# DNB Working Paper

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DeNederlandscheBank

EUROSYSTEEM

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Working Paper No. 580

December 2017

De Nederlandsche Bank NV
P.O. Box 98
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The Netherlands

# Mortgage arrears, regulation and institutions: Cross-country evidence[*]

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15 December 2017

**Abstract**

Using a newly constructed database for 26 countries over 2000-2014, we analyze cross-country and within-country differences in mortgage arrears. We find that macro-prudential policies (notably regulatory LTV ratios) are significantly negatively associated with the share of mortgage arrears in total residential debt. Our results suggest that better institutions are also associated with lower delinquency rates, both directly and by enhancing the impact of macro-prudential policies and the right to recourse. Moreover, we find that the effect of macro-prudential policies is conditioned by several mortgage market characteristics, like the maturity of loans, interest rate fixity, and tax deductibility of interest payments.

**Keywords***: mortgage arrears; macro-prudential regulation; institutions; mortgage market.
**JEL classifications***: C25; D14; E32; G15.

## 1. Introduction

The global financial crisis has highlighted the devastating effects that fragilities in the residential mortgage market may have on the financial system at large. The initial shock of an increase in mortgage arrears (due to a decline in house prices) in the US and some European countries was the trigger for a liquidity crisis that ultimately turned into a full-blown financial crisis.

Despite a significant contraction of the sector in the aftermath of the crisis, mortgage lending still accounts for a large share of both households' debt and banks' assets.[1] Yet, there are important differences in the depth of mortgage markets across countries. Likewise, as we argue in this paper, the incidence of mortgage arrears differs considerably across countries, as well as over time in individual countries. A better understanding of the factors that explain cross-country and within-country differences in mortgage delinquency is thus of great importance for policymakers for at least two reasons. First, mortgage defaults dilute the fundamentals of financial institutions and amplify disruptions in financial markets, as revealed during the financial crisis. Second, mortgage defaults reduce households' creditworthiness, thereby making it more difficult (in terms of volume and price) to access future financing. This may increase consumption volatility, both at the household and aggregate level, with repercussions for the real economy.

Against this background, this paper examines the incidence of mortgage arrears in a large sample of countries.[2] To this end, we explore the role played by various factors in explaining cross-country and within country differences in delinquency rates. These factors can be grouped into four main categories: macroeconomic variables, macro-prudential regulation, institutional factors, and housing market characteristics. Previous studies on mortgage defaults have investigated only subsets of these factors. We complement this literature and provide a more comprehensive view of variables associated with mortgage defaults, as well as of various interactions between different predictors of defaults.

Our paper makes four contributions. First, we provide a unique comparative dataset on mortgage arrears at the macro level for a reasonably large number of countries over 2000-2014, which allows us to analyze cross-country and within-country

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[1] The IMF's Global Financial Stability Report (2017) finds that the median household debt-to-GDP ratio in advanced economies was 63 percent in 2016, with mortgage debt accounting for more than 50 percent of total household debt. Similarly, Cerutti et al. (2017b) report that the median share of mortgages in total household debt in a sample of 53 countries was about 70 percent in 2011.

[2] Throughout the paper we use terms "arrears", "delinquency" and "default" interchangeably, referring to past due payment obligations.

differences in mortgage defaults. Although several previous papers have analyzed the determinants of mortgage defaults at the country level (see, for instance, Demyanyk et al., 2011; Blanco and Gimeno, 2012; Aron and Muelbauer, 2016; and Goodstein et al., 2017), only a few papers provide cross-country databases at the macro level. Our database contains more countries and covers a longer time period than those used in previous studies.[3] A careful study of aggregate data is pertinent given the paucity of micro data on mortgage defaults in many countries.

Second, our paper is among the first to examine to what extent macro-prudential policies are related to mortgage defaults. Recently, macro-prudential policies have become much more important in most countries, as the financial crisis showed that micro-prudential supervision needs to be complemented by macro-prudential policies to maintain financial stability. Several papers have examined the impact of such policies on credit growth and housing prices. For instance, Akinci and Olmstead-Rumsey (2017) argue that macro-prudential tightening is associated with lower bank and housing credit growth, as well as with lower house price inflation, but they do not examine the impact of macro-prudential policies on mortgage defaults.[4] Three previous studies come closer to this part of our work (Wong et al., 2011; Gerlach-Kristen and Lyons, 2015; and Allen et al., 2017). While these studies mainly focus on one single instrument aimed at borrowers' leverage, namely loan to value (LTV) ratios, we consider several other housing-targeted macro-prudential instruments which are aggregated in comprehensive indexes that capture changes in the intensity of their usage. Our results suggest that restrictive macro-prudential policies, and in particular regulatory LTV ratios, are associated with a reduction in mortgage defaults.

