Recourse and (strategic) mortgage defaults: Evidence from changes in housing market laws

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Abstract

We study the impact of changes in recourse legislation on mortgage defaults. Romania provides us with an ideal experimental setting to identify this impact. Using a large dataset of mortgage loans granted between 2003 and 2016, combined with individual income tax records, we exploit an exogenous variation in Romanian recourse policy and analyze the behavior of borrowers with mortgages issued under a creditor-friendly recourse regime after a change in policy limited lender recourse. We find robust evidence that eliminating penalties for default raises the probability of default for existing borrowers, encouraging a deterioration in payment discipline, especially for those traditionally considered least likely to default (i.e., those with higher income and lower leverage). Our findings highlight the ex-post effects of a switch from a creditor- to a debtor-friendly recourse policy. Broadly, our results point to the importance of assessing borrowers' default incentives before introducing legislation with retroactive applicability.

Keywords: Mortgage market; Recourse; Mortgage default; Moral hazard; Negative equity.

JEL classification: G21, G28, K11, R20, R30.

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1. Introduction

Mortgage delinquencies and foreclosures have severe implications for the affected households and, more generally, for financial stability.[1] Mortgage defaults affect the solvency of lending institutions, impeding their capacity to extend credit. In the aftermath of the Global Financial Crisis, housing markets, particularly mortgage debt, have been identified as the main drivers of the spillover effects on the real economy (Mian and Sufi, 2014a). Many borrowers defaulted on their mortgage obligations on both sides of the Atlantic. However, the default rates in Europe were markedly lower than in the U.S. One of the key reasons for this observed pattern has been the contrast between the European and U.S. recourse laws. In all European countries, mortgages are recourse loans. When the market value of a borrower's house upon foreclosure does not cover the mortgage debt, the lender can claim the borrower's personal (unsecured) assets, as well as their future income. In contrast, many U.S. states are non-recourse.[2] Lenders are limited in their claims to the secured asset only. Thus, borrowers are not further liable for any losses incurred by the lenders when the foreclosure sales proceedings do not cover their debts. Arguably, the borrowers' limited liability in non-recourse jurisdictions may contribute to a higher likelihood of mortgage default. This paper presents new evidence on how the provisions of recourse legislation influence default on mortgages.

Understanding the relationship between recourse procedures, as a form of credit forbearance, and borrower default is important for policymakers and financial institutions alike. The widespread policy of credit forbearance during the pandemic crisis of 2020 and the associated difficulties in estimating potential credit losses highlight this relationship's current relevance. Uncertainty about borrowers' attitudes towards repayment - caused by a moratorium on their payment obligations - could incentivize lenders to tighten credit conditions when credit defaults rise, amplifying spillover effects to the real economy. The existing literature provides valuable insights on the impact of recourse procedures on borrowers' attitudes towards default. Yet, most studies take a static approach: they examine various aspects of the default process by contrasting recourse vs. non-recourse states or countries. Relatively little is known about the dynamic effects of changes in recourse legislation in a given jurisdiction and the extent to which

[1] The negative effects spread across different dimensions. Mortgage defaults generate relocation costs for borrowers (Foote and Willen, 2018), reputation costs (e.g., lower credit scores; see Demyanyk et al., 2011), social stigma (Elul et al., 2010; Bhutta et al., 2017), and amplify downward trends in house prices (Gerardi et al., 2008; Campbell et al., 2011; Guren and McQuade, 2020) reducing lenders profitability and capitalization.

[2] Thirteen U.S. states do not allow for recourse in mortgage loan contracts (Páscoa and Seghir, 2020). Ghent and Kudlyak (2011) and Mitman (2016), among others, discuss the cross-state differences in recourse procedures in the U.S. Feldstein (2008) argues that U.S. mortgages are effectively non-recourse since lenders must seek judicial permission to foreclose a defaulted household even in states that have adopted a recourse legislation.

these changes are associated with the variation of mortgage probability of default. The reason is that estimates of the moral hazard effects are difficult to obtain since natural experiments such as time variation in recourse procedures for individual jurisdictions are rare.[3]

Our paper addresses this gap and provides empirical evidence on the incidence of mortgage arrears in a dynamic setting.[4] We study the case of Romania, where we can exploit the event of a change in the housing market laws, an event that is uniquely suited to study the incentives for mortgage default in a dynamic setting as the new law modified the status of *existing* mortgages from recourse to non-recourse loans. The introduction of the *Datio in Solutum* law (Giving in Payment law) and its retroactive applicability provisions allowed all borrowers to fully settle their liabilities by simply transferring the mortgage ownership to the lender (i.e., "walk away") without any deficiency judgments. Broadly, the introduction of non-recourse legislation has two potential implications. The first is an ex-ante effect. Banks become risk-averse (thus tightening credit standards) as their expected loss given default increases. The non-recourse regime can be seen as beneficial, as the risk is borne by economic agents that are better equipped to manage it. The second considers the ex-post effect of legislation: non-recourse encourages moral hazard by reducing borrowers' skin in the game (i.e., the potential loss in case of default). Our unique dataset allows us to focus on the latter effect. We use a granular dataset of mortgage loans provided by the National Bank of Romania's credit registry for our analysis. Our dataset consists of over 339 thousand unique mortgages originated between 2003 and 2016.[5] In addition, we complement the information from the credit registry with individual data from the Ministry of Finance. This permits us to derive affordability indicators reflecting borrowers' indebtedness.

First, we identify borrowers that defaulted on their mortgage obligations before and after the introduction of *Datio in Solutum* law, as well as those who requested to give in payment, to analyze how the law's introduction affects borrowers' mortgage repayment behavior. We consider a mortgage delinquent when it is over 90 days past due. Second, we relax the assumption that mortgage probability of default responds uniformly to the introduction of *Datio in Solutum* law and assess the potential asymmetric effects of several borrower and loan characteristics under the new recourse regime.

[3] An exception is Li and Oswald (2017), who show that changes in recourse laws are associated with a decline in mortgage approval rates and loan size at origination.

[4] Throughout the paper, we use "arrears", "delinquencies", and "defaults" interchangeably, referring to past due payment obligations.

[5] The loan-level data from the credit registry contains information about loan size at origination, the currency of denomination, residual maturity, current interest rate, current loan-to-value ratio, the name of the originating bank, the year of origination, and a selective number of borrowers' socio-economic characteristics.

Our main results can be summarized as follows. First, we complement the existing literature and show that low income, high indebtedness, large loan amounts at origination, foreign-currency denomination, high-interest rates, and negative equity (i.e., the outstanding mortgage exceeds the market value of the house) have strong positive associations with default. Second, we find robust evidence that switching from recourse to non-recourse leads to a 60 percent increase in the one-year probability of default for borrowers who could apply to give in payment, while not affecting those not eligible for requesting *Datio in Solutum*. For borrowers who requested *Datio in Solutum,* the average probability of default increases by 5.1 percentage points (i.e., a 30-fold increase). Third, our results suggest that the relationship between borrower and loan characteristics, and mortgage default, is non-monotonic. We observe the strongest effects on non-repayment after the introduction of *Datio in Solutum* for less-financially constrained borrowers (i.e., those with lower debt service to income ratios or higher incomes), those with negative equity, and for those with larger loan amounts at origination. Our findings are consistent with the idea of strategic default, as borrowers less leveraged (either because of higher income or lower debt) are expected to default less. At the same time, borrowers with negative equity and higher loan amounts stand to gain more from the difference between the outstanding mortgage debt and the current value of the collateral in a non-recourse environment.

Our paper adds to two main strands in the literature. First, it contributes to the growing literature on the determinants of mortgage default and especially to the literature studying the impact of recourse procedures on borrowers' probability of default. The empirical evidence on mortgage default points to a strong relationship between mortgage delinquencies and two important housing variables: home equity and recourse procedures.[6] Several papers indicate that borrowers with low or negative home equity are more likely to default (Guiso et al., 2013; Demiroglu et al., 2014; Foote and Willen, 2018). However, few papers argue that negative equity is a necessary but not a sufficient condition for default (Foote et al., 2008). Financially-constrained borrowers with negative equity default sooner than unconstrained borrowers as they value the immediate budget relief from default more highly relative to the longer-term costs (Campbell and Cocco, 2015). These papers show that besides negative equity, adverse macroeconomic (e.g., unemployment) or personal (e.g., reduction of income, job loss, illness, divorce) shocks that worsen borrowers' liquidity constraints may explain borrowers' default

[6] Default decisions may also depend on the borrower's house price expectations (Deng et al., 2000; Bhutta et al., 2010; Elul et al., 2010) and transaction costs (Bhutta et al., 2017). Guiso et al. (2013) show that borrowers' propensity to default is also determined by non-pecuniary factors, such as fairness, stigma, and morality.

behavior.[7] We add to this literature by showing that negative equity is positively associated with default and provide evidence that switching from recourse to non-recourse legislation leads to a 100 percent increase in the probability of default for underwater borrowers.

In addition to negative equity, another critical determinant of the mortgage default is the recourse legislation.[8] When considering specific recourse legislation, policymakers face the following trade-off: on the one hand, in a creditor-friendly recourse regime, borrowers bear all the default risk. When macroeconomic uncertainty arises, fearing financial distress, people start saving more because default is not an option. This may affect the aggregate demand and, subsequently, the business cycle. On the other hand, in a borrower-friendly recourse regime, lenders bear all the risk. Borrowers' limited liability may incentivize risk-taking in the housing market. The effects are twofold. First, the increase in moral hazard amplifies the housing price cycle. Second, lenders adjust their lending behavior to insure themselves against future delinquencies. They will impose higher costs (e.g., higher interest rates or larger down payments) on all borrowers to compensate for the potential losses. Higher financing costs and larger down payments may, in turn, limit housing consumption and affect the real economy.

Although the recourse is perceived as an efficient tool for deterring (strategic) defaults (Ambrose et al., 1997), empirical and theoretical findings are inconclusive. Several papers find that recourse mortgages are associated with a significantly lower likelihood of default (Demiroglu et al., 2014; Corbae and Quintin, 2015; Bhutta et al., 2017), with recourse reducing borrowers' sensitivity to negative equity (Ghent and Kudlyak, 2011). A few papers show that the effect of recourse on default rates is non-monotonic (Hatchondo et al., 2015) and may, in fact, incentivize risk taking in the housing market (Gete and Zecchetto, 2022). Stricter recourse policies may create conditions for lax lending standards that raise the loan-to-value (LTV) ratios and, therefore, may increase borrowers' indebtedness and probability of default. Additionally, a creditor-friendly recourse lowers the financing costs for borrowers with a high-risk profile and may cause more profound and persistent recessions. Our paper contributes to this literature and provides novel evidence on the impact of changes in recourse legislation on mortgage default. We differ from the existing papers by focusing on the dynamic effects of recourse policy. We are first to show the ex-post impact of a change from a creditor-friendly to a debtor-friendly recourse policy in the context of retroactive applicability of the new legislation.

[7] Studies supporting the dual-trigger hypothesis include, among others, Bajari et al. (2008), Connor and Flavin (2015), Bhutta et al. (2010, 2017), Fuster and Willen (2017), Gerardi et al. (2018), Schelkle (2018), and Pavan and Barreda-Tarrazona (2020).

[8] Recourse legislation has important implications not only in terms of borrowers' protection (Harris and Meir, 2016), but also for house prices (Nam and Oh, 2021), housing consumption (Hatchondo et al., 2015), lending activity (Meador, 1982; Pence, 2006; Li and Oswald, 2017), and economic recovery (Gete and Zecchetto, 2023).

Second, our paper relates to the literature on the impact of debt relief programs. The event studied in this paper shares some similarities with the U.S. refinancing programs (e.g., the Home Affordable Refinancing Program – HARP, and the Home Affordable Modification Program – HAMP) introduced in the aftermath of the Global Financial Crisis as a response to the widespread financial distress triggered by the housing market downturn.[9] However, there is an important distinction between the provisions of the Romanian recourse law and those of the U.S. programs. The main difference relates to the party that may request the modification of the loan agreement. While under the Romanian *Datio in Solutum* recourse law, the decision to terminate the loan contract and discharge mortgage obligations by transferring the property was in the borrowers' hands, the U.S. programs were implemented voluntarily by the financial intermediaries.[10] In the U.S., to qualify for the refinancing programs, a borrower had to satisfy beforehand several relevant eligibility criteria as a proof of financial hardship, including a specific loan-to-value ratio (for HARP) or a specific debt-to-income ratio (for HAMP). In contrast, in Romania, all existing and new borrowers with mortgages below 250,000 euro were eligible under the new recourse law, except for the borrowers that benefited from governmental guarantees under specific lending programs. As no specific prerequisites were specified regarding borrowers' indebtedness or payment delays, *Datio in Solutum* encouraged moral hazard as borrowers who could pay their debt were presented with an alternative option – to walk away from their mortgage obligations. Earlier studies focusing on loan modifications and refinancing programs report mixed results. Some papers find that these policies reduce mortgage default and prevent excessive foreclosures (Agarwal et al., 2017; Gabriel et al., 2021). Conversely, there is evidence that a foreclosure moratorium does not limit the default rates among borrowers who benefit from loan modification (Collins and Urban, 2018), or that mortgage modification programs are associated with a substantial strategic response among homeowners (Mayer et al., 2014).

The closest papers to ours are Artavanis and Spyridopoulos (2021) and O'Malley (2021). Artavanis and Spyridopoulos (2021) exploit the simultaneous introduction of a foreclosure moratorium and a new personal bankruptcy law in Greece and find that one-third of defaulters are strategic after the introduction of these programs. Similarly, O'Malley (2021) studies the introduction of a repossession law in Ireland that prohibited collateral enforcement on delinquent residential mortgages originated before a particular date and reports a significant

[9] Other U.S. programs introduced to prevent foreclosures include FHASecure (September 2007), Hope Now Alliance (October 2007), Teaser Freezer (December 2007), Hope for Homeowners (2008), and California Foreclosure Prevention Laws (2008).

[10] For details on the application of U.S. programs, see Agarwal et al. (2017, 2023), Foote and Willen (2018), and Piskorski and Seru (2018).

increase in default rates for borrowers that could benefit from the legal ruling. Our paper differs from these papers in that our natural experiment setup allows us to study the behavior of borrowers with mortgages issued under a recourse regime at a later date when the recourse legislation (which was supposed to have *permanent* applicability from the moment of enactment) changed. In these other papers, the focus is on a *temporary* suspension of collateral enforcement.

The rest of the paper proceeds as follows. Section 2 describes the institutional environment and provides an overview of Romanian recourse law. Section 3 presents a stylized theoretical framework that shows how the variation of recourse intensity may affect a borrower's repayment decision. Section 4 describes the dataset and presents stylized facts. Section 5 outlines the methodology. Section 6 presents the results and Section 7 concludes.

2. Legal framework

Datio in Solutum law no. 77/2016 was published in the Official Gazette of Romania no. 330 on 28 April 2016. The law introduced the giving in payment as a form of satisfying outstanding credit obligations. It offered mortgage borrowers the possibility to fully settle their liabilities with a credit institution by simply transferring the mortgage ownership without any deficiency judgments instead of repaying their debt. Put differently, the law introduced a form of mortgage debt relief (i.e., walk away), publicly announced as a social program for distressed borrowers who could not service their payment obligations.[11] All existing and new retail mortgage loans were eligible, except for loans over 250,000 euro and those granted under the *First Home* program.[12, 13]

Datio in Solutum law has created a series of challenges for the Romanian banking sector. Economists, politicians, and the public alike hotly debated the law's provisions. On the one hand, the law's promoters argued that many financially constrained borrowers would benefit from requesting *Datio in Solutum*, with expectations running as high as 80,000 potential

[11] See https://www.senat.ro/legis/PDF/2015/15L450EM.pdf.
[12] Corporate loans secured with real estate guarantees were not eligible. Likewise, mortgage loans for which the main collateral was not used as a dwelling, or those granted to borrowers that have been convicted for offenses connected with the loan, were not eligible either.
[13] The *First Home* program represents a governmental initiative introduced in 2009 to facilitate individuals' access to the purchase or construction of a dwelling by contracting state-guaranteed loans. The program brings several benefits for borrowers, such as preferential interest rates and lower down payments.

requests. Banks loan loss provisions increased in order to absorb higher expected losses, leading to a deterioration in the profitability and capitalization of the banking sector.[14]

However, the opposite was the case. Initially, the mortgage NPLs rate increased rapidly by 1.6 percentage points between May 2016 and June 2016 (Figure B.1). The probability of default for eligible loans exhibited a similar pattern, increasing from 0.8 percent in January 2016 to 1.2 percent in October 2016, while that for *First Home* loans was relatively unchanged (Figure B.2). Despite this short-term reaction, less than a tenth of the expected requests materialized. Second, the proponents thought that the law might enable a more efficient risk-sharing between lenders and borrowers, which may prevent future credit crises and enhance financial stability (Macovei, 2019).[15]

On the other hand, the law faced criticism on several grounds. The critics highlighted that one of the law's main shortcomings was its retroactive applicability to all existing loans. They pointed out that enacting the law with a backward-looking provision may have unintended consequences for new borrowers concerning the increased cost of credit, reduced approval rates, and lower credit amounts, thus reducing borrowers' access to finance.[16] As expected, banks tightened their credit standards as soon as the law was enacted by increasing the required down payments for mortgage loans to discourage new borrowers from walking away from their mortgage obligations. The median LTV for new mortgage loans decreased from 80 percent in March 2016 to 71 percent in September 2016 (Figure B.3).[17] Second, critics argued that the law might create moral hazard by incentivizing strategic behavior. Considering this (potential) undesired impact that the law could have on borrowers' attitudes toward repayment, the National Bank of Romania strongly advocated that the law should be based on clear principles that would distinguish between borrowers facing genuine affordability problems and opportunistic borrowers. As a result of the introduction of *Datio in Solutum* law, one of the most important systemic risks identified by the central bank for 2016 was the uncertain and unpredictable legislative framework in the financial and banking sectors (NBR, 2016).

