat{V}(\hat{\beta}) = (X'X)^{-1} \left(\sum_{i=1}^{n} \hat{u}_i^2 x_i x_i' \right) (X'X)^{-1}$$

where:

- X is the matrix of explanatory variables,
- $\hat{u}_i$ is the residual for observation i,
- x_i is the vector of values of the explanatory variables for observation i.

Variable	Estimate	Std. Error	z value	Pr($>|z|$)
(Intercept)	0.4816	0.12116	3.9745	7.053e-05 ***
treatment_centered	-2.6816	0.24233	-11.066	$<$ 2.2e-16 ***
policy_change_2016_centered	-1.1758	0.42610	-2.7595	0.00579 **
DID_2016_centered	1.7926	0.85219	2.1035	0.3542

Table 13: Robust standard errors for the logistic regression model for 2016

The robust standard errors confirm the significance of the coefficients for the intercept, treatment, and the 2016 policy change, but not for the interaction term (DID_2016). This indicates that the 2016 policy change did not have a significant impact on default rates in Belgium compared to France, even after correcting for heteroscedasticity.

Variable	Estimate	Std. Error	z value	Pr($>|z|$)
(Intercept)	0.42200	0.11776	3.5835	0.000339 ***
treatment_centered	-2.57089	0.23552	-10.9156	$<$ 2.2e-16 ***
policy_change_2020_centered	-0.70583	0.21885	-3.2252	0.001259 **
DID_2020_centered	0.67434	0.43770	1.5407	0.123397

Table 14: Robust standard errors for the logistic regression model for 2020

The robust standard errors confirm the significance of the coefficients for the intercept, treatment, and the 2020 policy change, but not for the interaction term (DID_2020). This indicates that the 2020 policy change did not have a significant impact on default rates in Belgium compared to France, even after correcting for heteroscedasticity.

7.6 Conclusion

Analysis of equality of variance tests, Student's t-tests and Diff-in-Diff models shows that policy changes in Belgium in 2016 and 2020 have had no significant impact on default rates compared to France. Robust standard error results reinforce this conclusion, indicating that the results are reliable.

8 Discussion and implications of the results

The results of our statistical analysis, using equality-of-variance tests, Student's t-tests and Diff-in-Diff models, clearly indicate that policy changes in Belgium in 2016 and 2020 had no significant impact on default rates compared with France. This lack of significant effect raises important questions about the effectiveness of restrictive policies concerning the Loan-to-Value (LTV) ratio as an instrument of financial regulation.

Policies aimed at limiting the LTV ratio are often justified by the need to reduce financial risk and improve housing market stability. However, the results show that these measures have not had the desired effect on default rates, suggesting that other factors may play a more determining role in the financial stability of borrowers, such as general economic conditions, income levels or the structure of the job market.

Restrictions on the LTV ratio can limit access to mortgages, particularly for first-time buyers and low-income households unable to afford a large down payment. While these restrictions have no significant effect on default rates, they can nevertheless have significant social consequences by reducing housing affordability, raising the question of fairness and equity in access to housing, a fundamental right for many individuals and families.

The results of this study suggest that policymakers may need to consider other

types of intervention to improve financial stability and the functioning of the housing market. For example, measures could be taken to improve household economic resilience, such as employment support policies, financial education programs or savings incentives.

9 Alternative LTV ratio system

Having established that the change in LTV policy has no significant impact on the probability of default, and not knowing the real motivations of the regulators behind these changes, it might be relevant to compare our Belgian system with that of Canada. Although these adjustments are most likely made with considerations of financial stability, it is hard to exactly infer in the underlying criteria or objectives, which purposefully desire to find a delicate balance between not having an excessively risky LTV while keeping the threshold at a level that allows credit accessibility.

This leads us to question the way LTV is currently managed in Belgium, and to consider potential alternatives. By widening our field of vision and looking at the Canadian system, we can identify different approaches. Canada uses an insurance principle that allows first-time buyers to borrow more than the country's maximum LTV, offering an interesting perspective from which to consider reforms in Belgium.

9.1 The LTV system in Canada

In Canada, the mortgage system is designed to make it easier for the first-time buyers, and others, to own their home using mortgage insurance. Any mortgage with an LTV greater than 80% must be insured. It is insured by organizations such as Canada Mortgage and Housing Corporation, Genworth Financial, and Canada Guaranty.