Third, we examine to what extent several institutional factors, that are often associated with the cost of default and efficiency of the judicial system, may explain cross-country differences in mortgage default rates. Only few studies that we are aware of do something similar. For example, Japelli et al. (2008) and Dygan-Bump and Grant (2009) argue that institutional factors may foster household credit but are also related to insolvencies. These studies report that institutional arrangements affect the sensitivity of household insolvencies to household debt. We complement these papers and show that better institutions are associated with lower levels of mortgage default.

Finally, we examine interaction effects and show how the relationship between

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[3] For instance, Wong et al. (2011) use data for 13 countries over the period 1991-2010, while Jappelli et al. (2008) employ data for 11 European Union member states over the period 1994-2001.

[4] Other relevant studies on the effects of macro-prudential policies include Claessens et al. (2013), Kuttner and Shim (2013), Vandenbussche et al. (2015), Zhang and Zoli (2016), and Cerutti et al. (2017b).

macro-prudential policies and mortgage defaults is conditioned by institutional arrangements. To this end we provide evidence that the effect of macro-prudential policies is enhanced by institutional quality: lower default rates are strongly associated with restrictive macro-prudential policies in the presence of better institutions. In addition, we find that certain characteristics of the mortgage market (such as loan maturity, the loans' interest rate type, and the tax deductibility of interest payments) are associated with fewer mortgage defaults when restrictive macro-prudential policies are in place. Likewise, the relationship between recourse procedures and mortgage arrears is enhanced by institutional quality. Apart from house prices, which have been considered in several previous studies, these other housing market variables have received hardly any attention in the literature.[5]

The paper is structured as follows. Section 2 provides a literature review identifying potential drivers of mortgage defaults. Section 3 describes the data sources and presents stylized facts. Section 4 presents the methodology and the results, while section 5 offers several robustness tests. Section 6 concludes.

## 2. What drives mortgage defaults?

### 2.1 Potential drivers

The theoretical literature suggests two main explanations of mortgage arrears: ability-to-pay and strategic default (Whitley et al., 2004). According to the ability-to-pay theory of default, individuals default involuntarily when they are unable to meet current payments. The strategic default theory holds that households choose to default voluntarily after a rational analysis of all future costs and benefits associated with continuing or not to meet the obligations of the mortgage. If a household faces affordability problems—which may be caused by a drop in income (e.g., due to unemployment), higher mortgage payments (e.g., due to higher interest rates), or a decline in house prices (leading to negative equity)—strategic default may be an option.[6]

Consistent with the strategic default view, there is evidence that borrowers facing a

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[5] An exception is the work by Aristei and Gallo (2012) who consider variables such as mortgage maturity in their analysis of Italian mortgage defaults.

[6] Both theories suggest that macroeconomic factors (such as lower house prices, higher interest rates and higher unemployment) may increase mortgage defaults by reducing the ability of households to pay their mortgages. Several studies focusing on mortgage defaults at the country level provide evidence for the importance of these macroeconomic variables (Whitley et al., 2004; Elul et al., 2010; Demyanyk et al., 2010; Magri and Pico, 2011; Banco and Gimeno, 2012; Aron and Muealbauer, 2016; and Goodstein et al., 2017). The same holds for studies using micro-level data for several countries (Diaz-Serrano, 2004; Gerlach-Kristen and Lyons, 2015).

financial shock are more likely to default on mortgage debt than on other forms of debt (e.g., credit cards), particularly those who have a preference for preserving liquidity (Cohen-Cole and Morse, 2009). Thus, a borrower may default if his gains exceed the perceived costs of the expected sanctions, including access to future finance and its price.[7] As pointed out by Jappelli et al. (2008), these costs not only depend on lenders' willingness to inflict sanctions, but on the entire set of institutional arrangements governing the credit market, such as the rule of law, creditor rights and bankruptcy laws. Likewise, Duygan-Bump and Grant (2009) show in their European panel study on household debt arrears that the extent to which adverse shocks matter depends on the punishment associated with default. In this paper we do not intend to provide empirical evidence for any of the aforementioned theories of mortgage default, nor to distinguish between various factors that have been associated with one particular type of default or the other. Instead, for the purpose of our empirical investigation, we use the insights from these theories to identify potential determinants of mortgage repayment.