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[14] Notification of Systemic Risk Buffer according to article 133 of Directive 2013/36/EU, National Bank of Romania, Financial Stability Department, available at https://www.esrb.europa.eu/pub/pdf/other/20161230_notification_ro_srb.en.pdf.

[15] Risk-sharing between lenders and borrowers has been associated with a reduction in the incidence of foreclosures and the severity of future housing crises (Piskorski and Tchistyi, 2011; Campbell, 2013; Eberly and Krishnamurthy, 2014; Mian and Sufi, 2014b; Mian et al., 2015). Risk-sharing may also limit negative externalities (Guiso et al., 2013; Melzer, 2017). These effects are beneficial during periods of adverse economic conditions (Piskorski and Seru, 2018).

[16] Increased protection for borrowers in default in the form of no deficiency judgments generates losses for lenders that are, in turn, indirectly transferred to new borrowers. Lenders reduce approval rates or restrict lending volumes (Lin and Oswald, 2017) and increase credit costs in the long run (Agarwal et al., 2017).

[17] Figure B.3. illustrates one dimension of how banks changed their lending behavior after the law's enactment. To estimate the impact of this legislation change, we focus our empirical analysis on loans granted before May 2016 to guarantee the alikeness of our set of loans.

Few months after the law had been enacted, lending institutions claimed that *Datio in Solutum* law was not in accordance with the Romanian Constitution and Civil Code and presented their unconstitutional objections to the Constitutional Court. The main arguments brought forward were the law's non-compliance with the principle of separation of power, the right to ownership, the non-retroactivity principle, the right to legal certainty, and freedom of commerce (Bulgaru and Lepădatu, 2016).

In October 2016, the Constitutional Court announced its decision on the credit institutions' objections of unconstitutionality related to the *Datio in Solutum* law. The Constitutional Court's decision no. 623/2016 was published in the Romanian's Official Gazette in January 2017 and stipulated that borrowers had the right to discharge their debt and give in payment their real estate property only if certain unforeseeability conditions, as certified by the Court of Law, were met. An immediate consequence of this ruling was that borrowers could not use the price devaluation of the real estate acquired through a credit agreement as a reason to discharge their debt by using *Datio in Solutum* law. The Constitutional Court's ruling clarified the legislative framework around the law, reducing the uncertainty for the banking sector. Following the decision, the mortgage NPLs rate decreased by 1.1 percentage points between January 2017 and February 2017 (Figure B.1).

Six years after the law had been enacted, there were 10,474 notifications to give in payment, out of which 60 percent of requests were submitted in 2016, 13 percent in 2017, and the remaining 27 percent between 2018 and September 2022. Most of the requests for *Datio in Solutum* were for loans denominated in euro and Swiss francs (i.e., 48 and 41 percent, respectively). The lending institutions contested 62 percent of all the requests (6,519), while 23 percent of them were still pending for approval as of September 2022. Only 14.5 percent (1,519) of all requests were approved, out of which 9.4 percent were represented by euro-denominated loans, 3.3 percent by Swiss francs loans, and 1 percent for loans in the domestic currency. The number and rate (i.e., the number of requests divided by total eligible customers) of requests for giving in payment have significantly decreased over the years.

3. Theoretical framework

We present a stylized theoretical framework to study how the variation of recourse intensity may affect a borrower's default decision. The interaction between recourse policy and borrower incentives might depend on the borrower's wealth, the value of the property and outstanding

mortgage balance, and the cost of bankruptcy.[18] To understand this interaction, we develop a simple one-period model that helps us derive empirical predictions.

Set-up

Consider a zero-interest, risk-neutral environment. In this economy, there is a borrower with a personal wealth W (for simplicity, we consider that the income is a component of this wealth, in addition to other assets). The borrower has a house that is currently worth H in market prices. The house was financed with a mortgage, and the borrower has a remaining balance M on this mortgage. Since the strategic default on the mortgage is not optimal when $H>M$ (because in this case, the borrower can sell the house and repay the mortgage), we assume that the borrower is underwater (or put differently, the borrower has negative equity because of a house price decline):

$$H < M. \quad (1)$$

We also assume that

$$W > M\text{-}H, \quad (2)$$

so that the borrower has enough (liquid) wealth to repay the outstanding debt in case of default.

There are non-zero costs for foreclosure (reflecting inefficiencies of the bankruptcy procedures), given by a parameter θ_C, with $0 \leq \theta_C \leq 1$: how much the lender can recover on the collateral. Basically, we assume that only a fraction $\theta_C H$ can be obtained upon borrower's default by selling the property in the market.[19]

The laws governing the housing market are given by a parameter θ that captures recourse intensity. Put differently, θ is a measure of how much recourse the lender has in case of borrower's default when proceeds from taking and selling the property (i.e., the collateral) are not sufficient to cover the borrower's debt.[20] We distinguish between two cases: recourse and non-recourse. In the recourse case, $\theta=\theta_R \in (0,1]$. The lender can pursue the borrower up to an amount $\theta_R(M-\theta_C H)$, representing the difference between the remaining balance on the loan,

[18] For simplicity, we abstract in our model from house price expectations (Foote et al., 2008) and idiosyncratic adverse shocks (such as job loss or health shock) specific to double-trigger models of default.

[19] An alternative interpretation for parameter θ_C is the fire sales effect: although the property's market price is H, the lender can realize the sale on short notice only at a discount.

[20] We abstract from general equilibrium considerations. For example, we ignore the fact that θ might influence H, the house's market price. Intuitively, when the recourse is more creditor-friendly (i.e., θ is larger), lenders might take more risk and increase risky lending as the borrowers bear most of the default risk. Such behavior may, in turn, increase the pressure on house prices. Our partial equilibrium approach is more appropriate to derive empirical predictions since our dataset consists exclusively of existing loans (i.e., we exclude loans granted after law enactment). Thus, the relationship between θ and H is less of a concern.

M, and the recovery price of the collateral, $\theta_C H$. The recourse procedure allows the lender to recover the partial loss of the outstanding loan. In the non-recourse case, $\theta=0$. The lender cannot recover anything from the borrower's personal wealth.

Equilibrium default decision for the recourse case

The borrower decides whether to continue paying the mortgage or default on their credit obligations. The purpose of our model is to show how various factors can affect the default decision. When the borrower repays their mortgage, the payoff is:

$$\Pi^R_{pay}=W+(H-M), \tag{3}$$

where W is the borrower's wealth, and $H-M$ is the loss due to the negative equity.

Now consider the borrower's payoff when they default on their payment obligations. Recall that when recourse is possible, the lender (partially) recovers the loan by selling the collateral at market price. In addition, the lender has recourse to the borrower's assets other than the property securing the mortgage. When the borrower defaults, they incur an opportunity cost C, reflecting a loss of reputation (e.g., due to negative impact on borrower's credit score) that may limit access to future funding. We assume that this cost is decreasing in wealth: $C(W)=C_R(1+1/W),\ C_R>0$.[21] The intuition for this functional form is as follows: for wealthier people, the loss of reputation is less critical than for the less affluent. Better-off people are less dependent on future borrowing because they can finance their consumption and investments from their wealth.[22] Then, the borrower's payoff from default is:

$$\Pi^R_{default}=W-\theta_R(M-\theta_C H)-C_R(1+1/W), \tag{4}$$

where $W-\theta_R(M-\theta_C H)$ is the borrower's remaining wealth net of repayment to their creditor,[23] and $C_R(1+1/W)$ is the opportunity cost of default.

The borrower has incentives to default instead of repaying their debt for $\Pi^R_{default} \geq \Pi^R_{pay}$, corresponding to (use (3) and (4)):

$$H \leq H_R^* = \frac{1-\theta_R}{1-\theta_R\theta_C}M - \frac{C_R}{1-\theta_R\theta_C}\left(1+\frac{1}{W}\right). \tag{5}$$

[21] In the absence of reputational considerations, our results would be stronger. Borrowers would have higher moral hazard incentives when information about their past actions is not shared among lenders. The lack of reputational costs corresponds to $C_R=0$. In Section 6 we empirically test whether wealthy people behave differently.

[22] Note that non-pecuniary costs (see Guiso et al.,2013, among others) are ignored in this model.

[23] Upon default, the lender takes the collateral and sells it at a discounted market price $\theta_C H$. The realized negative equity $\theta_C H-M$ is then claimed from the borrower's wealth W, and its recovery depends on the intensity of recourse procedure θ_R.

The expression (5) suggests that the default strategy can only dominate the repayment strategy when the market house price H is sufficiently low. The intuition is that the benefit to the borrower of choosing to default strategically is proportional to negative equity (which increases when the house prices are low, other things equal). The cost of defaulting is invariant to the scale of negative equity.

We can demonstrate that the borrowers' decision towards repayment is as follows:

- For θ_R=1 (i.e., full recourse on borrower's wealth), the borrower repays their mortgage regardless of the recovery rate (i.e., for any $0 \leq \theta_C \leq 1$) and the market value of the house, H.
- For $0<\theta_R<1$ (i.e., partial recourse on borrower's wealth), the borrower defaults strategically regardless of the recovery rate (i.e., for any $0 \leq \theta_C \leq 1$), but only when the market value of the house is low enough (i.e., $H \leq H_R^*$, with H_R^* given in (5)). For $H > H_R^*$, the borrower repays the mortgage.

This leads to an important prediction about the recourse procedure's intensity: the absence of full recourse creates incentives for strategic default when house prices are low.

Next, we show how the borrower's strategy (i.e., the decision on whether to default strategically or not) depends on the recourse intensity, on their wealth, on the residual mortgage balance, on the cost of default, and the recovery rate.

First, strategic default is less attractive under stricter recourse legislation.[24] The intuition for this result is that borrowers are less likely to default when lenders can collect a larger share of debt that is not covered by the foreclosures' proceedings, or when lenders are more likely to deny borrowers fully settlement of their liabilities by simply transferring the mortgage ownerships without any deficiency judgments. In other words, stronger creditor rights are associated with fewer incentives for strategic default. Second, the range of parameter values for which the borrower chooses to default strategically is strictly increasing in borrower's wealth W.[25] This result shows that, in our framework, wealthier borrowers have higher strategic incentives. The reason is that a higher wealth reduces the opportunity cost of default associated with the loss of reputation (that may, in turn, impede access to future credit), making default more attractive. Third, a higher outstanding mortgage balance M has a positive relationship with the likelihood of default.[26] The reason is that, ceteris paribus, a larger debt obligation

[24] By taking derivative $\frac{\partial H_R^*}{\partial \theta_R}$ we can show that $\frac{\partial H_R^*}{\partial \theta_R} = \frac{\theta_C - 1}{(1-\theta_R\theta_C)^2} - \frac{\theta_c C_R}{(1-\theta_R\theta_C)^2} \cdot (1 + \frac{1}{W}) < 0$.

[25] By taking derivative $\frac{\partial H_R^*}{\partial W}$ we can show that $\frac{\partial H_R^*}{\partial W} = \frac{C_R}{1-\theta_R\theta_C} \cdot \frac{1}{W^2} > 0$.

[26] By taking derivative $\frac{\partial H_R^*}{\partial M}$ we can show that $\frac{\partial H_R^*}{\partial M} = \frac{1-\theta_R}{1-\theta_R\theta_C} > 0$.

increases the payoff from default. Fourth, a lower opportunity cost of default C_R expands the range of parameter values for which the borrower defaults.[27] Low cost of default may result from a weaker institutional environment (e.g., less information sharing across creditors), which makes the penalty associated with default less severe. Finally, the recovery rate θ_C expands the range of parameter values for which a borrower chooses to default strategically.

Equilibrium default decision for the non-recourse case

Recall that our baseline model allows for a strictly positive parameter θ_R:$0<\theta_R\leq 1$. Consider now the effect of eliminating the possibility of recourse: $\theta_R=0$. When the borrower repays their mortgage, the payoff is similar to (3):

$$\Pi^{NR}_{pay}=W+(H-M), \tag{6}$$

where W is the borrower's wealth, and $H-M$ is the loss due to the negative equity. Now consider the borrower's payoff when they default on their payment obligations. When recourse is not possible anymore, the lender cannot recover anything from the borrower's assets beyond the property securing the mortgage. We assume that the opportunity cost of default remains the same as in the baseline model: $C_R(1+1/W)$.[28] The borrower's payoff from default is (similar to (4)):

$$\Pi^{NR}_{default}=W-C_R(1+1/W), \tag{7}$$

where W is the borrower wealth (which remains unaffected by default), and $C_R(1+1/W)$ is the opportunity cost of default.

The borrower has incentives to default instead of repaying their debt for $\Pi^{NR}_{default} \geq \Pi^{NR}_{pay}$, corresponding to (use (6) and (7)):

$$H \leq H^*_{NR} = M - C_R\left(1+\frac{1}{W}\right). \tag{8}$$

Similar to (5), the expression (8) suggests that the default strategy can only dominate the repayment strategy when the market house price H is sufficiently low. We can show that the threshold value H^*_{NR} (given in (8)) is larger than H^*_R (given in (5)).[29] Accordingly, the

[27] By taking derivative $\frac{\partial H^*_R}{\partial C_R}$ we can show that $\frac{\partial H^*_R}{\partial C_R} = -\frac{1}{1-\theta_R\theta_C}\cdot\left(1+\frac{1}{W}\right) < 0$.

[28] In a non-recourse environment, the opportunity cost of default might be higher than in a recourse economy as lenders would restrict access to credit in anticipation of strategic defaults (e.g., they may require higher up-front payments or limit the size of loans). Choosing a higher cost C_R into the model would not qualitatively affect our results.

[29] We can rewrite the inequality $H^*_R \leq H^*_{NR}$ as $-\theta_R\theta_C C_R\left(1+\frac{1}{W}\right) \leq \theta_R(1-\theta_C)M$.

borrower chooses to default for a wider range of parameter values. This is the main prediction of our model. It suggests that in the absence of a recourse procedure, borrowers are more likely to default strategically. The evolution of H_{NR}^{*} in response to changes in W, M, and C_R is similar to the evolution of H_R^{*}, confirming our theoretical predictions from the scenario with recourse. A borrower is more likely to default when their wealth W, or outstanding mortgage balance M, are higher, as well as when the opportunity cost of default C_R is lower.[30]

4. Data

To study the relationship between changes in the recourse procedure and mortgage defaults, we exploit the loan-level data from the credit registry provided by the National Bank of Romania. The registry covers all mortgages above 4,500 euros on the banks' balance sheets at the time of the analysis (i.e., 99% of existing loans). The dataset consists of 7 quarterly vintages from December 2014 to June 2016, thus providing an adequate time frame to study the potential effects triggered by the implementation of *Datio in Solutum* law. We classify a borrower as defaulting when her loan becomes non-performing (i.e., when the borrower encounters delays of more than 90 days in repaying credit obligations after the loan is included in a specific vintage) in the fourth quarter after the origination date of the vintage. In the case of debtors with multiple loans, we monitor the payment behavior only for mortgage loans.[31]

The loan-level data contains information about loan size at origination, the currency of denomination, residual maturity, current interest rate, as well as the name of the originating bank and the year of origination.[32] In the case of interest rate and residual maturity we construct a weighted average by outstanding balance for borrowers with multiple loans, while currency of denomination, year of origination and bank of origination are taken from the loan with the largest balance outstanding.

The registry also collects a selective number of borrowers' socio-economic characteristics (e.g., age, income, county of residence). This detailed information about borrower and loan characteristics allows for a granular analysis of the recourse law's impact on borrowers' behavior. We control in our empirical analysis for originating bank's risk-taking

[30] One can verify that $\frac{\partial H_{NR}^{*}}{\partial W} = C_R \cdot \frac{1}{W^2} > 0$, and $\frac{\partial H_{NR}^{*}}{\partial M} = 1 > 0$, and that $\frac{\partial H_{NR}^{*}}{\partial C_R} = -(1 + \frac{1}{W}) < 0$.

[31] Information regarding default is kept for 7 years in the credit registry.

[32] The residual maturity is the period in years from the moment of our analysis to the loan's contractual maturity. The interest rate is updated monthly, pointing to the current credit conditions. Approximately 90 percent of mortgage loans have a variable rate; therefore, the current interest rate is a better indicator of affordability problems than the interest rate at origination. Appendix A sets forth the definitions for the main variables used in the empirical analysis.

profile and state of the economy at the date of loan origination by introducing bank, year, and vintage dummies.

We apply several restrictions on our dataset. First, we exclude borrowers with multiple mortgage loans at the moment of creating specific vintages as they do not represent a typical borrower that acquires a property for residential purposes. Rather, they are motivated by speculative or buy-to-let investment strategies (Kelly et al., 2015).[33] Second, when constructing our vintages, we exclude the loans that "disappeared" from banks' balance sheets from December 2015 to June 2017, since we cannot determine their non-performance status (i.e., they are censored). Finally, we do not include borrowers that are already in default (i.e., they encounter payment delays of over 90 days) as our main aim is to quantify the impact of the introduction of *Datio in Solutum* on performing borrowers' behavior. Intuitively, the introduction of *Datio in Solutum* should not affect the incentives of borrowers with non-performing loans as they had already registered delays on their payment obligations before the law was enacted.