The insurance helps the lender against the default by the borrower. The borrower is required to pay a premium on mortgage insurance which may be added to the total loan amount or paid in one time at closing. This premium also varies based on LTV. The higher the LTV, the higher will be the premium.

For example, if the LTV is 95%, the premium is 4% of the amount borrowed. To

be able to apply for mortgage insurance, there are several requirements from the borrower; included here are a clean credit history record and excellent capability of repayment. Furthermore, insured loans must comply with the guidelines of the CMHC, one of which is that the maximum amortization period should not be greater than 25 years.

The process of getting an insured loan begins when the home buyer submits a mortgage application to the bank or lender. If the LTV is over 80%, the lender submits a simultaneous application for mortgage insurance to an insurer, such as CMHC. This insurer assesses this application in view of the borrowers' risk criteria and financial capabilities. Provided that the insurer accepts the application, it issues an insurance policy regarding default protection to the lender. The borrower is entitled to close the mortgage when the insurance is accepted. Other methods of paying for the premium involve including the amount within the total of the loan and as an upfront separate payment.

9.2 Comparative table of LTV systems in Belgium and Canada

Characteristics	**Belgium**	**Canada**
Maximum LTV	90% for first-time buyers	100% with mortgage insurance
Mortgage Insurance	Not required for LTV $\leq 90\%$	Required for LTV $> 80\%$
Lender Protection	Moderate	High with mortgage insurance
Interest Rates	Potentially higher	Potentially lower with insurance
Homeownership Accessibility	Good for first-time buyers	Very good with low initial down payment
Complexity	Relatively simple	Additional conditions for high LTV loans

Table 15: Comparison of LTV System in Belgium and Canada

Canada's LTV system, with the use of mortgage insurance for loans with LTVs over 80%, offers an interesting alternative for Belgium. By making home buying more accessible while protecting lenders, this system could inspire reforms in Belgium to improve housing affordability without compromising financial stability.

10 Further analysis

To extend this analysis further, it would be exciting to potentially look a couple of different things toward upcoming directions. vspace0.5cm
One first way to push the analysis further regards the data: Indeed, it would be very interesting to be able to proceed along the same kind of work but based on the severity of losses for banks if this level of data was available. By doing this research with those data available on loss severity, another hypothesis can be explored with respect to the reason for changes in LTV ratio policy in Belgium.

Another area of future research is examining the timeframe of our data. Since our policy changes happen in 2016 and 2020 while our analysis takes place in 2024, it might be the case that the policy changes did not have the desired effect and that this also takes place later on. Thus it would be really interesting to see if these results are replicated also in a few years. Moreover, our data relate to defects in France with a starting point in 2015. This gives us the slightest indication of the trend before the modification in 2016. This could be interesting to research for further accuracy.

Finally, it would also have been interesting to see the results obtained with the Synthetic Control Method. This last one actually being a more accurate method applied than the Difference-in-Differences, it reduces potential bias, and hence the better results are robust. Our efforts to obtain results using this method were, however, in vain because of a R package impossible to install on our computer.

11 Limitations

Our analysis is based on a number of assumptions and has certain limitations that it is important to highlight.

First of all, our worldwide LTV comparison analysis is a theoretical ratio for a person living alone. This ratio would therefore be different for people living as a couple. Secondly, this analysis is an average per country, so we can easily imagine that if the person lives in the city, the price of housing will be more expensive, and if he or she lives in the country, the price of housing will be cheaper. It is therefore important to bear in mind that this ratio is theoretical, but that very few people find themselves in this exact situation.

Furthermore, the additional costs associated with buying a property, such as notary fees, property taxes and insurance costs, have not been taken into account in the housing affordability calculations. These costs vary enormously from country to country, and they affect the ability of the households to buy a house.

Proceeding to our statistical tests data, we observe that for our 2016 model data: our data is not stationary, which is to say that test results for 2016 are to be taken with caution.

Another assumption is made that Covid-19 pandemic had a similar impact on the economy of each studied country. Such an assumption, however, ignores the possibility of variation in the economic responses of countries. The state aids in terms of the support measures from respective governments may have differed greatly in terms of speed, amount, and targeting between countries. Some countries have brought in direct subsidies, state-guaranteed loans, or tax deferrals, while others may have focused on indirect or sectoral support.