In addition to macroeconomic and institutional factors, regulation, and in particular macro-prudential policies targeting the household sector, may influence developments in the mortgage market. Although there is increasing evidence that macro-prudential policies affect housing credit growth and house price increases (see Galati and Moessner (2013, 2017) for excellent reviews on the implementation and effectiveness of various macro-prudential tools) there is only limited evidence whether these instruments influence the incidence of mortgage defaults. For example, Wong et al. (2011) investigate the role of maximum LTV ratios on mortgage delinquency by estimating the responsiveness of delinquency ratios to changes in property prices and to macroeconomic fluctuations. These authors find that maximum LTV ratios are effective in reducing the systemic risk stemming from the boom-and-bust cycle of housing markets. Likewise, Gerlach-Kristen and Lyons (2015) argue for a policy enforcing LTV limits in order to reduce arrears as their evidence suggests that defaults seem particularly strong in countries with high LTV ratios. Using micro-simulations, Allen et al. (2017) find that loan-to-value policies reduce the impact of interest rate shocks on household vulnerabilities in Canada.

Finally, mortgage market characteristics may affect the likelihood of mortgage default. One important factor that plays a role in deciding for or against default is recourse legislation. If the price of a property is less than the value of the mortgage (i.e., a household has negative equity), default is less attractive under recourse legislation as the household remains responsible for the negative equity. Under non-

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[7] For instance, in the models of Kocherlakota (1996), Kehoe and Levine (2001) and Chatterjee et al. (2007) households compare the costs of default with the benefits of reneging on their debts and default if it is advantageous to do so.

recourse mortgage legislation, any shortfall between the mortgage and the property value is borne by the lender. Most of the European countries and many states in the U.S. allow mortgage lenders to claim borrowers' financial assets when the collateral falls short of the loan balance. Evidence from the U.S. supports the hypothesis that homeowners in states with recourse legislation are less likely to default (Ghent and Kudlyak, 2011; Li and Oswald, 2017).

The type of loan (fixed vs. flexible interest rate) and loan maturity could also have an impact on mortgage defaults. Borrowers are more likely to face difficulties in making their mortgage-related payments when interest rates are more volatile (the impact being larger for variable-rate mortgages) and/or when the periodic installments are higher (as for loans with short maturities). Another feature of the mortgage market that may be conducive to an increase in households' leverage, and subsequently to more arrears, is the tax treatment of interest payments. Some countries give (sometimes generous) preferential treatment to mortgages (in the form of deductibility of interest payments) as part of broader government intervention to encourage homeownership. Yet, in other countries such favorable tax treatment is more limited or even non-existing.

## 2.2 Previous studies

Three different types of studies on the determinants of mortgage defaults can be discerned in the literature, namely individual country studies, multiple country studies, and panel studies. These studies consider different dimensions of the variation in mortgage defaults and they all have benefits as well as shortcomings. Although conclusions in these studies are often phrased in terms of causality, generally the data available do not allow for strong identification strategies (like, for example, dif-in-dif). The same holds for our data. We therefore are cautious in claiming that the relationships identified are causal.

Several studies examine the development of mortgage arrears over time in individual countries, either using macro or micro level data (see Aristei and Gallo, (2012), Gerlach-Kristen and Lyons (2015), and Aron and Muelbauer (2016) for reviews). A major advantage of individual country studies is that the respective time series data is immune from the problem of international data comparability. A major disadvantage of this type of studies is that several potential determinants of mortgage default cannot be considered (e.g., different institutional arrangements and credit market characteristics).

Cross-country regressions can account for some of these variables. A good example is the study by Japelli et al. (2008) who use cross-country regressions for 45 countries

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to show how the size of the household credit market is associated with institutional variables like enforcement of creditor rights and information sharing arrangements. Other papers consider several countries using micro databases (e.g., Diaz-Serrano, 2004; Duygan-Bump and Grant, 2009). Using micro data has the advantage that individual borrower characteristics can be considered. However, as the number of countries in this type of studies is generally restricted due to paucity of micro data (Aron and Muelbauer, 2016), a disadvantage is the limited variability in the cross-country determinants of mortgage defaults.

An alternative is therefore using panel data at the macro level. This is done, for instance, in studies by Japelli et al. (2008) and Wong et al. (2011) which were discussed earlier. The main advantage of the panel approach is that it allows for both cross-country and within-country variables to be considered. Our analysis shows the importance of accounting for both dimensions as there is considerable variation in mortgage defaults both across countries and within a country. However, this comes at the cost of not accounting for the potential contribution of individual borrower characteristics in explaining mortgage delinquency.

## 3. Data

This section describes our newly constructed database for mortgage defaults as well as the various data sources from which information on the macroeconomic variables, macro-prudential tools, institutional arrangements, as well as mortgage markets characteristics have been obtained.