In our main empirical estimation we include *First Home* loans as a control group.[34] These specific loans benefit from government guarantees and are not eligible for *Datio in Solutum.* Put differently, the law's introduction should not impact the payment discipline of borrowers with *First Home* loans. Our initial dataset contains 1,9 million mortgage-data points and covers 339 thousand unique borrowers representing approximately 98 percent of the mortgage loans on banks' balance sheets at the time of the analysis.

For most of our empirical specifications that focus on the effect of the introduction of *Datio in Solutum* on the probability of default and associated non-linear effects, we consider a dataset consisting of standard mortgage loans only. This dataset contains 932 thousand mortgage-data points over seven quarterly vintages (December 2015 – June 2017), representing 165 thousand unique debtors. We restrict our sample for two quarters before and five quarters after the introduction of the law to isolate the noise and potential effects of other events.

We complement the information from the credit registry with individual income data from the Ministry of Finance. This allows us to obtain information about borrowers' indebtedness, which we use for deriving affordability indicators (e.g., debt-service-to-income ratio). We employ the methodology from Nier et al. (2019) for calculating debt service by

[33] Calculating loan-specific characteristics such as loan-to-value is more difficult for these borrowers. Our robustness test shows that including these borrowers does not affect our main results.

[34] Our sample is split roughly equally between standard mortgage loans (49 percent of the total) and *First Home* loans (51 percent). The *First Home* program was initially denominated in euros. Starting from August 2013, banks granted these loans only in domestic currency. Thus, the share of foreign-currency denominated loans for *First Home* was close to 100% between 2009 to 2012, decreasing to 75% in 2013 and going to zero in 2014.

considering the borrowers' overall indebtedness (i.e., by including consumer loan payments).[35] We classify borrowers in four different income categories: those earning below the medium wage, those earning between the medium wage and double the medium wage, those earning above double the medium wage, and those with unrecorded income.[36] Borrowers that are not in the Ministry of Finance's database are included in the category "unrecorded income" to distinguish them from borrowers with recorded information. Borrowers with unrecorded income represent 17 percent of our sample. Thus, excluding them might bias the estimation results. While we cannot rule out the fact that (some of) these borrowers might have additional sources of income either from unrecorded work or from other family members, we cannot compute their individual debt-service-to-income (DSTI) ratio.

Descriptive statistics

Table 1 presents the sample characteristics for the main variables used in our empirical analysis, highlighting the key differences between borrowers with standard vs. *First Home* loans. Borrowers with a standard mortgage loan tend to be older, with a mean age of 40 years compared to 34 years for *First Home* borrowers, and they have higher monthly incomes on average (800 vs. 641 euros). Standard mortgage loans have shorter maturities (18.5 vs. 24 years), larger amounts at origination (49,840 vs. 40,750 euros), and a higher degree of indebtedness (mean DSTI of 84 percent compared to 75 percent). The mean current LTV ratio is 84 percent for standard mortgage loans, while for *First Home* mortgage loans LTV cannot be computed due to governmental guarantees.

Table 2 provides summary statistics for our main variables conditioned on whether or not borrowers hold 90 days past-due loans or requested *Datio in Solutum*. The mean monthly income for performing borrowers is around two times larger than for non-performing borrowers (791 vs. 473 euros). The average monthly income for borrowers requesting *Datio in Solutum* is similar in magnitude with that of borrowers who did not request *Datio in Solutum*. Performing borrowers are significantly less indebted (as indicated by the DSTI ratio) than non-performing borrowers (89 vs. 161 percent). Likewise, borrowers that did not request *Datio in Solutum* are significantly less indebted than borrowers that requested *Datio in Solutum* (89 vs. 133 percent).

[35] Approximately 25 percent of borrowers in our sample have consumer loans in addition to their mortgages. Calculating loan-specific characteristics such as loan-to-value is more difficult for these borrowers. Our robustness test shows that including these borrowers does not affect our main results.

[36] The Ministry of Finance data contains information about borrowers' annual income for 2014 and 2015, and monthly income for 2016. When unavailable, the monthly income is calculated by dividing the annual income by 12. As a result of this approach, when a borrower is unemployed for some time during the year, their income is underestimated for the months they were employed.

Table 1. Summary statistics for main variables of interest – standard mortgage loans vs. *First Home* loans

	Standard mortgage			*First Home* mortgage			Difference
Variable	**N**	**Mean**	**St. dev**	**N**	**Mean**	**St. dev**	
Age[1)]	932,958	40	8	1,016,000	34	6	6***
Monthly income[2)]	744,439	799	810	862,535	641	535	158***
Current debt-service-to-income ratio[3)]	744,439	84	91	862,535	75	82	9***
Interest rate[3)]	932,958	4.50	0.91	1,016,000	4.18	0.73	0.32***
Residual maturity[1)]	932,958	18.5	7.0	1,016,000	24.0	5.1	-5.50***
Loan size at origination[2)]	932,958	49,840	36,570	1,016,000	40,750	15,290	9,090***
Foreign - currency denomination [3)]	932,958	68	47	1,016,000	62	49	6***

Notes: This table shows the summary statistics of the data used in the empirical analysis. See the appendix for the definitions of variables. [1)] years, [2)] amount in euro, [3)] percent. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Non-performing borrowers took out, on average, larger loans than performing borrowers (69,305 vs. 49,850 euros), with longer residual maturity (20 vs. 18.5 years), and with significantly higher current LTV ratios (117 vs. 83 percent). We present in Appendix A additional summary statistics for our sample along several dimensions: (i) by year of origination, (ii) by loan currency, (iii) by loan amount at origination, (iv) by current LTV, (v) by income group, and (vi) by the level of DSTI.

A similar pattern emerges when we compare the mean values of loan characteristics conditional on the status of *Datio in Solutum* request. Borrowers requesting *Datio in Solutum* have, on average, loans that are twice as large as borrowers that did not request *Datio in Solutum* (94,200 vs. 49,770 euros), with longer residual maturity (23 vs. 18.5 years), and higher current LTV ratios (168 vs. 83 percent). Non-performing borrowers are slightly underwater. On average, the value of their property is lower than the outstanding mortgage by almost 1,000 euros. The situation is much worse for borrowers requesting *Datio in Solutum*: their outstanding mortgage is, on average, with 21,760 euros higher than the current value of their property.

Table 2. Mean values for main variables by performance status and *Datio in Solutum* request – standard mortgage loans

Variable	Performing borrowers	Non-performing borrowers	Difference	Did not request DiS	Requested DiS	Difference
Monthly income[1)]	791	473	318***	790	799	-9
Current debt-service-to-income ratio[2)]	89	161	-72***	89	133	-44***
Current loan-to-value ratio[2)]	83	117	-34***	83	168	-85***
Interest rate[2)]	4.6	4.8	-0.2***	4.6	4.5	0.1***
Residual maturity[3)]	18.5	19.9	-1.4***	18.5	22.9	-4.4***
Loan size at origination[1)]	49,854	69,305	-19,451***	49,771	94,206	-44,435***
Equity[1)]	13,587	-989	14,576***	13,657	-21,762	35,419***

Notes: This table shows the mean values for the main variables conditional on borrowers' performing status and *Datio in Solutum* request. [1)] amount in euro, [2)] percent, [3)] years. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5. Methodology

In this section, we present the methodology used to assess the impact of *Datio in Solutum* on the borrower's probability of default and test the theoretical predictions from Section 3.

The probability of default is calculated using a pooled logit model where the dependent variable is a dummy-type variable $y_{i,t}$ which equals 1 if the borrower has delays longer than 90 days. The regressors are 12-month lagged borrower and loan characteristics (*t-1)*. The baseline model is a standard difference-in-difference estimation, as follows:

$$y_{i,t} = \alpha + \beta_0 * Standard\ mortgage_i + \beta_1 * DiS\ period_t + \beta_2 * Standard\ mortgage_i * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}, \quad (9)$$

where the indices *i* and *t* stand for borrower and time, respectively, *Standard mortgage* is a dummy variable that equals 1 for standard mortgage loans and 0 for *First Home* loans, *DiS period* is a dummy variable that equals 1 starting from 2016Q2 onwards and 0 before, *Z* and *L* are vectors of borrower and loan characteristics, respectively, and $\varepsilon_{i,t}$ is a scalar disturbance term which is assumed to be i.i.d.. We control for borrower characteristics such as current income, indebtedness (i.e., DSTI), and age. The vector of loan characteristics consists of loan size at origination, the currency of denomination, current LTV, residual maturity, and current interest rate. We include bank and year of origination fixed effects to control for different risk

policies across banks and macroeconomic conditions at origination, respectively. County fixed effects account for regional differences in the housing market.

The main coefficient of interest is β_2 as we seek to isolate the impact of the introduction of *Datio in Solutum* on the standard mortgage loans' probability of default compared to that of *First Home* loans, which were not eligible and thus represent our control group. A positive coefficient β_2 indicates that the default probability increased after the law's enactment for borrowers eligible for debt release. The estimated probability of default for borrower *i* at vintage *t* is calculated as:

$$PD_{i,t} = \frac{e^{y_{i,t}}}{1+e^{y_{i,t}}}. \quad (10)$$

We also estimate an alternative regression that replaces the *DiS period* dummy with dummies for quarterly vintages. This empirical specification allows us to observe a more granular effect of the introduction of *Datio in Solutum* by each quarter and identify in which periods the probability of default increased the most.

As a second step in our analysis, we run regressions using a sample with only standard mortgage loans as we try to estimate the impact of requesting *Datio in Solutum* on probability of default for eligible loans. We employ the following empirical specification:

$$y_{i,t} = \alpha + \beta_1 * DiS\ period_t + \beta_2 * DiS\ request_{i,t} * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}, \quad (11)$$

where *DiS period* is a dummy variable that equals 1 starting from 2016Q2 onwards and 0 before that, *DiS request* is a dummy that equals 1 for borrowers with a standard mortgage loan who requested *Datio in Solutum* and 0 for those who did not, and *Z* and *L* are vectors of borrower and loan characteristics, respectively. In this specification, coefficient β_1 captures changes in payment discipline for borrowers with standard mortgages after the introduction of *Datio in Solutum*. Our main coefficient of interest is β_2 which allows us to identify the impact of requesting *Datio in Solutum* on repayment.

Finally, using the sample with standard mortgage loans, we focus our analysis on the relationship of several borrower and loan characteristics with repayment behavior. We use the following specification:

$$y_{i,t} = \alpha + \beta * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + + Origination\ FE + County\ FE + \varepsilon_{i,t}, \quad (12)$$

where a positive coefficient β indicates that the probability of default of standard mortgages increased after the law's enactment in 2016Q1.

To test our theoretical model's predictions, we extend model (12) by including interaction terms between the *DiS period* dummy and borrower and loan characteristics. We interact the *DiS period* with borrower characteristics to test whether (and which) characteristics are significantly associated with an increase in the probability of default following the enactment of the law:

$$y_{i,t} = \alpha + \beta_0 * DiS\ period_t + \sum_{j=1}^{k} {\beta_1}^j\ Borrower_{dummy}{}^{j}_{i,t-1} + \\ + \sum_{j=1}^{k} {\beta_2}^j\ Borrower_{dummy}{}^{j}_{i,t-1} * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + \\ + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}\ , \quad (13)$$

where $Borrower_{dummy}{}^{j}_{i,t-1}$ is a dummy that equals 1 if the variable of interest (e.g., income or DSTI) is in a specified category *j*, for borrower *i*, at time *t*, and 0 otherwise. If the ${\beta_2}^j$ coefficients are statistically significant, we interpret this as evidence of an asymmetric effect of the *DiS period* for different borrower characteristics. While *Income* and *DSTI* variables are continuous in our dataset, we construct dummy variables to identify non-linear effects across different groups. For example, by interacting the dummy *Income group* with *DiS period*, we can test for the presence of wealth effect following the conjecture that higher-income borrowers have a lower opportunity cost of defaulting. For income, we consider four distinct groups: unrecorded income, below medium wage, between medium wage and double the medium wage, and greater than double the medium wage. Likewise, for DSTI, we consider three groups: bellow 50%, between 50% and 100%, and above 100%. This allows us to control whether the impact of introduction of *Datio in Solutum* was stronger either for borrowers with financial difficulties (i.e., as proxied by a high DSTI) or incentivized strategic default (i.e., for borrowers with low DSTI who could, at least in theory, comfortably service their debt).

We use a similar specification to test the interactions between the *DiS period* and several loan characteristics:

$$y_{i,t} = \alpha\ + \beta_0 * DiS\ period_t\ + \sum_{j=1}^{k} {\beta_1}^j\ Loan_{dummy}{}^{j}_{i,t-1} + \\ + \sum_{j=1}^{k} {\beta_2}^j\ Loan_{dummy}{}^{j}_{i,t-1} * DiS\ period_t\ + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + \\ + Origination\ FE + County\ FE + \varepsilon_{i,t}, \quad (14)$$

where $Loan_{dummy}{}^{j}_{i,t-1}$ is a dummy that equals 1 if the variable of interest (e.g., loan size at origination and current LTV) is in a specified category and 0 otherwise. For the current LTV we consider the groups of borrowers with LTV below and above 100 percent. The latter category encompasses borrowers for whom the outstanding loan exceeds their house value.

This specification allows us to test whether having the legal possibility to default without recourse increases the probability of default for borrowers with negative equity. We also consider an *unrecorded* category for mortgage loans with other types of guarantees besides real estate as their primary collateral, for which we cannot construct a meaningful measure of current LTV.

6. Results

This section presents the empirical results on the impact of the introduction of *Datio in Solutum* law on standard mortgage loans' probability of default. Table 3 shows regressions results for the difference-in-difference estimation from equation (9). The coefficient of the *Standard mortgage* loan dummy is positive and statistically significant, suggesting that standard mortgage loans (i.e., our treatment group consisting of loans that are eligible for *Datio in Solutum* request) are riskier than *First Home* loans (0.19 percent vs. 0.03 percent probability of default) in the period before the introduction of *Datio in Solutum*.

The coefficient of *DiS period* dummy in column (1) captures the effect of the introduction of *Datio in Solutum* on *First Home* loans, our control group. As expected, the coefficient is statistically insignificant, suggesting that the payment discipline of borrowers with *First Home* loans did not deteriorate as a result of the introduction of *Datio in Solutum*, as these borrowers were not eligible to apply. Finally, the coefficient of interaction *Standard mortgage * DiS period*, which captures the impact of *Datio in Solutum* on standard mortgage loans, is positive and statistically significant, indicating that the probability of default of standard mortgage loans increased substantially after the law's introduction. The average estimated probability of default increased by 60 percent in the period after the enactment of the law (from 0.19 to 0.30 percent).[37]

In column (2) we replace the *DiS period* dummy with quarterly vintage dummies. This approach allows us to observe a more granular effect of the introduction of *Datio in Solutum*. Consistent with the results from column (1), standalone coefficients for quarters show the changes in the probability of default for *First Home* borrowers by each vintage compared to 2016Q1. All coefficients are insignificant, confirming that the introduction of *Datio in Solutum* did not affect the payment discipline of borrowers with *First Home* loans. Our coefficients of

[37] We obtain similar results (unreported, available on request) when we replicate the difference-in-difference specification using a matched sample to compare the repayment behavior for similar borrowers with different types of mortgages. We match borrowers on observable characteristics using a nearest-neighbor model based on age, income, indebtedness, loan amount and year of origination, maturity, currency, and county.

interest are the interaction terms between the *Standard mortgage* dummy and individual quarter dummies. Our results show that the introduction of *Datio in Solutum* had an immediate effect. We observe the largest impact during the 2016Q2 and 2016Q3 when the average estimated probability of default for standard mortgage loans was 0.30 and 0.4 percent, respectively (see Figure C. 1). During these two quarters we also observe the largest number of applications for *Datio in Solutum* (see Figure B4). For 2017Q1 and 2017Q2, the interaction coefficients are statistically insignificant. These quarters coincide with a fall in the number of *Datio in Solutum* requests after the law was declared unconstitutional in January 2017.

Our following analyses reveal the importance of borrower and loan characteristics for understanding the probability of default response to the introduction of *Datio in Solutum* law. Table 5 presents the estimates for the effect of the enactment of *Datio in Solutum* on the borrower's probability of default based on the model from equation (12). In column (1) we show how borrower and loan characteristics affect the probability of default without controlling for the change in recourse legislation. All coefficients in column (1) have the expected sign and confirm the findings from existing literature. In line with the results of previous studies (see,

Table 4 presents estimates for the model specified in equation (11), capturing the impact of requesting *Datio in Solutum* on the probability of default for eligible loans (i.e., standard mortgage loans). In column (2) we control for borrower characteristics. In column (3) we control for borrower and loan characteristics. The coefficient of the *DiS period* dummy is positive in all specifications and becomes statistically significant in column (3) when including all controls. This result indicates some deterioration in payment discipline for all borrowers with a standard mortgage loan after the introduction of *Datio in Solutum*. The average estimated probability of default increased for these borrowers from 0.18 to 0.23 percent during the period when the law was active. The coefficient of interaction between *DiS request* and *DiS period* dummies is positive and statistically significant for all specifications. These results suggest that requesting *Datio in Solutum* fostered a substantial deterioration in payment discipline. The average estimated probability of default for borrowers who requested *Datio in Solutum* during the period when the law was active increased by approximately five percentage points compared to the period before the law's introduction (from 0.17 to 5.34 percent).