Finally, it also must be underlined, however, that the wage indexation and adjusting mechanisms in France and Belgium are very different. While in France, the

adjustments of wages can be done centrally or through company or branch negotiations, the effect of those collective bargaining settlements is quite formidable; in Belgium, it is directly connected to the level of inflation and heavily implemented. This impacts the purchasing power for workers and the costs for employers. These differences in wage policies can result in a huge impact on the economy of each country and on the comparability of economic data.

12 Conclusion

This analysis of the evolution and impact of loan-to-value (LTV) policies in various countries, and particularly in Belgium, has revealed several key points to highlight.

LTV policies have been underlined by the comparison between different countries, including their differentiated impacts on housing affordability and financial stability. Drawing a comparison with countries that are most economically similar to Belgium may then suggest that each country has adjusted its LTV policies according to its economic, political, and social context.

This work makes a comparison of LTV policies with countries most similar to Belgium economically. It appears that every country adjusts its LTV policies in accordance with its individual economic, political, and social context.

We applied a set of statistical tests to our policy changes in 2016 and 2020 to deduce an answer: equality of variance tests, Student's t-tests, Diff-in-Diff, and logit models all indicated that there was no significant impact of policy changes on the home loan default rate in Belgium relative to France.

These results clearly raise many questions about the effectiveness of LTV policies as a tool of financial regulation. That result suggests that factors other than LTV policies like the severity of banks' expected losses are reasons for change, but in the absence of data, it is impossible for us to say with certainty.

Such limitations of this study need to be kept in mind while interpreting the results: variable impact of the Covid-19 pandemic on the economies of different countries and differences in wage indexation mechanisms between France and Belgium. At the same time, such diversity of social protection systems and economic support policies can also introduce biases into the analysis that call for a more refined and differentiated analytical approach.

More rigorous collection and analysis of the data would give a better understanding of the implications of the LTV policies and their alternatives that may be considered in an attempt to strengthen financial stability and housing affordability. This also shows that it can help in ascertaining the resilience of the household economy through employment support policies, financial education programs, and savings incentives.

13 Appendix

13.1 Costs to have a credit in each country

Country	Total amount for house	Maximum loaned money	Money to bring
Belgium	361,680.00	325,512.00	36,168.00
Sweden	261,284.00	222,091.40	39,192.60
Denmark	425,248.00	340,198.40	85,049.60
Finland	188,600.00	179,170.00	9,430.00
France	344,288.00	292,644.80	51,643.20
Israel	655,615.00	491,711.25	163,903.75
Canada	437,858.91	437,858.91	Insurance price

Table 16: Summary of home-buying costs and lending policies by country expressed in EUR

13.2 Results of R tests

13.2.1 Hypothesis of the model

```
> print(adf_test_log_diff3_2016)

        Augmented Dickey-Fuller Test

data:  data_long %>% filter(year >= 2016) %>% .$log_default_rate_diff3
Dickey-Fuller = -2.7106, Lag order = 1, p-value = 0.3017
alternative hypothesis: stationary

> print(adf_test_log_diff3_2020)

        Augmented Dickey-Fuller Test

data:  data_long %>% filter(year >= 2020) %>% .$log_default_rate_diff3
Dickey-Fuller = -4.4967, Lag order = 1, p-value = 0.01
alternative hypothesis: stationary
```

Figure 3: Stationarity

```
> print(bptest_2016_mixed)

        studentized Breusch-Pagan test

data:  log_default_rate ~ fitted(model_2016_mixed)
BP = 2.3895, df = 1, p-value = 0.1222

> print(bptest_2020_mixed)

        studentized Breusch-Pagan test

data:  log_default_rate ~ fitted(model_2020_mixed)
BP = 1.5673, df = 1, p-value = 0.2106
```

Figure 4: Homoskedasticity

```
> print(dw_test_2016)

        Durbin-Watson test

data:  log_default_rate ~ fitted(model_2016_ar)
DW = 0.84405, p-value = 0.005614
alternative hypothesis: true autocorrelation is greater than 0

> print(dw_test_2020)

        Durbin-Watson test

data:  log_default_rate ~ fitted(model_2020_ar)
DW = 1.6198, p-value = 0.2751
alternative hypothesis: true autocorrelation is greater than 0
```

Figure 5: Autocorrelation

```
> print(shapiro_test_2016_mixed)

        Shapiro-Wilk normality test

data:  residuals(model_2016_mixed)
W = 0.94806, p-value = 0.3954

> print(shapiro_test_2020_mixed)

        Shapiro-Wilk normality test

data:  residuals(model_2020_mixed)
W = 0.94498, p-value = 0.3517
```