### 3.1. Mortgage default

We collected information about mortgage defaults in 26 countries covering the period 2000-2014. Since data on actual defaults is not available for most countries in our sample, we use the ratio of the total value of mortgage arrears (over 3 months past due) to total value of outstanding mortgage loans as a proxy for mortgage defaults.[8] Data on mortgage arrears is collected from the respective central banks or from supervisory authorities.[9] As shown in the first row of Table 1, there is significant variability in annual default rates. The ratio ranges from 0.01% to 28.6% per annum

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[8] This proxy has been used in previous studies (Duygan-Bump and Grant, 2009) and is in line with the guidelines on the definition of default as proposed by the European Banking Authority (see the consultation paper *Guidelines on the application of the definition of default under Article 178 of Regulation (EU) 575/2013 (EBA/CP/2015/15)*. Moreover, the cross-country consistency of this definition allows for international comparison.

[9] Detailed information on the main sources for the data is available at request. At the country level data is available with either monthly, or quarterly, or annual frequency. We use the average of monthly or quarterly default rates where annual information is not available.

with a mean of 3.2%. Average mortgage defaults over the sample period differ sharply across countries (see Figure 1), ranging from below 1% in Australia, Canada, Denmark, and the Netherlands, among others, to above 8% in Greece, Hungary, Ireland, and the Philippines.

Figure 1. Average mortgage default rates per country (2000-2014)
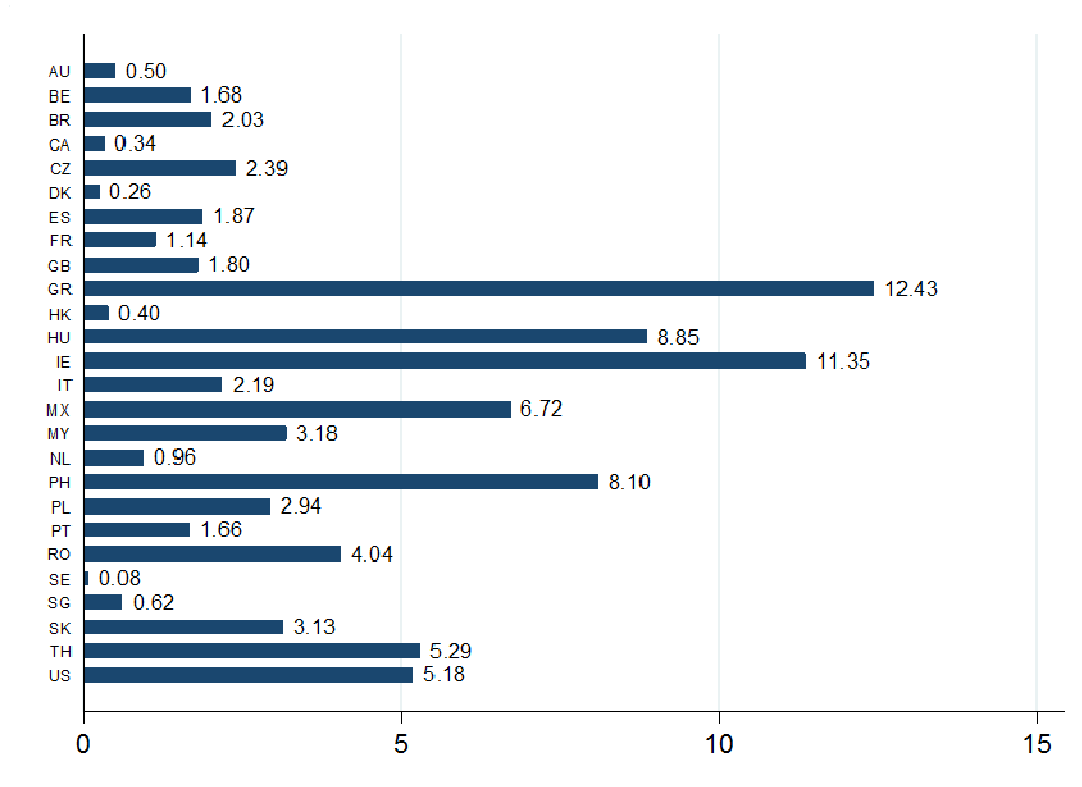


As Table A.1 in Appendix A shows, there is also substantial variation within countries. Some countries have experienced significant fluctuations in the annual default rates during 2000-2014 (for example, Mexico from around 3% to a maximum of 18.5%, or Hungary from around 3% to a maximum of 14%, or the Philippines from around 3% to a maximum of 15%). Table 1 shows that the between country variation (3.42) is slightly larger than the within country variation (2.75), however the two numbers are relatively close.[10] This points to the importance of both within and cross-country variation of default rates and suggests that a panel data approach is appropriate for

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[10] The within variation number for mortgage defaults refers to the deviation from each country's average, and therefore some of those deviations are negative.

studying mortgage delinquency.