Table 3. Introduction of *Datio in Solutum* and probability of default

The table reports the results of logit regressions that examines the impact of the introduction of *Datio in Solutum* law on the mortgage's probability of default. We employ a difference-in-difference approach, using the following specification: $y_{i,t} = \alpha + \beta_0 * Standard\ mortgage_i + \beta_1 * DiS\ period_t + \beta_2 * Standard\ mortgage_i * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}$, where the indices *i* and *t* stand for borrower and time, respectively, $Standard\ mortgage$ is a dummy that equals 1 for borrowers with a standard mortgage loan and 0 for borrowers with a *First Home* loan, *DiS period* is a dummy that equals 1 from 2016Q2 onwards and 0 before. *Z* and *L* are vectors of borrower and loan characteristics, respectively. The regressors are 12-month lagged (*t-1)*. The dependent variable is a dummy y_{it} that equals 1 if the borrower's loan is more than 90 days past due. The sample for model (1) consists of quarterly vintages between 2015Q4 – 2017Q1 period. For model (2), we replace *DiS period* with *Quarterly vintage* dummies to observe a more granular effect of the introduction of *Datio in Solutum* and we expand our sample till 2017Q2. Robust standard errors are shown in brackets. ∗∗∗, ∗∗, and ∗ indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: Probability of default	**(1)**	**(2)**
Standard mortgage	0.5667***	0.6410***
	(0.1464)	(0.1893)
DiS period	0.1950	
	(0.1403)	
Standard mortgage * DiS period	0.2744*	
	(0.1489)	
2015Q4		-0.0483
		(0.2359)
2016Q2		0.1095
		(0.2256)
2016Q3		0.2892
		(0.2162)
2016Q4		-0.0710
		(0.2347)
2017Q1		0.2477
		(0.2172)
2017Q2		0.3264
		(0.2144)
Standard mortgage * 2015Q4		0.0541
		(0.2520)
Standard mortgage * 2016Q2		0.3407**
		(0.2397)
Standard mortgage * 2016Q3		0.4668**
		(0.2296)
Standard mortgage * 2016Q4		0.4873**
		(0.2485)
Standard mortgage * 2017Q1		-0.1708
		(0.2338)
Standard mortgage * 2017Q2		-0.0867
		(0.2301)
Observations	1,635,957	1,948,044
Bank FE	Yes	Yes
Origination FE	Yes	Yes
County FE	Yes	Yes
Borrower and loan characteristics	Yes	Yes
Pseudo R2	0.132	0.127
Likelihood	-15132	-17574

Our following analyses reveal the importance of borrower and loan characteristics for understanding the probability of default response to the introduction of *Datio in Solutum* law. Table 5 presents the estimates for the effect of the enactment of *Datio in Solutum* on the borrower's probability of default based on the model from equation (12). In column (1) we show how borrower and loan characteristics affect the probability of default without controlling for the change in recourse legislation. All coefficients in column (1) have the expected sign and confirm the findings from existing literature. In line with the results of previous studies (see,

Table 4. *Datio in Solutum* request and standard mortgage loans probability of default

The table reports the results of logit regressions that examines the impact of requesting *Datio in Solutum* on the standard mortgage's probability of default. We employ a difference-in-difference approach, using the following specification: $y_{i,t} = \alpha + \beta_1 * DiS\ period_t + \beta_2 * DiS\ request_{i,t} * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}$, where the indices i and t stand for borrower and time, respectively *DiS period* is a dummy that equals 1 from 2016Q2 onwards and 0 before, *DiS request* is a dummy that equals 1 for borrowers with a standard mortgage loan who requested *Datio in Solutum* and 0 for those who did not. *Z* and *L* are vectors of borrower and loan characteristics, respectively. The regressors are 12-month lagged (*t-1)*. The dependent variable is a dummy y_{it} that equals 1 if the borrower's loan is more than 90 days past due. Robust standard errors are shown in brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: Probability of default	**(1)**	**(2)**	**(3)**
DiS period	0.032	0.036	0.237***
	(0.051)	(0.052)	(0.054)
DiS request * DiS period	4.209***	4.173***	3.278***
	(0.060)	(0.062)	(0.073)
Age		0.004	0.008**
		(0.003)	(0.003)
Income		-0.020***	-0.020***
		(0.001)	(0.001)
DSTI			0.163***
			(0.019)
Amount at origination			0.002***
			(0.000)
Currency = 2, EUR			0.516***
			(0.082)
Currency = 3, CHF			0.678***
			(0.110)
LTV			0.718***
			(0.061)
No LTV information = 1			0.927***
			(0.096)
Residual maturity (years)			0.016***
			(0.005)
Interest rate			0.222***
			(0.032)
Observations	932,958	932,958	932,356
Bank FE	No	No	Yes
Origination FE	No	No	Yes
County FE	No	Yes	Yes
Pseudo R2	0.0739	0.0921	0.132
Likelihood	-15153	-14854	-14201

e.g., Foote et al., 2008; Kelly and McCann, 2016; and Gerardi et al., 2018), we find that higher-income borrowers are less likely to default on their mortgages, while borrowers with unrecorded income (most of them unemployed) are the most likely to default (Figure C. 2, left panel). Consistent with previous studies (see, e.g., Kelly and O'Toole, 2018; Kim et al., 2018; de Haan and Mastrogiacomo, 2020), our results reveal that borrowers' indebtedness (as proxied by DSTI) has a strong positive association with default. Mortgage loans with higher amount at origination (Figure C. 5, left panel) and those with higher current LTV are significantly associated with an increase in the probability of default (Figure C. 4, left panel).[38] Likewise, higher interest rates are significantly associated with a rise in the delinquency probability.

[38] The results are consistent with findings reported in Bajari et al. (2008), Demyanyk and Van Hemert (2009), Elul et al. (2010), Demiroglu et al. (2014), Gerardi et al. (2018), and Kim et al. (2018).

Table 5. Mortgage default probability.

The table reports the results of logit regressions that examine the impact of the introduction of *Datio in Solutum* on standard mortgages' probability of default. We use data over quarterly vintages between 2015Q4- 2017Q2 period and estimate alternative versions of the following regression specification: $y_{i,t} = \alpha + \beta * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}$, where the indices *i* and *t* stand for borrower and time, respectively, *DiS period* is a dummy that equals 1 from 2016Q2 onwards and 0 before, *Z* and *L* are vectors of borrower and loan characteristics, respectively. The regressors are 12-month lagged (*t-1)*. The dependent variable is a dummy y_{it} that equals 1 if the borrower's loan is more than 90 days past due. Robust standard errors are shown in brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: Probability of default	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
DiS period		0.491***	0.593***	0.499***	0.492***	0.507***
		(0.053)	(0.063)	(0.053)	(0.053)	(0.056)
Income group = Unrecorded	0.561***	0.561***		0.570***	0.573***	0.602***
	(0.073)	(0.072)		(0.072)	(0.073)	(0.076)
Income group = Medium - double medium wage	-0.501***	-0.498***	-0.501***	-0.488***	-0.500***	-0.481***
	(0.067)	(0.067)	(0.068)	(0.067)	(0.067)	(0.071)
Income group = Above double medium wage	-0.963***	-0.957***	-0.935***	-0.953***	-0.952***	-0.905***
	(0.082)	(0.082)	(0.089)	(0.082)	(0.082)	(0.087)
DSTI	0.301***	0.314***		0.320***	0.324***	0.327***
	(0.027)	(0.027)		(0.027)	(0.027)	(0.029)
Age	0.007*	0.006*	0.006	0.005	0.007**	0.006
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)
Amount at origination (k Euros)	0.006***	0.006***	0.006***	0.007***		0.006***
	(0.001)	(0.001)	(0.001)	(0.001)		(0.001)
Currency = 2, EUR	0.481***	0.467***	0.503***	0.531***	0.466***	0.688***
	(0.082)	(0.082)	(0.098)	(0.082)	(0.082)	(0.088)
Currency = 3, CHF	0.946***	0.944***	0.879***	1.202***	0.943***	1.473***
	(0.106)	(0.107)	(0.128)	(0.104)	(0.107)	(0.111)
LTV	0.960***	0.956***	1.020***		0.958***	
	(0.059)	(0.059)	(0.071)		(0.060)	
No LTV information = 1	1.177***	1.155***	1.281***		1.174***	
	(0.095)	(0.095)	(0.115)		(0.095)	
Residual maturity (years)	0.019***	0.022***	0.019***	0.030***	0.022***	0.035***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)
Interest rate	0.271***	0.321***	0.344***	0.317***	0.327***	0.329***
	(0.029)	(0.029)	(0.034)	(0.029)	(0.029)	(0.032)
DSTI = 50%-100%			0.493***			
			(0.080)			
DSTI >100%			0.834***			
			(0.082)			
LTV >100%				0.650***		
				(0.058)		
LTV = Unrecorded				0.497***		
				(0.079)		
Amount at origination = 30k -60k Euros					0.088	
					(0.065)	
Amount at origination = 60k -90k Euros					0.460***	
					(0.076)	
Amount at origination >90k Euros					0.715***	
					(0.084)	
Negative equity						0.062***
						(0.007)
Observations	932,356	932,356	743,900	932,356	932,356	820,772
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Origination FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R2	0.0845	0.0873	0.0994	0.0834	0.0870	0.0828
Likelihood	-14978	-14931	-10395	-14996	-14936	-13238

Our results show that borrowers with mortgage loans in foreign currencies are more likely to default than borrowers with loans in domestic currency. In column (2), we add the *DiS period* dummy as an explanatory variable. We expect that default to being more likely during

the period when *Datio in Solutum* law was active. The coefficient of our main variable of interest is positive and statistically significant, suggesting that after the introduction of *Datio in Solutum*, the average probability of default increased by 65 percent compared to the period when the law was not active.[39] Our results complement the findings from the literature (see, e.g., Jones, 1993; Demiroglu et al., 2014; and Chan et al., 2016), by showing that a change in recourse regime toward a debtor-friendly policy leads to higher mortgage probability of default.

In columns (3), (4), and (5), we use alternative measures for DSTI, current LTV, and the amount at origination, respectively, to highlight the non-monotonic effects of these variables. The results in column (3) reveal that the marginal effect of DSTI is non-linear, statistically and economically significant.[40] An increase in the DSTI from below 50% to a range between 50% and 100% raises the probability of default by 62 percent, a result consistent with Nier et al. (2019) (see Figure C. 3, left panel). This suggests that a borrower's indebtedness harms the repayment probability, particularly when the ratio exceeds 50%. We obtain similar results for the current LTV ratio in column (4). Our LTV measure captures both the impact of changes in the collateral value and the role of loan amortization. The marginal effect of high LTV (i.e., higher than 100%) on the probability of default is 89 percent higher than for low LTV (i.e., LTV below 100%).[41] These results are consistent with those reported in Foote et al. (2009), Ellul et al. (2010), and Goodstein et al. (2017). The average probability of default for borrowers in the category "*LTV Unrecorded*" is similar to those with LTV above 100%, showing that borrowers with other types of collateral have a similar risk level as borrowers with negative equity (see Figure C. 4, left panel). The impact of the loan amount is also non-monotonic (column 5), yet much smaller in magnitude than those of DSTI and LTV. The marginal effects show that the highest probability of default is observed for the loans with the highest amounts at origination (i.e., above 90,000 euros) (see Figure C. 5, left panel). Column (6) considers an alternative proxy for the negative equity constructed as the difference between the collateral and the principal outstanding value. The coefficient for this proxy is also positive and statistically significant, suggesting that the probability of default is higher for larger negative equity, a result consistent with Elul et al. (2010).

[39] Controlling for all other characteristics, the introduction of *Datio in Solutum* increases the probability of default from 0.17 percent to 0.28 percent for an average borrower.

[40] For this specification we include in our sample only borrowers for whom we can calculate their indebtedness (i.e., borrowers with recorded income).

[41] Controlling for all other characteristics, an average borrower with a LTV ratio below 100 percent has a probability of default of 0.18 percent compared to 0.34 percent for one with a LTV above 100 percent.

Table 6 shows the estimation results of interactions between the *DiS period* dummy and borrower characteristics based on the model depicted in equation (13). Column (1) shows the interaction effects of the *DiS period* dummy and borrower's income category, compared to the category *Below medium wage*. Regardless of income level, the introduction of *Datio in Solutum* increases the borrowers' probability of default (see Figure C.2, right panel). The effect is more pronounced for borrowers with the highest incomes, as indicated by the positive and statistically significant interaction coefficients between the *DiS period* dummy with *Medium - double medium wage* and *Above double medium* dummies. Figure C. 2 illustrates the marginal effects of borrowers' income on the probability of becoming delinquent, showing that the average probability of default increased by 250 percent for borrowers with the highest incomes compared to only 60 percent for debtors with income below the medium wage. [42,43] This result supports our theoretical model's predictions and suggests that better-off borrowers may potentially have incentives for strategic default because their higher wealth reduces the opportunity cost of default.

In column (2), we interact the *DiS period* dummy with indicators for DSTI. The interaction coefficients are statistically insignificant, indicating a uniform deterioration in payment discipline. However, by looking at the marginal effects of DSTI on borrowers probability of default as illustrated in Figure C. 3 (right panel), we observe a strong impact on non-repayment for less-financially constrained borrowers (i.e., those with DSTI below 50 percent). The introduction of *Datio in Solutum* increases the probability of default for borrowers with DSTI below 50 percent by 110 percent, while for the most indebted borrowers (i.e., DSTI above 100 percent) it leads to a 70 percent increase.[44] These findings are again consistent with the idea of strategic default because less-leveraged borrowers (either because of higher income or lower debt) are expected to default less.

[42] Controlling for all other characteristics, the average probability of default for a borrower with an income higher than double the medium wage increases from 0.04 percent to 0.14 percent after the introduction of the *Datio in Solutum* law.
[43] Controlling for all other characteristics, the average probability of default for a borrower with an income below the medium wage increases from 0.2 percent to 0.32 percent after the introduction of the *Datio in Solutum* law.
[44] Controlling for all other characteristics, the average probability of default for borrowers with a DSTI below 50 percent increases from 0.07 to 0.15 percent, while for borrowers with a DSTI above 100 percent it increases from 0.2 to 0.34 percent.

Table 6. Mortgage default probability. Borrower characteristics and Datio in Solutum.

The table reports the results of logit regressions that examine the potential asymmetric effects of specific borrower attributes on standard mortgage loans probability of default under *Datio in Solutum*. We use data over quarterly vintages between 2015Q4- 2017Q2 period and estimate alternative versions of the following regression specification: $y_{i,t} = \alpha + \beta_0 * DiS\ period_t + \sum_{j=1}^{k} \beta_1{}^j\ Borrower\ dummy_{i,t-1}^j + \sum_{j=1}^{k} \beta_2{}^j\ Borrower\ dummy_{i,t-1}^j * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}$, where the indices *i* and *t* stand for borrower and time, respectively, *DiS period* is a dummy variable that equals 1 from 2016Q2 onwards and 0 before, $Borrower\ dummy_{i,t-1}^j$ is a dummy that equals 1 if the variable of interest (e.g., income or DSTI) is in a specified category *j*, for borrower *i*, at time *t*, and 0 otherwise, *Z* and *L* are vectors of borrower and loan characteristics, respectively. The regressors are 12-month lagged (*t-1)*. The dependent variable is a dummy y_{it} that equals 1 if the borrower's loan is more than 90 days past due. Robust standard errors are shown in brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: Probability of default	**(1)**	**(2)**
DiS period	0.442***	0.731***
	(0.075)	(0.149)
Income group = Unrecorded	0.761***	
	(0.116)	
Income group = Medium - double medium wage	-0.834***	
	(0.146)	
Income group = Above double medium wage	-1.441***	
	(0.183)	
DiS Period * Income group = Unrecorded	-0.235**	
	(0.116)	
DiS Period * Income group = Medium - double medium wage	0.428***	
	(0.159)	
DiS Period * Income group = Above double medium wage	0.605***	
	(0.194)	
DSTI = 50%-100%		0.452**
		(0.182)
DSTI >100%		1.012***
		(0.159)
DiS Period * DSTI = 50%-100%		0.031
		(0.197)
DiS Period * DSTI >100%		-0.220
		(0.167)
Observations	932,356	744,034
Bank FE	Yes	Yes
Origination FE	Yes	Yes
County FE	Yes	Yes
Borrower and loan characteristics	Yes	Yes
Pseudo R2	0.0882	0.0997
Likelihood	-14917	-10392

Table 7 provides the results of the model described in equation (14), where the *DiS period* dummy interacts with loan characteristics. The results from column (1) show that the introduction of *Datio in Solutum* had a non-linear impact on the probability of default conditional on the value of the current LTV. Borrowers with a current LTV above 100 percent are more likely to default than borrowers with LTV below 100 percent. As shown in Figure C. 4 (right panel), the introduction of *Datio in Solutum* leads to a 36 percent increase in the probability of default for borrowers with a LTV ratio below 100 percent. In comparison, for those with LTV above 100 percent, it leads to a 100 percent increase.[45]

[45] Controlling for all other characteristics, the average probability of default for borrowers with a LTV ratio below and above 100 percent increases from 0.14 to 0.19 percent and from 0.20 to 0.40 percent, respectively.

Table 7. Mortgage default probability. Loan characteristics and *Datio in Solutum*.