Figure 6: Normality

13.2.2 Results of statistical tests

```
> print(levene_test_2016)
Levene's Test for Homogeneity of Variance (center = median)
      Df F value Pr(>F)
group  1  1.6036 0.2235
      16
> print(levene_test_2020)
Levene's Test for Homogeneity of Variance (center = median)
      Df F value Pr(>F)
group  1  1.2354 0.2828
      16
```

Figure 7: Levene test

```
> print(t_test_2016)

        Two Sample t-test

data:  default_rate by as.factor(year >= 2016)
t = 0.53773, df = 16, p-value = 0.5982
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -555324.3  932796.7
sample estimates:
mean in group FALSE  mean in group TRUE
         1073757.5           885021.3

> print(t_test_2020)

        Two Sample t-test

data:  default_rate by as.factor(year >= 2020)
t = 0.795, df = 16, p-value = 0.4382
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -291060.5  640358.2
sample estimates:
mean in group FALSE  mean in group TRUE
          983613.7           808964.9
```

Figure 8: Student t-test

```
Call:
lm(formula = default_rate ~ treatment + policy_change_2016 +
    DID_2016, data = data_long)

Residuals:
    Min      1Q  Median      3Q     Max
-191992  -46962       0   52372  198008

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)          1600000     109690  14.587 7.36e-10 ***
treatment1          -1052485     155124  -6.785 8.81e-06 ***
policy_change_20161  -298008     116343  -2.561   0.0226 *
DID_2016              218544     164534   1.328   0.2053
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 109700 on 14 degrees of freedom
Multiple R-squared:  0.9528,    Adjusted R-squared:  0.9427
F-statistic: 94.17 on 3 and 14 DF,  p-value: 1.61e-09

> summary(model_2020)

Call:
lm(formula = default_rate ~ treatment + policy_change_2020 +
    DID_2020, data = data_long)

Residuals:
    Min      1Q  Median      3Q     Max
-165262  -39470    8343   39008  163815

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)          1436185      38739  37.073 2.23e-15 ***
treatment1           -905142      54786 -16.522 1.41e-10 ***
policy_change_20201  -227432      58109  -3.914  0.00156 **
DID_2020              105566      82178   1.285  0.21978
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 86620 on 14 degrees of freedom
Multiple R-squared:  0.9706,    Adjusted R-squared:  0.9642
F-statistic: 153.8 on 3 and 14 DF,  p-value: 5.954e-11
```

Figure 9: Diff in diff

```
> print(robust_se_2016)

t test of coefficients:

                      Estimate  Std. Error     t value  Pr(>|t|)
(Intercept)         1.6000e+06  7.7610e-11  2.0616e+16 < 2.2e-16 ***
treatment1         -1.0525e+06  1.0976e-10 -9.5892e+15 < 2.2e-16 ***
policy_change_20161 -2.9801e+05  5.2058e+04 -5.7245e+00 5.254e-05 ***
DID_2016             2.1854e+05  5.8172e+04  3.7569e+00  0.002124 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> print(robust_se_2020)

t test of coefficients:

                    Estimate Std. Error  t value  Pr(>|t|)
(Intercept)          1436185      58355  24.6112 6.354e-13 ***
treatment1           -905142      59603 -15.1861 4.323e-10 ***
policy_change_20201  -227432      77664  -2.9284   0.01101 *
DID_2020              105566      80270   1.3151   0.20960
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 10: Robust se

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This study assesses the impact of loan-to-value (LTV) policies on mortgage default rates in Belgium. First, it compares housing affordability in Belgium with that of economically similar countries such as France, Denmark, Finland, Sweden, Canada and Israel.
We will see that Belgium is in the middle of the pack when it comes to housing affordability, with a theoretical time to obtain a mortgage of 2.88 years.
The analysis focuses on policy changes in 2016 and 2020 in Belgium. The results show that policy adjustments in 2016 and 2020 had no significant effect on mortgage default rates.
Statistical tests, including equality of variance tests, Student's t-tests and Diff-in-Diff models, indicate that policy changes had no significant impact on default rates in Belgium compared to France.
These results raise questions about the effectiveness of LTV policies as a tool of financial regulation.
Other factors, such as general economic conditions and income levels, appear to play a more decisive role in the financial stability of borrowers.

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