## 3.2. Macroeconomic variables

We control for macroeconomic conditions using three macroeconomic variables: unemployment, changes in house prices and interest rates spread. Previous studies have documented a strong relationship between these variables and mortgage defaults. Data on unemployment comes from the World Development Indicators (World Bank) database. Data on house prices is from the Bank of International Settlements and the European Mortgage Federation (2015). As a proxy for the interest rate we use the spread between the long-term government bond yield and the rate of treasury bills. The spread captures borrowers' financial constraints by linking the yields relevant for borrowing costs and for savings.[11] The sources for these variables are the IMF's International Financial Statistics and FRED Economic Data (St. Louis Fed). Table B.1 in Appendix B provides summary statistics at the country level.

In our sample, there is a positive relationship between unemployment and annual default rates (Figure 2), as well as between the interest rate spread and mortgage defaults (Figure 3). On the contrary, house prices seem to be negatively correlated with mortgage defaults over the period 2000-2007. This relationship becomes (weakly) positive after 2007 suggesting that the flattening of house prices following the financial crisis has been associated with an increase in mortgage arrears (Figure 4).

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[11] An increase in the spread may signal affordability problems for mortgage borrowers. There are two potential sources for spread widening. On the one hand, it can be caused by an increase in mortgage costs (usually linked to the long-term yield) that is not compensated by a similar increase in the savings rate (usually linked to the short-term yield). On the other hand, the spread widens when the savings rate decreases more than mortgage costs.

Table 1. Summary statistics of the variables used in the cross-country analysis

| Variable | N | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| **Mortgage defaults** | 289 | 3.2 | 4.24 | 0.01 | 28.6 |
| Between variation | | | 3.42 | 0.08 | 12.43 |
| Within variation | | | 2.75 | -5.90 | 19.30 |
| **Macroeconomic variables** | | | | | |
| Unemployment | 390 | 7.61 | 4.34 | 0.7 | 27.2 |
| House prices (%) | 306 | 4.35 | 8.35 | -18.74 | 31.15 |
| Interest spread | 344 | 1.6 | 2.87 | -8.5 | 35.47 |
| **Macro-prudential policy** | | | | | |
| Macro-pru policy index | 390 | 0.23 | 0.76 | -1 | 5 |
| Macro-pru instruments | 390 | 0.48 | 2.67 | -6 | 11 |
| LTV index | 390 | 0.05 | 0.35 | -1 | 2 |
| **Institutional quality** | | | | | |
| Legal rights | 24 | 6.88 | 2.37 | 3 | 10 |
| Rule of law | 24 | 0.69 | 0.11 | 0.47 | 0.87 |
| Property protection | 26 | 6.44 | 0.88 | 5.1 | 8.1 |
| Investor protection | 26 | 6.42 | 1.54 | 4.3 | 9.3 |
| Creditor rights | 26 | 1.81 | 1.11 | 0 | 4 |
| Institutional quality index (IQ) | 23 | -0.02 | 1.75 | -2.76 | 3.08 |
| **Mortgage market** | | | | | |
| Average maturity | 26 | 26.31 | 7.45 | 15 | 45 |
| Recourse | 24 | 0.79 | 0.41 | 0 | 1 |
| Loan type | 26 | 0.15 | 0.36 | 0 | 1 |
| Funding type | 24 | 0.63 | 0.48 | 0 | 1 |
| Tax deductibility | 26 | 0.62 | 0.49 | 0 | 1 |

*Notes*: This table shows summary statistics of the data used in the empirical analysis. See the main text for variables definitions. Tables A.1 (Appendix A) and B1-B3 (Appendix B) provide summary statistics at the country level.
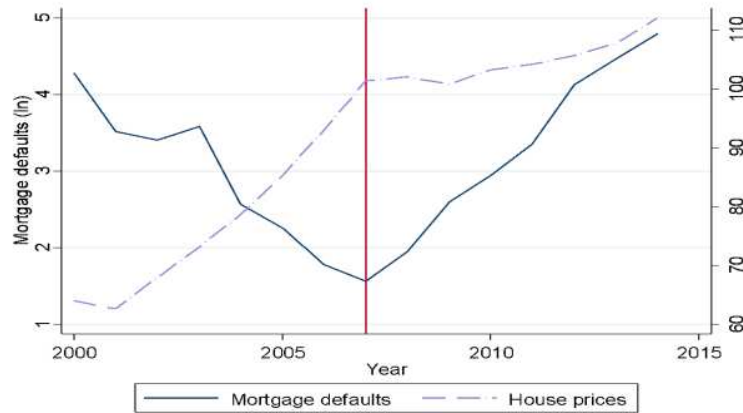
Figure 2. Mortgage defaults and unemployment
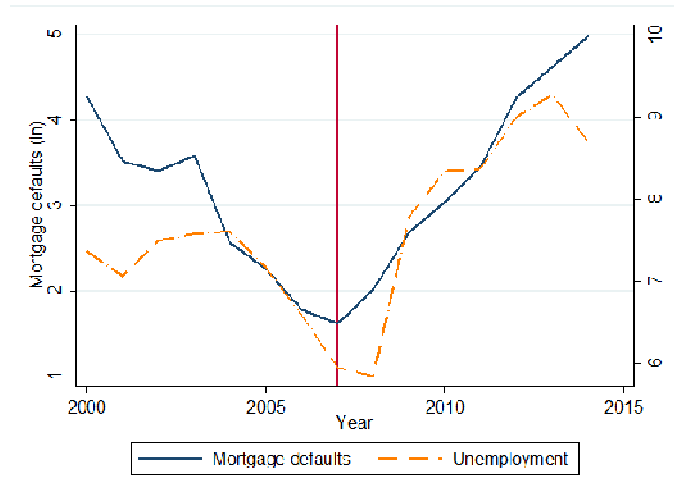