The table reports the results of logit regressions that examine the potential asymmetric effects of specific loan attributes on standard mortgage loans probability of default under *Datio in Solutum* law. We use data over over quarterly vintages between 2015Q4- 2017Q2 period and estimate alternative versions of the following regression specification: $y_{i,t} = \alpha + \beta_0 * DiS\ period_t + \sum_{j=1}^{k} \beta_1{}^j\ Loan_{dummy}{}^j_{i,t-1} + \sum_{j=1}^{k} \beta_2{}^j\ Loan_{dummy}{}^j_{i,t-1} * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}$, where the indices *i* and *t* stand for borrower and time, respectively, *DiS period* is a dummy that equals 1 from 2016Q2 onwards and 0 before, $Loan_{dummy}{}^j_{i,t-1}$ is a dummy that equals 1 if the variable of interest (e.g., loan size at origination and current LTV) is in a specified category and 0 otherwise, *Z* and *L* are vectors of borrower and loan characteristics, respectively. The regressors are 12-month lagged (*t-1)*. The dependent variable is a dummy y_{it} that equals 1 if the borrower's loan is more than 90 days past due. Robust standard errors are shown in brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: Probability of default	**(1)**	**(2)**
DiS period	0.311***	0.244**
	(0.079)	(0.108)
LTV >100%	0.367***	
	(0.101)	
LTV = Unrecorded	0.445***	
	(0.168)	
DiS Period * LTV >100%	0.364***	
	(0.106)	
DiS Period * LTV = Unrecorded	0.080	
	(0.181)	
Amount at origination = 30k -60k Euros		-0.052
		(0.121)
Amount at origination = 60k -90k Euros		0.097
		(0.143)
Amount at origination > 90k Euros		0.443***
		(0.142)
DiS Period * Amount at origination = 30k -60k Euros		0.185
		(0.137)
DiS Period * Amount at origination = 60k -90k Euros		0.466***
		(0.155)
DiS Period * Amount at origination > 90k Euros		0.354**
		(0.149)
Observations	932,356	932,356
Bank FE	Yes	Yes
Origination FE	Yes	Yes
County FE	Yes	Yes
Borrower and loan characteristics	Yes	Yes
Pseudo R2	0.0837	0.0873
Likelihood	-14990	-14931

These findings are consistent with our theoretical model's predictions - negative equity, as proxied by a current LTV ratio higher than 100 percent, has a positive and statistically significant association with default.[46] For borrowers with other types of collateral the introduction of the *Datio in Solutum* law leads to a 50 percent increase in the probability of default.

Results reported in column (2) show that the introduction of *Datio in Solutum* led to a statistically significant deterioration in payment discipline for borrowers with the highest loan amounts at origination. The interaction coefficients between the *DiS period* dummy and *Amount*

[46] Ghent and Kudlyak (2011) and Demiroglu et al. (2014) report similar results for underwater homeowners in non-recourse states in the U.S.

at origination between 60,000 and 90,000 Euros dummy, as well as the interaction with *Amount at origination above 90,000 Euros* dummy, are positive and statistically significant. In terms of the average probability of default, these borrowers also experienced the most significant increases in relative terms: 105 percent for those with an amount at origination between 60,000 and 90,000 Euros, and 80 percent for those with amounts above 90,000 Euros. These values are significantly higher than the 25 percent increase for borrowers with amounts at origination below 30,000 Euros (see Figure C. 5, right panel).[47]

Robustness tests

We conduct several robustness tests to investigate whether our results are robust to alternative modeling specifications. First, we re-estimate the model from equation (12) using the linear probability ordinary least squares model (OLS). Table 8 presents the results. Similar to Gerardi et al. (2018) and O'Malley (2021), we run two alternative OLS models. In column (1), we use an OLS specification with bank, year of origination, and county fixed effects. In column (2), we provide the OLS estimates without fixed effects. In both specifications, the coefficient for the *DiS period* dummy is positive and significant, indicating an increase in the probability of default of 0.11 percentage points, in line with our results from Table 5.

Second, we implement a difference-in-difference approach in column (3) using our logit model from equation (9), including borrowers with multiple loans in our sample. The coefficient of interaction between *Standard mortgage* and *DiS period* dummies is positive, statistically significant, and has a similar magnitude as in our baseline estimation. This result confirms the robustness of our estimates from Table 3. The coefficient of the *Multiple loans* dummy is positive but insignificant, suggesting that borrowers with multiple loans are not riskier than borrowers with one mortgage loan.

Finally, we employ the nearest-neighbor matching methodology. By running a logit regression with borrowers with similar characteristics but different in their *Datio in Solutum* request status, we can address the concern that borrowers who have applied for *Datio in Solutum* might have a higher probability of default ex-ante.

[47] Controlling for all other characteristics, the average probability of default for borrowers with an amount at origination between 60,000 and 90,000 Euros and above 90,000 Euros increases from 0.17 to 0.35 percent, and from 0.25 to 0.45 percent, respectively. Likewise, the average probability of default for borrowers with an amount at origination below 30,000 Euros increases from 0.16 to 0.20 percent.

Table 8. Robustness to different estimation methods.

The table reports the results of robustness tests for our main results on the impact of the introduction of *Datio in Solutum* on the mortgage's probability of default. Model 1 shows the results of OLS estimation with bank, year of origination, and county fixed effects. Model 2 shows OLS estimates without fixed effects. We estimate the following regression specification: $y_{i,t} = \alpha + \beta * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + \varepsilon_{i,t}$, where the indices *i* and *t* stand for borrower and time, respectively, *DiS period* is a dummy that equals 1 from 2016Q2 onwards and 0 before, *Z* and *L* are vectors of borrower and loan characteristics, respectively. The regressors are 12-month lagged *(t-1)*. The dependent variable is a dummy y_{it} that equals 1 if the borrower's loan is more than 90 days past due. Model 3 implements a difference-in-difference approach using the following specification: $y_{i,t} = \alpha + \beta_0 * Standard\ mortgage_i + \beta_1 * DiS\ period_t + \beta_2 * Standard\ mortgage_i * DiS\ period_t + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Bank\ FE + Origination\ FE + County\ FE + +\varepsilon_{i,t}$, where $Standard\ mortgage$ is a dummy that equals 1 for borrowers with a standard mortgage loan and 0 for borrowers with a *First Home* loan. We include in our sample borrowers with multiple loans. Robust standard errors are shown in brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: Probability of default	**(1)**	**(2)**	**(3)**
	OLS	OLS	Logit
Standard mortgage			1.9301***
			(0.1502)
DiS period	0.00119***	0.00114***	0.2178
	(0.000)	(0.000)	(0.1404)
Standard mortgage * DiS period			0.2653*
			(0.1485)
Multiple loans			0.0447
			(0.1176)
Income group = Unrecorded	0.00119***	0.00124***	0.5320***
	(0.000)	(0.000)	(0.0642)
Income group = Medium - double medium wage	-0.00127***	-0.00123***	-0.6070***
	(0.000)	(0.000)	(0.0655)
Income group = Above double medium wage	-0.00222***	-0.00215***	-1.0233***
	(0.000)	(0.000)	(0.0777)
DSTI	0.00090***	0.00093***	0.2619***
	(0.000)	(0.000)	(0.0233)
Age	0.00001	0.00001	0.0065*
	(0.101)	(0.330)	(0.0034)
Amount at origination (k Euro)	0.00003***	0.00003***	0.0063***
	(0.000)	(0.000)	(0.0006)
Currency = 2, EUR	0.00062***	0.00057***	0.3814***
	(0.000)	(0.000)	(0.0822)
Currency = 3, CHF	0.00370***	0.00301***	0.9379***
	(0.000)	(0.000)	(0.1090)
LTV	0.00307***	0.00271***	0.9453***
	(0.000)	(0.000)	(0.0611)
No LTV information	0.00284***	0.00232***	1.2248***
	(0.000)	(0.000)	(0.1000)
Residual maturity (years)	0.00002**	0.00001	0.0261***
	(0.039)	(0.422)	(0.0046)
Interest rate	0.00070***	0.00059***	0.2418***
	(0.000)	(0.000)	(0.0319)
Observations	932,958	932,958	1,663,854
Banks FE	Yes	No	Yes
Origination FE	Yes	No	Yes
County FE	Yes	No	Yes
R2	0.00378	0.00301	0.131
Likelihood	1.472e+06	1.472e+06	-15675

We estimate the following logit model for the probability of requesting *Datio in Solutum:*

$$Datio\ in\ Solutum_{i,t} = \alpha + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Origination\ FE + \\ + Vintage\ FE + \varepsilon_{i,t}. \quad (15)$$

We estimate the model using vintages over the 2016Q2 - 2017Q1 period (i.e., when *Datio in Solutum* law was active). *Z* and *L* are vectors of borrower and loan characteristics, respectively.

We use the estimated propensity score to create a nearest-neighbor matched sample which consists of equal shares of borrowers who have requested *Datio in Solutum* and those who have not. We report the results in Table 9. Results from column (1) show that borrowers with a higher level of indebtedness, holding foreign-currency denominated loans, having larger loan amounts at origination and a higher current LTV ratio are more likely to request *Datio in Solutum.* Having a higher income reduces the likelihood of applying to give in payment. Turning to the matched-logit regression in column (2), the coefficient of the *DiS request* dummy is positive and statistically significant, indicating an average probability of default for borrowers who requested *Datio in Solutum* of 12.1%, 2.5 times higher than our estimates from Table 5. The impact of asking *Datio in Solutum* is similar to that estimated with the OLS methodology. These results show that the selection effect does not impact the robustness of our results.

Table 9. Nearest-neighbor model.

Model (1) reports the results of logit regressions that examines the probability of requesting *Datio in Solutum*. We employ the following specification: $Datio\ in\ Solutum\ request_{i,t} = \alpha + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Origination\ FE + Vintage\ FE + \varepsilon_{i,t}$. The dependent variable is a dummy $Datio\ in\ Solutum\ request$ that equals 1 for borrowers with a standard mortgage loan who requested *Datio in Solutum* and 0 for those who did not. The indices *i* and *t* stand for borrower and time, respectively. *Z* and *L* are vectors of borrower and loan characteristics, respectively. The regressors are 12-month lagged *(t-1)*. For model (2), we estimate the impact of requesting *Datio in Solutum* on the standard mortgage's probability of default using a nearest-neighbor matched sample. We employ the following specification: $y_{i,t} = \alpha + \beta_1 * DiS\ request_{i,t} + \gamma' Z_{i,t-1} + \mu' L_{i,t-1} + Origination\ FE + Vintage\ FE + \varepsilon_{i,t}$. The dependent variable is a dummy y_{it} that equals 1 if the borrower's loan is more than 90 days past due. *DiS request* is a dummy that equals 1 for borrowers with a standard mortgage loan who requested *Datio in Solutum* and 0 for those who did not. Robust standard errors are shown in brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	**(1)** ***Datio in Solutum*** **request**	**(2)** **Probability of default**
DiS request		3.2411***
		(0.2251)
Income	-0.0021***	-0.0049***
	(0.0005)	(0.0018)
DSTI	0.0884***	-0.0021
	(0.0184)	(0.0535)
Currency = 2, EUR	0.5072***	0.2694
	(0.0915)	(0.2853)
Currency = 3, CHF	2.0287***	-0.7513**
	(0.1002)	(0.3122)
Amount at origination (EUR)	0.0109***	0.0009
	(0.0004)	(0.0011)
Residual maturity (years)	0.0536***	-0.0576***
	(0.0037)	(0.0125)
LTV	1.9270***	0.5530***
	(0.0514)	(0.1686)
Unrecorded LTV = 1	2.5405***	1.0165***
	(0.0955)	(0.3133)
Observations	706,110	6,731
Vintage FE	Yes	Yes
Origination FE	Yes	Yes

7. Conclusions

We empirically investigate whether and how changes in recourse legislation affect mortgage repayment. Using a granular dataset of mortgage loans originating from 2003-2016, combined with individual income tax records, we analyze the impact of introducing a new recourse law that has retroactively changed the status of standard mortgage loans from recourse to non-recourse on borrowers' probability of default.

We find strong evidence for the impact of *Datio in Solutum* on payment discipline. As a result of the legislative change, the average probability of default for borrowers with standard mortgage loans increased by 60 percent after the law's enactment. In contrast, the probability of default for *First Home* loans, which were not eligible to give-in payment, was unaffected. The increase was significantly larger for borrowers who applied to give in payment. These results are robust to controlling for the higher ex-ante riskiness of borrowers who requested *Datio in Solutum.*

Our findings indicate that better-off, less-leveraged borrowers, as well as those with negative equity, exhibit the highest increase in the probability of default in the new non-recourse regime. These results point to the fact that *Datio in Solutum* law, which was enacted to offer debt relief to borrowers in financial distress, bears unintended consequences. Namely, given the lax eligibility criteria, the law incentivized borrowers to default strategically. Our findings inform the discussion about which policy measures may be more effective in supporting vulnerable mortgage holders. Our results confirm the conjecture that excessive protection of borrowers can lead to moral hazard. Legislative changes, such as the switch from a creditor- to a debtor-friendly recourse policy, come not only with social benefits but also with potentially significant costs. Ad-hoc changes in recourse policy without a careful assessment of critical aspects such as eligibility criteria may be counterproductive, contributing to the accumulation of loan losses in the banking system, which in turn affect the solvency of lending institutions, impeding their capacity to extend credit to the real economy. Thus legislators may want to encourage lenders to pursue individual restructuring solutions catered to borrowers' needs to enhance social benefits while containing the undesirable potential costs instead of implementing broad-based changes to legislation that may contribute toward legislative uncertainty.

References

Agarwal, S., Amromin, G., Ben-David, I., Chomsisengphet, S., Piskorski, T., and Seru, A. (2017). Policy intervention in debt renegotiation: Evidence from the home affordable modification program, *Journal of Political Economy*, 125, 654–712.

Agarwal, S., Amromin, G., Chomsisengphet, S., Landvoigt, T., Piskorski, T., Seru, A., and Yao, V. (2023). Mortgage refinancing, consumer spending, and competition: Evidence from the home affordable refinancing program, *Review of Economic Studies*, 90(2), 499–537.

Ambrose, B.W., Buttimer, R.J., and Capone, C.A. (1997). Pricing mortgage default and foreclosure delay, *Journal of Money, Credit and Banking*, 29, 314–325.

Artavanis, N.T. and Spyridopoulos, I. (2021). Determinants of strategic behavior: Evidence from a foreclosure moratorium, Working paper.

Bajari, P., Chu, C.S., and Park, M. (2008). An empirical model of subprime mortgage default from 2000 to 2007, NBER Working Paper No. 14625.

Bhutta,N., Dokko, J., and Shan, H. (2010). The depth of negative equity and mortgage default decisions, Federal Reserve Board of Governors Working Paper 2010-35.

Bhutta, N., Dokko, J., and Shan, H. (2017). Consumer ruthlessness and mortgage default during the 2007 to 2009 housing bust, *Journal of Finance*, 72 (6), 2433-2466.

Bulgaru, A. and Lepădatu, D. (2016). Datio in solutum – novelty aspects, *Bulboacă & Asociații Herald*, December 2016.

Campbell, J.Y. (2013). Mortgage market design, *Review of Finance*, 17, 1–33.

Campbell, J.Y. and Cocco, J.F. (2015). A model of mortgage default, *Journal of Finance*, 70(4), 1495–1554.

Campbell, J.Y., Giglio, S. and Pathak, P. (2011). Forced sales and house prices, *American Economic Review*, 101, 2108–31.

Chan, S., Haughwout, A., Hayashi, A., and Van Der Klaauw, W. (2016). Determinants of mortgage default and consumer credit use: The effects of foreclosure laws and foreclosure delays, *Journal of Money, Credit and Banking*, 48(2–3), 393–413.

Connor, G. and Flavin, T. (2015). Strategic, unaffordability and dual-trigger default in the Irish mortgage market, *Journal of Housing Economics*, 28, 59–75.

Corbae, D. and Quintin, E. (2015). Leverage and the foreclosure crisis, *Journal of Political Economy*, 123(1), 1-65.

Demiroglu, C., Dudley, E., and James, C. (2014). State foreclosure laws and the incidence of mortgage default, *Journal of Law and Economics*, 57, 225-280.

Demyanyk, Y., Koijen, R.S.J., and Van Hemert, O.A.C. (2011). Determinants and consequences of mortgage default, Federal Reserve Bank of Cleveland Working Paper No. 10-19R.

Deng, Y., Quigley, J.M., and Order, R.V. (2000). Mortgage terminations, heterogeneity and the exercise of mortgage options, *Econometrica*, 68, 275–307.

Eberly, J. and Krishnamurthy, A. (2014). Efficient credit policies in a housing crisis, *Brookings Papers on Economic Activity*, Fall, 73-118.

Elul, R., Souleles, N.S., Chomsisengphet, S., Glennon, D., and Hunt, R. (2010). What "triggers" mortgage default?, *American Economic Review*, 100, 490–494.

Feldstein, M. (2008). How to help people whose home values are underwater - The economic spiral will get worse unless we do something about negative equity, *Wall Street Journal*, November 18.

Foote, C.L., Gerardi, K., and Willen, P.S. (2008). Negative equity and foreclosure: Theory and evidence, *Journal of Urban Economics*, 64, 234–245.

Foote, C., Gerardi, K., Goette, L., and Willen, P. (2009). Reducing foreclosures: No easy answers, *NBER Macroeconomics Annual*, 24, 89–138.

Foote, C.L. and Willen, P.S. (2018). Mortgage-default research and the recent foreclosure crisis, *Annual Review of Financial Economics*, 10, 59–100.

Fuster, A. and Willen, P. (2017). Payment size, negative equity, and mortgage default, *American Economic Journal: Economic Policy*, 9(4), 167-191.

Gabriel, S., Iacoviello, M., and Lutz, C. (2021). A crisis of missed opportunities? Foreclosure costs and mortgage modification during the great recession, *Review of Financial Studies*, 34(2), 864–906.