*Notes:* The figure plots the evolution of the cross-country averages for the mortgage default rates and the unemployment rate. The series are obtained by averaging the respective variables across countries for each year in the sample. The red line indicates the start of the financial crisis.

Figure 3. Mortgage defaults and interest rate spread
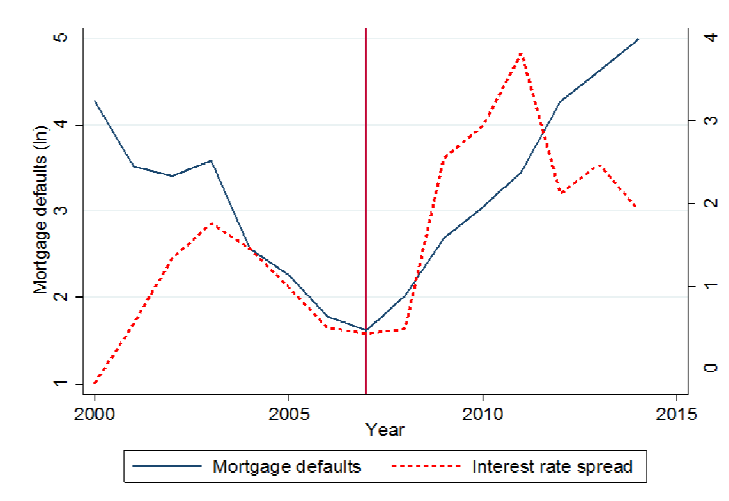


*Notes:* The figure plots the evolution of the cross-country averages for the mortgage default rates and the interest rate spread. The series are obtained by averaging the respective variables across countries for each year in the sample. The red line indicates the start of the financial crisis.

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Figure 4. Mortgage defaults and house prices



*Notes:* The figure plots the evolution of the cross-country averages for the mortgage default rates and the house prices. The series are obtained by averaging the respective variables across countries for each year in the sample. The red line indicates the start of the financial crisis.

### 3.3 Macro-prudential policy

The presence of macro-prudential instruments that target the housing market, as well as their usage across time, may also be related not only to cross-country, but also to within country differences in default rates. For the purpose of our study we take information on macro-prudential policy from Akinci and Olmstead-Rumsey (2017) and Cerutti et al. (2017a). The macro-prudential index compiled by Akinci and Olmstead-Rumsey (2017) (*Macro-pru policy index* or *MPI*, hereafter) takes four instruments into account that target the housing sector (i.e., loan-to-value cap, debt service-to-income cap, capital and provisioning requirements). For this reason, we choose the MPI to be the main proxy for macro-prudential policy in our study.[12] The index is constructed as follows: for each instrument a monthly value of 1 is assigned if the measure is introduced or tightened in the respective month. If the macro-prudential instrument is loosened, a monthly value of -1 is assigned. If there is no action taken with respect to that instrument, a value of 0 is recorded. The individual monthly indexes are aggregated to the quarterly level and the index used is the aggregate of the changes of the four instruments within each quarter.

To explore a more comprehensive set of macro-prudential measures designed for both the real estate and the non-real estate sector, we use the database of Cerutti et

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[12] The index covers 57 advanced and emerging economies over the period 2000-2013.

al. (2017a) which provides an index that aggregates over five instruments (capital buffers, interbank exposure limits, concentration limits, loan to value ratio limits, and reserve requirements; *Macro-pru instruments*, hereafter).[13] For both *Macro-pru policy* and *Macro-pru instruments*, a larger positive value suggests a tightening process.[14]

Finally, since the data from the above-mentioned sources show that LTV caps are the most commonly used instrument, we also collect information about changes in the regulatory LTV ratios for all countries in our sample (from Cerutti et al., 2017a) and create an index that captures tightening and easing of this particular macro-prudential tool.

To illustrate the relationship between the intensity in the usage of macro-prudential tools and the incidence of mortgage defaults, Figure 5 plots average defaults rates across countries as a function of the macro-pru policy index (MPI). As shown in the figure, a clear pattern emerges: the higher the value of the index (i.e., a more restrictive lending environment), the lower the average level of mortgage defaults. This relationship seems stronger over the 2008-2014 period.[15]

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[13] The index is very similar to Akinci and Olmstead-Rumsey's index. It captures quarterly tightening and easing of macro-prudential tools in 64 countries over the period 2000-2014. We use for our analysis the cumulative indexes for each prudential tool. The cumulative index sums in each quarter the tightening net of easing since 2000 in order to capture the tightness of the respective tool at a given point in time.

[14] Both indexes are measured at a quarterly basis. We derive the annual values for each index by cumulating the quarterly values per annum. Table B.1 in Appendix B provides summary statistics at the country level.

[15] The macro-prudential policies targeted at the housing sector have been used more actively after 2008, a period in which mortgage arrears have increased sharply (see Figure A.1, Appendix A).

Figure 5. Mortgage defaults and intensity of macro-pru policy index (MPI)
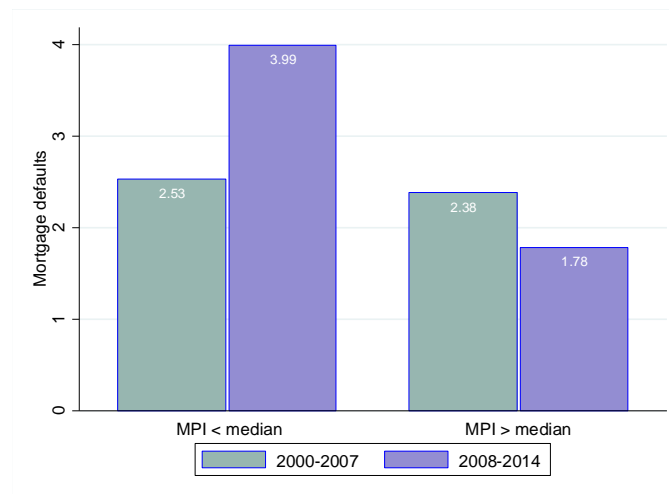


*Notes*: The figure plots the cross-country average mortgage default rates when the macro-pru policy index (MPI) is below and above its median, respectively (where the median is computed at the panel level). The average defaults are computed across countries in the sample for the period before and after the beginning of the financial crisis, conditional on the value of the index.

## 3.4 Institutional quality

To capture cross-country differences in institutional and legal frameworks we compile an index of institutional quality (*IQ*, hereafter). The index is based on five selected indicators of institutional quality which capture judicial efficiency, bankruptcy regulation and property protection. Our IQ index is the first principal component of these indicators.

The first institutional variable we consider is the strength of the Legal Rights index from the World Bank's Doing Business database. The index measures the degree to which collateral and bankruptcy laws protect the rights of borrowers and lenders thereby facilitating lending. The index ranges from 0 to 12, with higher scores indicating that these laws better enable access to credit. The second measure we use is the Rule of Law index from the World Justice Project (2015). The index provides a comprehensive description of the extent to which countries adhere to the rule of law in practice. This index ranges from 0 to 1, where 1 signifies the highest score. Finally, we collect data on three different proxies for the protection of property. We use an index for the protection of Physical Property from the International property rights index (2015) (the index takes values ranging from 0 to 1, where 1 signifies the highest score), an index for Investor Protection from the World Bank's Doing Business

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database (the index ranges from 0 to 10, where 10 signifies the highest score), and an index that measures the Creditors Rights against defaulting borrowers (ranging from 0 = poor creditor rights to 4 = strong rights; source: Djankov et al., 2007).[16]

In constructing our institutional quality index (see Appendix C for details about the principal component analysis) we retain only the first component which explains 61.3% of the total variation of the institutional variables. The loadings of each of the five variables on the first component are balanced, with Legal Rights and Physical Property having the highest loadings (49.19% and 49.88%, respectively), followed by Investor Protection (42.80%), Rule of Law (41.04%) and Creditor Rights (39.7%).

Figure 6 illustrates the relationship between our index for institutional quality and the incidence of mortgage defaults. We distinguish between countries with high vs. low institutional quality and plot the average defaults rates across these countries before and after 2008. The outcome is indicative for the importance of institutional arrangements in reducing the magnitude of arrears, both before and after the financial crisis: the higher the average quality of institutions, the lower the average mortgage defaults ratio.