Gerardi, K., Herkenhoff, K.F., Ohanian, L.E., and Willen, P.S. (2018). Can't pay or won't pay? Unemployment, negative equity, and strategic default, *Review of Financial Studies*, 31, 1098–1131.

Gerardi, K., Shapiro, A.H., and Willen, P.S. (2008). Subprime outcomes: Risky mortgages, homeownership experiences, and foreclosures, Federal Reserve Bank of Boston Working Paper No. 07-15.

Gete, P. and Zecchetto, F. (2023). Mortgage design and slow recoveries. The role of recourse and default, *Review of Economic Studies,* https://doi.org/10.1093/restud/rdad055.

Ghent, A. and Kudlyak, M. (2011). Recourse and residential mortgage default: Evidence from U.S. states, *Review of Financial Studies*, 24(9), 3139-3186.

Goodstein, R., Hanouna, P., Ramirez, C. D., and Stahel, C. W. (2017). Contagion effects in strategic mortgage defaults, *Journal of Financial Intermediation*, *30*, 50–60.

Guiso, L., Sapienza, P., and Zingales, L. (2013). The determinants of attitudes toward strategic default on mortgages, *Journal of Finance*, 68(4), 1473-1515.

Guren, A.M. and McQaude, T.J. (2020). How foreclosures exacerbate housing downturns?, *Review of Economic Studies*, 87(3), 1331–1364.

Haan, L. de, and Mastrogiacomo, M. (2020). Loan to value caps and government-backed mortgage insurance: Loan-level evidence from Dutch residential mortgages, *De Economist*, 168, 453-473.

Harris, R. and Meir, A. (2016). Recourse structure of mortgage: A comparison between the US and Europe, *CESifo DICE Report*, 4.

Hatchondo, J., Martinez, L., and Sanchez, J. (2015). Mortgage defaults, *Journal of Monetary Economics*, 76, 173-190.

Jones, L. D. (1993). Deficiency judgments and the exercise of the default option in home mortgage loans, *Journal of Law and Economics,* 36, 115–38.

Kelly, R., O'Malley, T., and O'Toole, C. (2015). Designing macroprudential policy in mortgage lending: Do first time buyers default less?, Research Technical Papers 02/RT/15, Central Bank of Ireland.

Kelly, R., and McCann, F. (2016). Some defaults are deeper than others: Understanding long-term mortgage arrears, *Journal of Banking and Finance*, 72, 15–27.

Kelly, R., and O'Toole, C. (2018). Mortgage default, lending conditions and macroprudential policy: Loan-level evidence from UK buy-to-lets, *Journal of Financial Stability*, *36*, 322–335.

Li, W. and Oswald, F. (2017). Recourse and residential mortgages: The case of Nevada, *Journal of Urban Economics*, 101, 1–13.

Macovei, C. (2019). Highlights of the Romanian perspective of *Datio in Solutum* for consumer borrowers, *Tilburg Law Review*, 24, 89–104.

Mayer, C., Morrison, E., Piskorski, T., and Gupta, A. (2014). Mortgage modification and strategic behavior: Evidence from a legal settlement with Countrywide, *American Economic Review*, 104, 2830–2857.

Meador, M. (1982). The effects of mortgage laws on home mortgage rates, *Journal of Economics and Business*, 34, 143–148.

Melzer, B.T. (2017). Mortgage debt overhang: Reduced investment by homeowners at risk of default, *Journal of Finance*, 72, 575–612.

Mian, A. and Sufi, A. (2014a). House of debt: How they (and you) caused the great recession, and how we can prevent it from happening again, *University of Chicago Press*.

Mian, A. and Sufi, A. (2014b). What explains the 2007–2009 drop in employment?, *Econometrica*, 82, 2197–2223.

Mian, A., Sufi, A., and Trebbi, F. (2015). Foreclosures, house prices, and the real economy, *Journal of Finance*, 70, 2587–2634.

Mitman, K. (2016). Macroeconomic effects of bankruptcy and foreclosure policies, *American Economic Review*, 106(8), 2219-2255.

Nam, T. and Oh, S. (2021). Non-recourse mortgage law and housing speculation, *Journal of Banking & Finance*, *133*, 106292.

National Bank of Romania (NBR) (2016). Financial stability report, December 2016.

National Bank of Romania (NBR) (2017). Financial stability report, May 2017.

Nier, E., Popa, R., Shamloo, M., and Voinea, L. (2019). Debt service and default: Calibrating macroprudential policy using micro data, IMF Working Paper No. 182.

O'Malley, T. (2021). The impact of repossession risk on mortgage default, *Journal of Finance*, 76, 623-650.

Páscoa, M.R. and Seghir, A. (2020). Recourse loans and Ponzi schemes, *Economic Theory*, 70, 527–550.

Pavan, M. and Barreda-Tarrazona, I. (2020). Should I default on my mortgage even if I can pay? Experimental evidence, *Journal of Economic Dynamics and Control*, 110, 103733.

Pence, K.M. (2006). Foreclosing on opportunity: State laws and mortgage credit, *Review of Economics and Statistics*, 88, 177–182.

Piskorski, T. and Seru, A. (2018). Mortgage market design: Lessons from the Great Recession, *Brookings Papers on Economic Activity*, Spring 2018.

Piskorski, T. and Tchistyi, A. (2011). Stochastic house appreciation and optimal mortgage lending, *Review of Financial Studies*, 24, 1407–1446.

Schelkle, T. (2018). Mortgage default during the U.S. mortgage crisis, *Journal of Money, Credit and Banking*, 50, 1101–1137.

Appendix A.1. Variables definitions and data sources

Variable	Abbreviation	Definition	Source
Datio in Solutum	DiS	Equals 1 if a borrower requests *Datio in Solutum*, 0 otherwise.	Central Credit Registry
Borrower characteristics			
Income	Income	Borrower's current income. We classify borrowers in 4 categories: unrecorded income, below medium wage, average-double average wage, above double-average wage.	Ministry of Public Finance
Current debt-service-to-income ratio	DSTI	Borrower's overall indebtedness (that includes consumer loan obligations) relative to current income. We classify borrowers in 3 categories according to the individual DSTI ratio: below 50%, 50%-100%, and above 100%. Winsorized at 300%.	Central Credit Registry and Ministry of Public Finance.
County of residence	County	County where the loan was issued.	Central Credit Registry
Loan characteristics			
Bank	Bank FE	Originating bank. We take the bank of origination for the largest loan by outstanding balances in case of multiple loans.	Central Credit Registry
Loan size at origination	Amount at origination	Loan amount at origination. We construct 4 loan categories: below 30k, 30k-60k, 60k-90k, above 90k. We normalize the amount by the Euro exchange rate at origination.	Central Credit Registry
Currency of denomination	Currency	Loan currency. We classify loans in 3 categories: domestic currency (RON-denominated), Euro (EUR), and Swiss francs (CHF). We take the currency of denomination for the largest loan by outstanding balances in case of multiple loans.	Central Credit Registry
Current loan-to-value ratio	LTV	Outstanding loan amount divided by the current value (updated every 2 years) of the property. We classify loans in 3 categories: bellow 100%, above 100%, and no information. Winsorized at 200%.	Central Credit Registry
Residual maturity	Maturity	The number of years until maturity. We use a weighted average by outstanding balances in case of multiple loans.	Central Credit Registry
Current interest rate	Interest rate	Current interest rate. Information is available at the bank and loan level (differentiated by loan category, maturity, and currency). We use a weighted average by outstanding balances in case of multiple loans.	Monetary Balance Sheet, Central Credit Registry
Equity	Equity	The difference between the outstanding loan amount and the current value of the property (in euro).	Central Credit Registry

Appendix A.2. Additional descriptive statistics

After the *Datio in Solutum* law had been enacted, the Central Credit Registry started to keep track of borrowers' requests by recording a special flag in the month of their application for debt forgiveness. During the period covered by our study, there were 7,500 requests recorded, namely 6,172 unique borrowers. After excluding all consumer loans, we identify 2,542 requests filled by borrowers with a mortgage loan, representing 2,396 unique borrowers.[48] Figure B.4 in the Appendix shows the evolution of *Datio in Solutum* requests for the mortgage and secured consumer loans. We exclude from our dataset the requests for *Datio*

[48] Our dataset includes 250 borrowers that requested *Datio in Solutum* for both mortgage and consumer loans. We exclude all other secured consumer loans (which are eligible for requesting *Datio in Solutum*) because of their limited impact on the real estate market.

in Solutum associated with non-performing mortgage loans that were experiencing repayment difficulties before introducing the law (1,185 requests). After applying these filters, our dataset includes 1,312 unique requests representing 51 percent of the borrowers with mortgage loans who requested *Datio in Solutum*. Figure B.5 depicts the number of loans included in each vintage, as well as the number of loans included in our dataset for which *Datio in Solutum* has been requested. We observed the highest number of *Datio in Solutum* requests in September 2016.

Figure B.6 illustrates the strong relationship between a *Datio in Solutum* request and the probability of a loan becoming non-performing. On average, over the period June 2016 to June 2017, 12 percent of borrowers in our sample who requested *Datio in Solutum* defaulted on their loans. The highest default rate (32 percent) was observed in 2016 Q3. This compares with an average delinquency rate of 0.2 percent among borrowers with standard mortgage loans who did not request *Datio in Solutum* and 0.03 percent for borrowers with *First Home* loans.

The evolution of credit volume of standard mortgage loans across time has been strongly correlated with changes in credit market regulations. Romania introduced borrower-based macroprudential policies in 2003 by implementing a DSTI cap for both mortgage (35 percent) and consumer (30 percent) loans and an LTV cap at the origination of 75 percent. Together with high-interest rates prevailing at that time, these restrictive measures harmed credit supply and real estate prices. Standard mortgage loans granted before 2007 represent only 13 percent of our sample. These loans are almost exclusively denominated in euro, a consequence of large interest rate differential between domestic currency RON- and Euro-denominated loans. After joining the European Union in 2007, Romania introduced an approach based on self-regulation, which allowed banks to set credit standards following their in-house models rather than using the central bank's restrictive limits. Loans granted between 2007 and 2008 represent around 30 percent of our sample. These loans were issued during the peak of the housing boom and just before the effects of the Global Financial Crisis were felt in Romania. They have the largest unconditional probability of default, as well as the highest rate for *Datio in Solutum* requests (Figure B.7). Furthermore, these loans have the largest median amount at origination (due to high real estate prices at that moment) and the highest median current LTV ratio (due to loosen credit standards at origination combined with the collapse of real estate prices during the crisis) (Figure B.8). Finally, loans issued over 2007-2008 were almost exclusively denominated in foreign currency (92 percent), with 23 percent of foreign currency loans being granted in Swiss francs (Figure B.9).

In the aftermath of the Global Financial Crisis, risk-averse lenders tightened their credit standards while borrowers suffered from debt overhang. This combination of supply and demand factors depressed the volume of new loans issued after 2008. Both the lower median amount at origination and lower median LTV ratio for loans granted after 2008 reflect the fall in property prices.

Under the European Systemic Risk Board's recommendations on lending in foreign currencies, the National Bank of Romania implemented in 2012 a differentiated LTV-cap based on the type of borrower (i.e., hedged or unhedged regarding FX risk) and loan currency.[49] The LTV cap was set at 85 percent for domestic-currency loans. For euro-denominated foreign-currency loans issued to unhedged borrowers, the cap was set at 75 percent to increase collateralization and reduce borrower's default incentives triggered by a fall in real estate prices. In our sample, the share of loans denominated in domestic currency increased from 6 percent in 2011 to 30 percent in 2012 and further to 84 percent in 2014 (Figure B.9). Loans granted between 2012 and 2016 have lower unconditional default and *Datio in Solutum* request rates (Figure B.7) than those granted before 2012. Explanations for this pattern relate to favorable macroeconomic conditions and the enhanced supervision of the National Bank of Romania, ensuring that banks maintain high credit standards and limit foreign currency lending to unhedged borrowers.

Most of the loans in our standard mortgage sample were issued in euro (60 percent), followed by loans in domestic currency (30 percent), with loans in Swiss francs making up only 10 percent of the sample. Borrowers with RON-denominated loans have the lowest probability of default (0.12 percent), followed by borrowers with euro-denominated loans (0.26 percent). Borrowers with Swiss francs-denominated loans have the highest probability of default (0.7 percent) and the largest percentage of *Datio in Solutum* requests (1.6 percent) (Figure B.10). The high risk of Swiss francs-denominated loans is mainly due to the decision of the Swiss National Bank to unpeg the franc in January 2015 and scrap the euro 1.2 per Swiss franc floor. These actions triggered the appreciation of the Swiss franc versus the local currency and led to an increase in the debt service for borrowers with credit exposures in Swiss francs.

Regarding the loan amount at origination, 33 percent of borrowers have loans under 30,000 euro, while 40 percent have loans between 30,000 euro and 60,000 euro. Only 11 percent of loans are above 90,000 euro. Nevertheless, we observe that borrowers with the highest amounts at origination have the highest percentage of *Datio in Solutum* requests and the highest probability of default (Figure B.11).

[49] NBR Regulation No. 17/2012 on certain lending conditions.

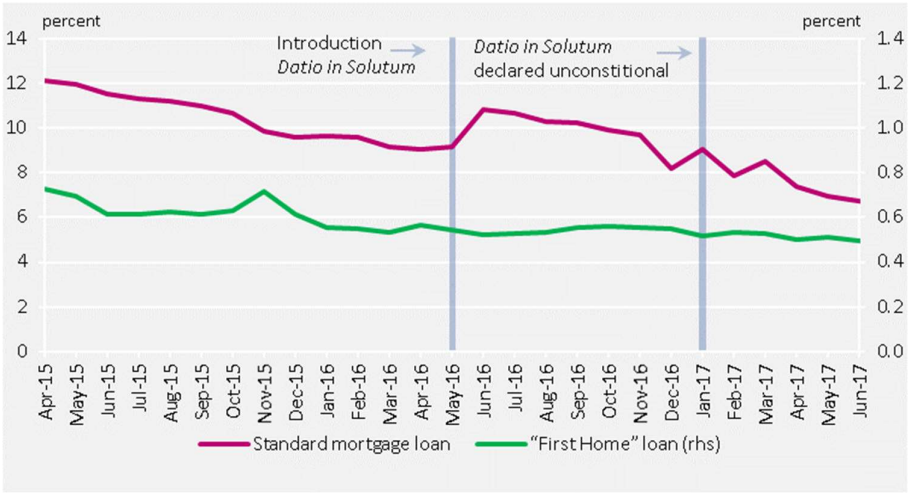
From the distribution of the number of loans conditional on the current LTV ratio, we observe that around 25 percent of loans have an LTV ratio below 50 percent, with an additional 40 percent between 50 and 100 percent. A quarter of loans have a current LTV greater than 100 percent. These loans also have the highest delinquency and *Datio in Solutum* request rates (Figure B.12). Note that the LTV indicator is available only for mortgages with a residence as the primary collateral (i.e., 88 percent of loans in our sample). Banks update the value of collateral in the credit register every 2 years. Therefore, the current LTV ratio represents the ratio between the loan's current outstanding amount and the collateral's updated value, allowing us to identify borrowers with negative equity (i.e., where the residual amount of the loan exceeds the collateral value). Mortgages with other types of collateral receive a special dummy in our empirical model to single them out when using the LTV ratio as an explanatory variable.

Regarding the income category, borrowers with incomes below the medium wage represent the largest category (approximately 30 percent), followed by those with income between medium and double medium wage, and above double the medium wage, with each category representing approximately 25 percent of borrowers. The category of borrowers with unrecorded income represents approximately 20 percent of the sample (Figure B.13). As expected, borrowers with low or no recorded income have the highest probability of default, while those with the highest income have the lowest probability of default. However, these borrowers have similar rates of requesting *Datio in Solutum* (approximately 0.35 percent). This pattern suggests that changes in recourse legislation did not benefit only the less well-off borrowers facing affordability problems (Figure B.13 and Figure B.14).

Finally, around 45 percent of standard mortgage borrowers in our sample have a DSTI below 50 percent (Figure B.15). Unsurprisingly, the probability of default increases with indebtedness. Borrowers with DSTI greater than 100 percent have the highest delinquency rates (0.6 percent) and have a larger percentage of *Datio in Solutum* requests than the other groups (Figure B.15). Debtors with unrecorded income represent around 20 percent of the sample and have a similar probability of default compared to those with DSTI greater than 100 percent.

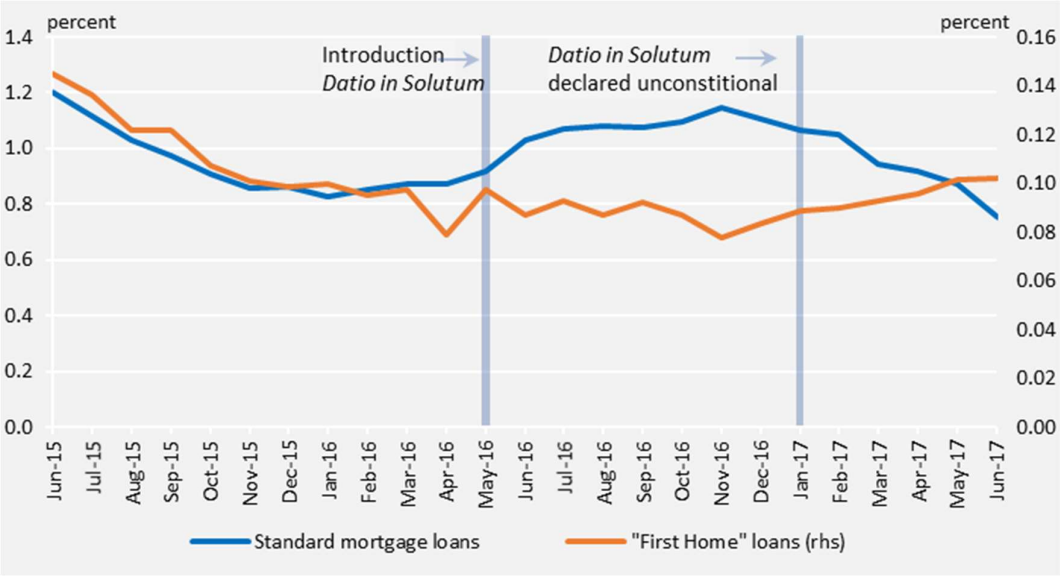
Appendix B. Figures

Figure B.1. NPLs rate by mortgage type



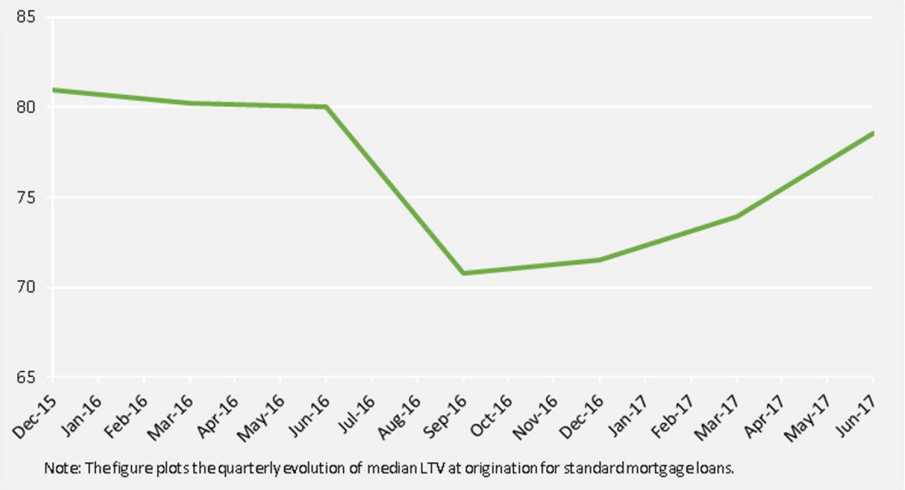
Notes: The figure plots the evolution of monthly NPLs rate conditional on the mortgage type. The NPLs rate is computed using the European Banking Authority definition that considers loans with delays above 90 days and loans flagged as unlikely to pay.

Figure B.2. Probability of default by loan type



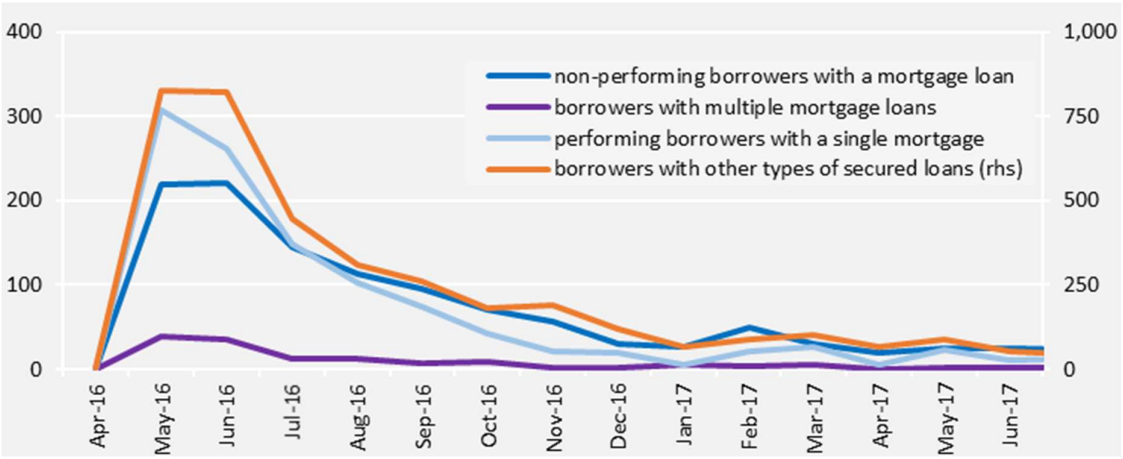
Notes: The figure plots the evolution of yearly probability of default conditional on the type of mortgage loan. The probability of default is estimated on a one-year horizon, representing the share of borrowers who transitioned from being performing to having 90 days delays four quarters afterwards.

Figure B.3. Median LTV of new standard mortgage loans



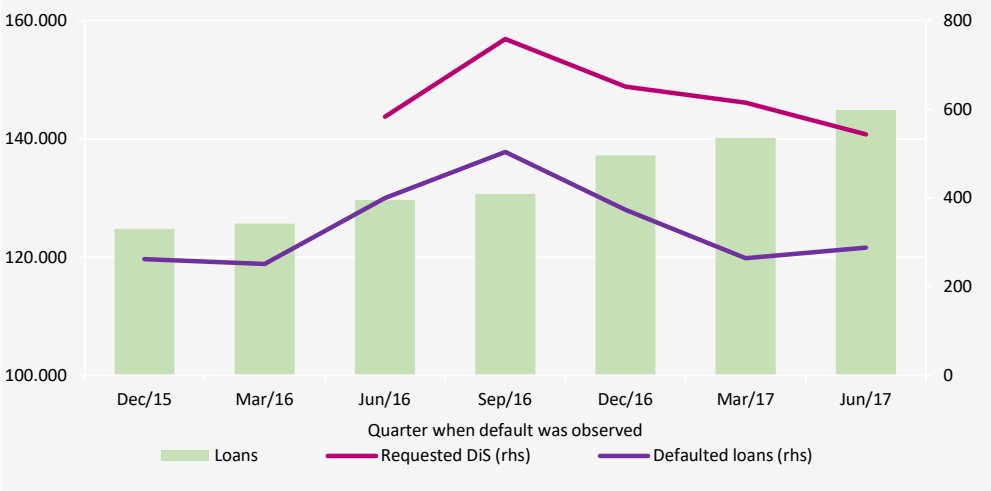
Notes: The figure plots the quarterly evolution of median LTV at origination for standard mortgage loans.

Figure B.4. *Datio in Solutum* requests by borrower type



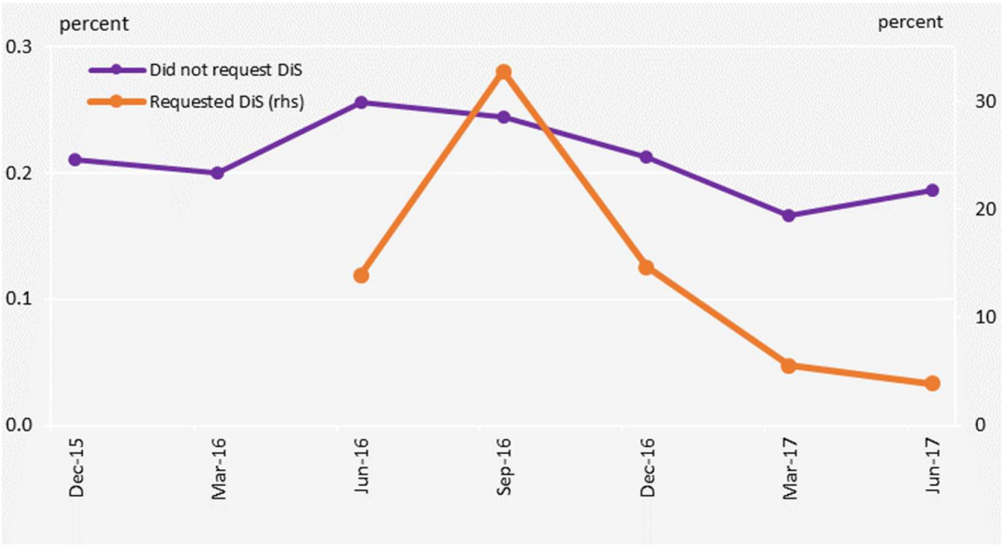
Notes: The figure plots the evolution of *Datio in Solutum* requests for different borrower categories. *Non-performing borrowers with a mortgage loan* captures the number of monthly requests from borrowers with loans that were 90 days past-due before the law was introduced. *Borrowers with multiple mortgage loans* captures the number of monthly requests from borrowers with multiple mortgage loans. *Performing borrowers with a single mortgage* captures the number of monthly requests from borrowers with one performing mortgage loan at the time of the request. *Borrowers with other types of secured loans* captures the monthly requests from borrowers with consumer loans secured by real estate assets.

Figure B.5. Performing loans, non-performing loans, and *Datio in Solutum* requests



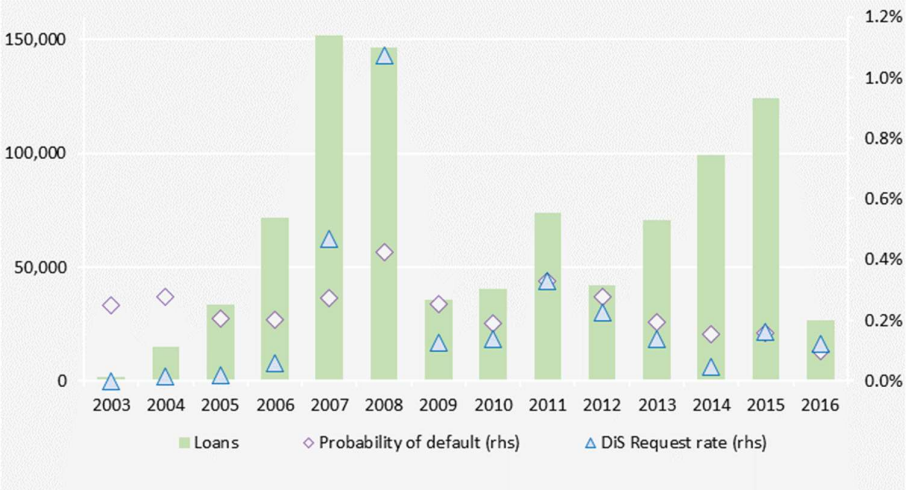
Notes: The figure plots the quarterly evolution of performing and non-performing loans and the number of *Datio in Solutum* requests. *Loans* captures the number of loans included in each vintage. *Requested DiS* captures the number of loans for which *Datio in Solutum* has been requested within 12 months after the vintage was created. *Defaulted loans* captures the number of loans that recorded delays greater than 90-days 4 quarters after the creation of the vintage.

Figure B.6. Probability of default by *Datio in Solutum* request



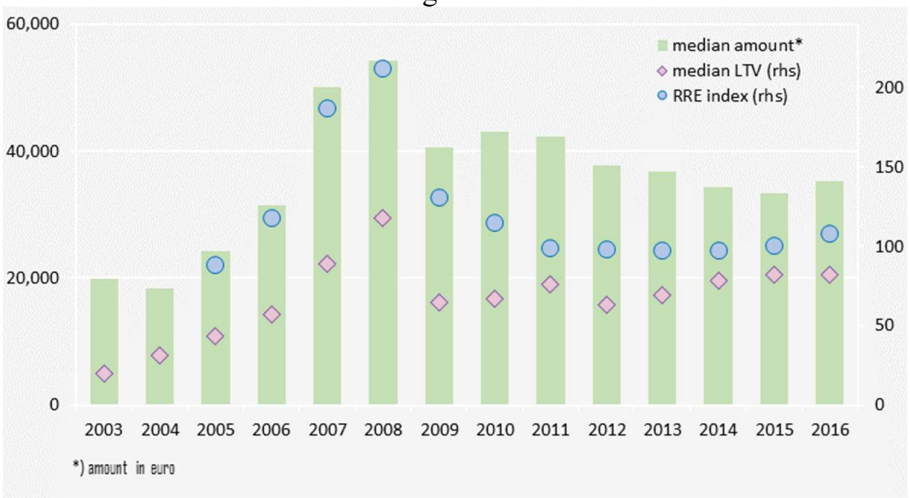
Notes: The figure plots the quarterly evolution of probability of default for loans with and without requests for *Datio in Solutum*. The probability of default is estimated on a one-year horizon and captures the share of loans that recorded delays greater than 90-days 4 quarters after the creation of the vintage.

Figure B.7. Number of loans, probability of default, and *Datio in Solutum* request rate by year of origination



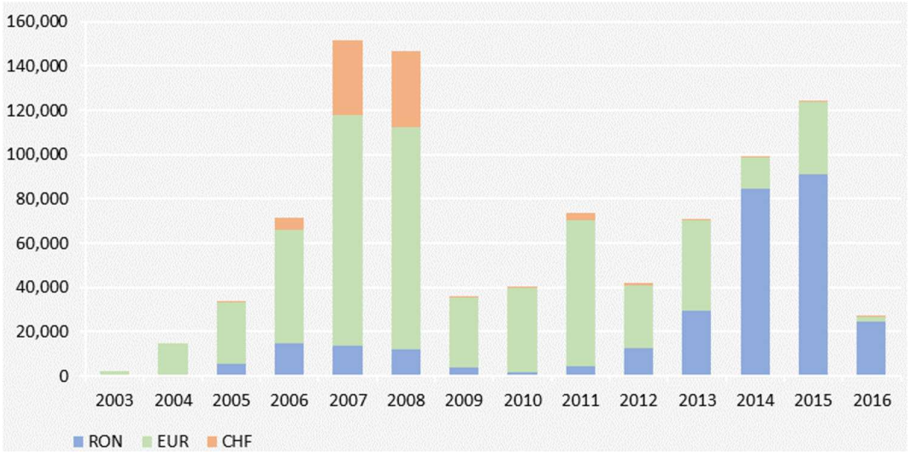
Notes: The figure plots the evolution of the number of loans, probability of default, and *Datio in Solutum* request rate conditional on the year of loan origination. *Loans* captures the number of loans per year. *Probability of default* captures the share of non-performing loans in the total number of loans issued in that year. *DiS request rate* captures the share of loans with *Datio in Solutum* request in the total number of loans issued in that year.

Figure B.8. Median amount at origination and median current LTV ratio by year of origination



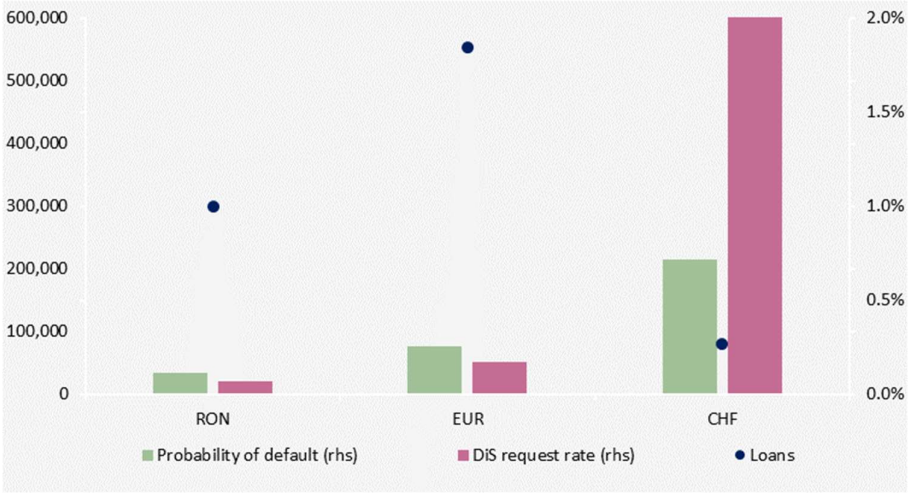
Notes: * Amount in Euro. The figure plots the evolution of median amount at origination, median current LTV ratio, and the real estate price index conditional on the year of loan origination. *Median amount* captures the median amount at origination in Euro (we use the Euro average exchange rate of the respective month for loans issued in other currencies). *Median LTV* captures the median value for the ratio between the outstanding amount and the latest value of the collateral for loans issued in a given year. *RRE index* captures the real price index. The index is computed using information from the Romanian National Institute of Statistics (before 2010) and from Eurostat (from 2010 onwards).

Figure B.9. Number of loans by year of origination and currency



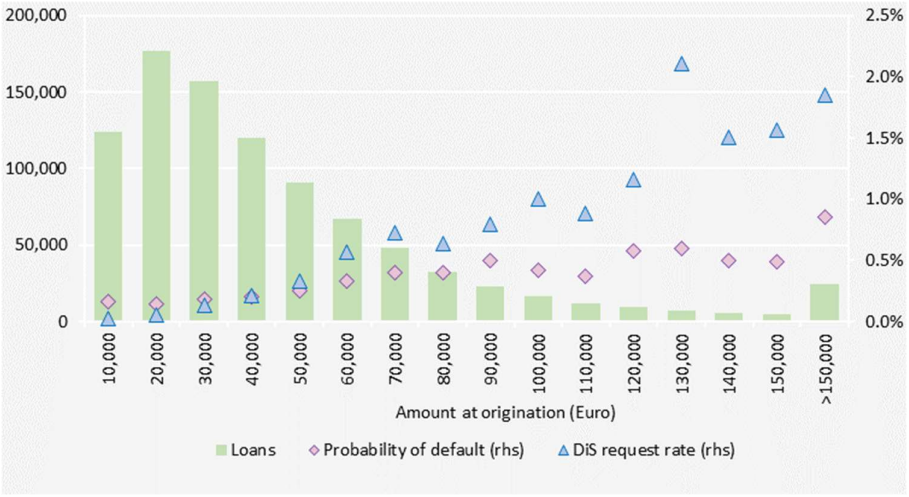
Notes: The figure plots the evolution of the number of loans per year conditional on loan currency.

Figure B.10. Number of loans, probability of default, and *Datio in Solutum* request rate by currency



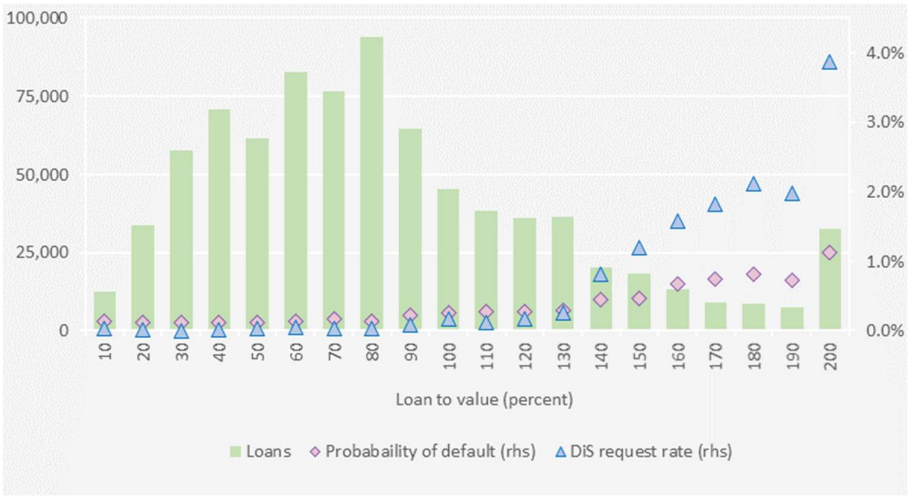
Notes: The figure plots the number of loans, probability of default, and *Datio in Solutum* request rate conditional on loan currency. *Loans* captures the total number of loans denominated in a specific currency. *Probability of default* captures the share of non-performing loans in the total number of loans denominated in a specific currency. *DiS request rate* captures the share of loans with *Datio in Solutum* request in the total number of loans denominated in a specific currency.

Figure B.11. Number of loans, probability of default, and *Datio in Solutum* request rate by amount at origination



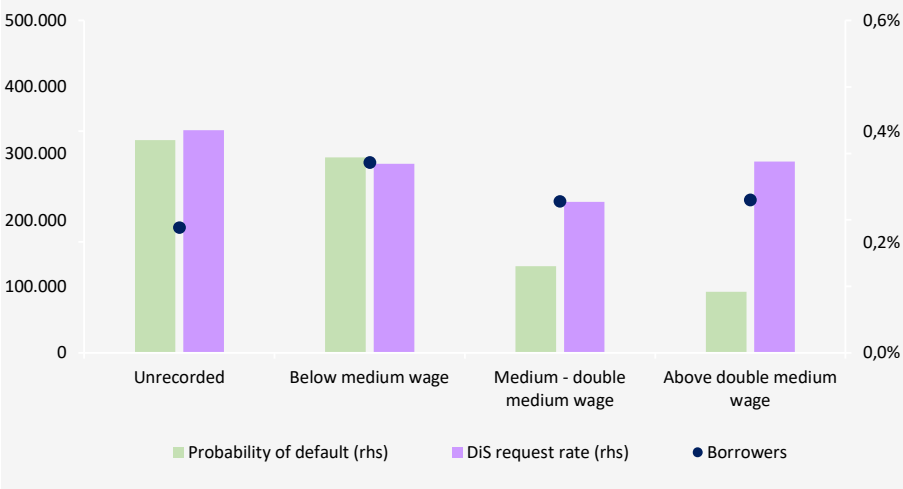
Notes: The figure plots the evolution of the number of loans, probability of default, and *Datio in Solutum* request rate conditional on loan amount at origination. *Loans* captures the total number of loans with size at origination in a specific interval. *Probability of default* captures the share of non-performing loans in the total number of loans with size at origination in a specific interval. *DiS request rate* captures the share of loans with *Datio in Solutum* request in the total number of loans with size at origination in a specific interval.

Figure B.12. Number of loans, probability of default, and *Datio in Solutum* request rate by LTV



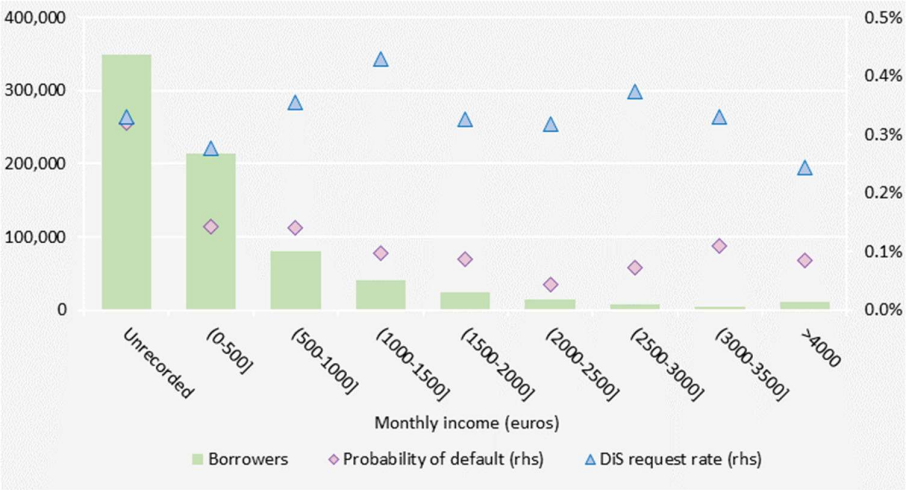
Notes: The figure plots the distribution of the number of loans, probability of default, and *Datio in Solutum* request rate conditional on the level of the current LTV. *Loans* captures the total number of loans with the current LTV in a specific LTV bracket. *Probability of default* captures the share of non-performing loans in the total number of loans with current LTV in a specific LTV bracket. *DiS request rate* captures the share of loans with *Datio in Solutum* request in the total number of loans with current LTV in a specific LTV bracket.

Figure B.13. Number of borrowers, probability of default, and *Datio in Solutum* request rate by income category



Notes: The figure plots the number of borrowers, probability of default, and *Datio in Solutum* request rate conditional on income group. *Borrowers* captures the total number of borrowers within a specific income group. *Probability of default* captures the share of non-performing loans in the total number of loans taken by borrowers from a specific income group. *DiS request rate* captures the share of loans with *Datio in Solutum* request in the total number of loans taken by borrowers from a specific income group.

Figure B.14. Number of borrowers, probability of default, and *Datio in Solutum* request rate by monthly income



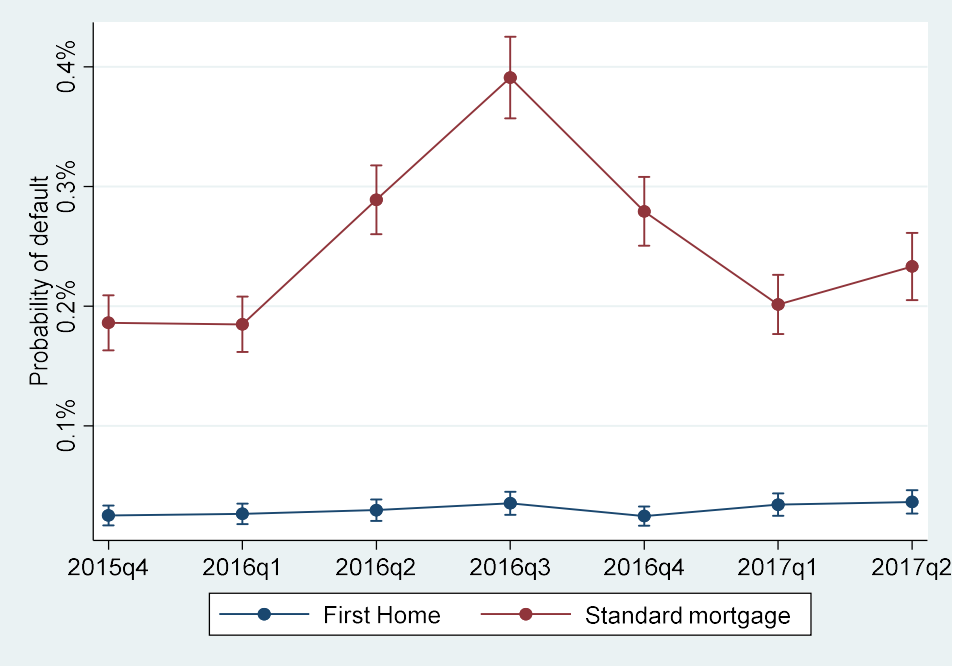
Notes: The figure plots the borrowers' distribution, probability of default, and *Datio in Solutum* request rate conditional on monthly income (expressed in euro). *Borrowers* captures the total number of borrowers with a monthly income in a specific bracket. *Probability of default* captures the share of non-performing loans in the total number of loans taken by borrowers with a monthly income in a specific bracket. *DiS request rate* captures the share of loans with *Datio in Solutum* request in the total number of loans taken by borrowers with a monthly income in a specific bracket.

Figure B.15. Number of borrowers, probability of default, and *Datio in Solutum* request rate by DSTI level

Notes: The figure plots the borrowers' distribution, probability of default, and *Datio in Solutum* request rate conditional on the DSTI level. *Borrowers* captures the total number of borrowers with DSTI in a specific DSTI bracket. *Probability of default* captures the share of non-performing loans in the total number of loans taken by borrowers with DSTI in a specific DSTI bracket. *DiS request rate* captures the share of loans with *Datio in Solutum* request in the total number of loans taken by borrowers with DSTI in a specific DSTI bracket.

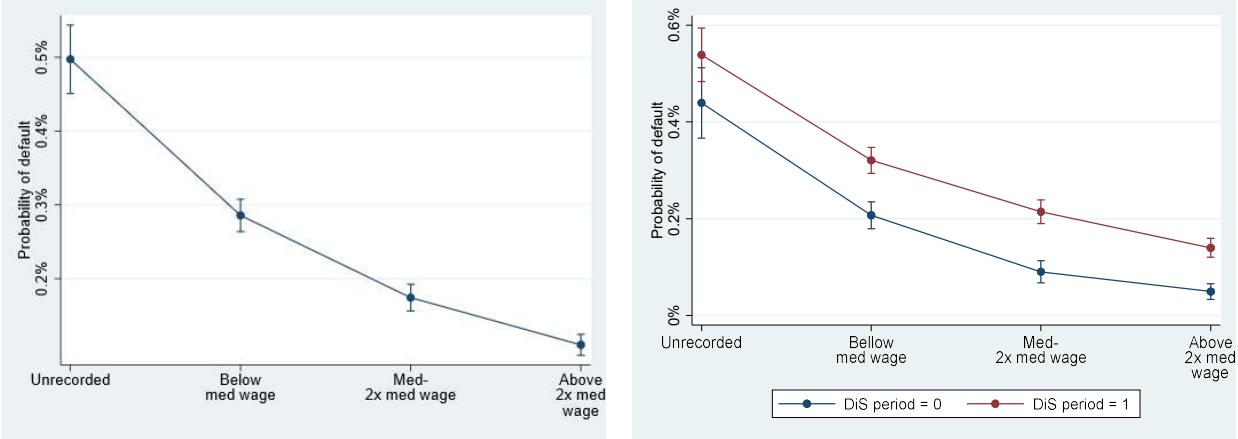
Appendix C. Marginal effects

Figure C. 1 Average probability of default by quarter



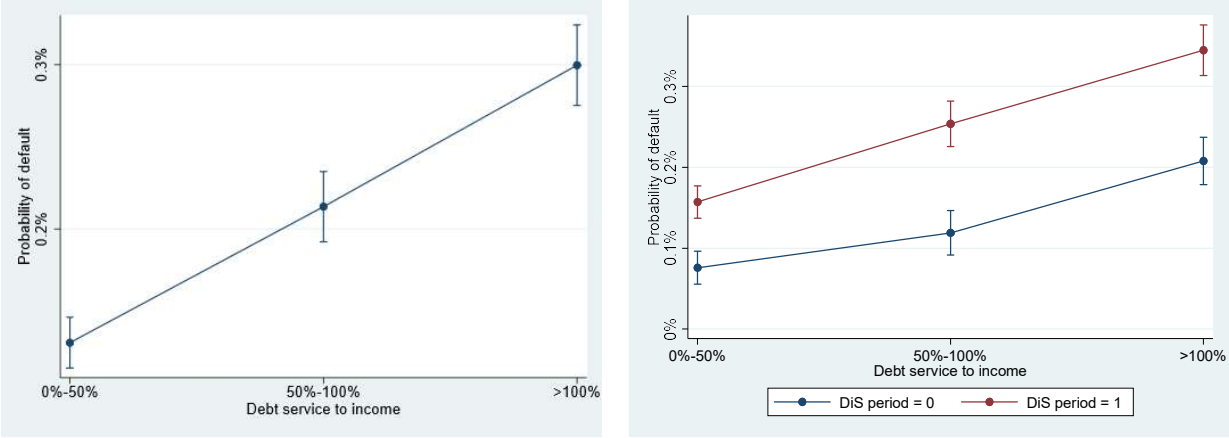
Notes: The figure plots the average probability of default by quarter and type of mortgage loan.

Figure C. 2 Income marginal effect



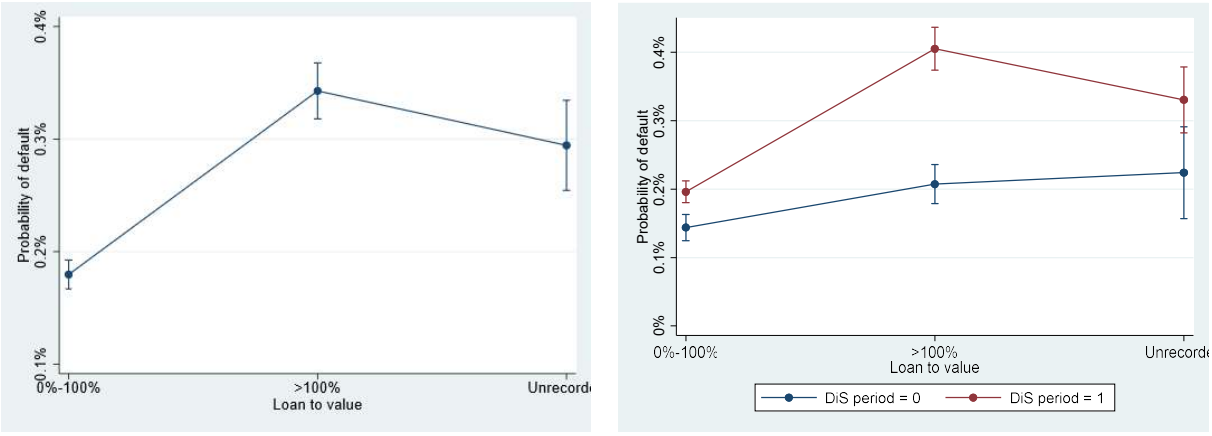
Notes: The left panel plots the marginal effect of income. The right panel plots the marginal effect of income conditional on *Datio in Solutum* period dummy.

Figure C. 3 DSTI marginal effect



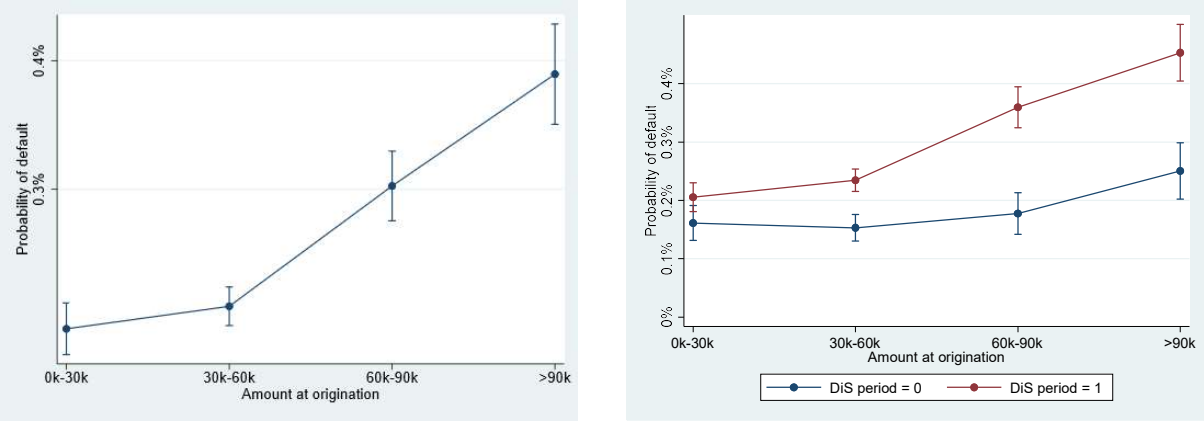
Notes: The left panel plots the marginal effect of DSTI. The right panel plots the marginal effect of DSTI conditional on *Datio in Solutum* period dummy.

Figure C. 4 Current LTV ratio marginal effect



Notes: The left panel plots the marginal effect of current LTV ratio. The right panel plots the marginal effect of current LTV ratio conditional on *Datio in Solutum* period dummy.

Figure C. 5. Amount at origination marginal effect



Notes: The left panel plots the marginal effect of amount at origination. The right panel plots the marginal effect of amount at origination conditional on *Datio in Solutum* period dummy.