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[16] Table B.2 in Appendix B provides an overview of the institutional quality variables at the country level.
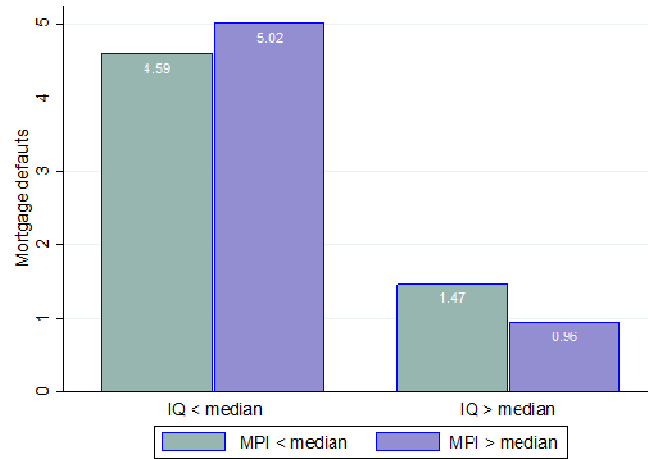
Figure 6. Mortgage defaults and Institutional Quality index (IQ)
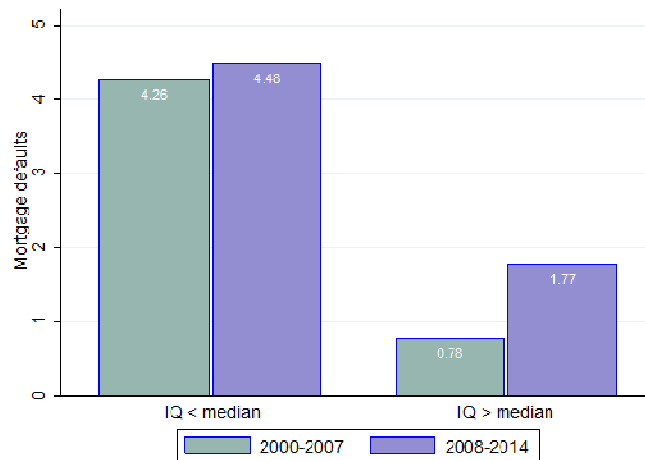


*Notes*: The figure plots the cross-country average mortgage default rates when the institutional quality index (IQ) is below and above its median, respectively. The average defaults are computed for countries in the sample with IQ larger (lower) than the median and for the period before and after the beginning of the financial crisis.

Moreover, we notice that the effects of macro-prudential policies and institutional quality on mortgage defaults are mutually reinforcing (Figure 7). We distinguish here between countries with high vs. low MPI. For each of these two categories we plot the average defaults rates across countries as a function of institutional quality (as proxied by our newly constructed index). As shown in Figure 7, the beneficial effect of the MPI on defaults becomes stronger in countries with better institutions.

Figure 7. Mortgage defaults, intensity of macro-pru policy index (MPI) and Institutional Quality index (IQ)



*Notes*: The figure plots the cross-country average mortgage default rates when the institutional quality index (IQ) is below and above its median, respectively. The average defaults are computed conditionally on the macro-pru policy index (MPI) being below and above its median, respectively (where the median is computed at the panel level).

## 3.5 Mortgage market

We collect data on various mortgage market characteristics for the countries in our sample. Data on loan type (fixed vs. variable mortgage rate), average maturity (in years), bank funding type (retail vs. other sources such as covered bonds or securitization), and degree of lender recourse (full recourse vs. no or partial recourse) comes from Cerutti et al. (2015) and the European Mortgage Federation (2015). Data on real estate taxes (e.g., tax deductibility of interest payments) comes from Cerutti et al. (2015) and the International Bureau of Fiscal Documentation (Tax research platform).

Table 1 reports sample statistics for these characteristics. The average maturity of mortgage loans ranges from 15 to 45 years, with a mean of 26 years. In most of the countries in our sample a full recourse procedure is in place. There are important differences with respect to the importance of fixed-interest vs. variable-rate mortgages: the latter category (which consists of both variable-rate mortgages and a mix of fixed and variable-rate mortgages) seems to be present in a larger number of countries. More than half of the countries allow for some form of tax deductibility and have retail deposits as the preferred source for bank funding.

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Figure 8 illustrates how average mortgage default rates vary according to different terciles of the maturity distribution. A longer maturity is, on average, associated with lower mortgage default rates. This may be caused by an increase in the periodic payments affordability. However, this effect corresponds to very long maturities (i.e., the third tercile). This indicates that maturity is only associated with lower defaults if it is substantially longer than 26 years, the average maturity in our sample. Likewise, as shown in Figure 9, average default rates across countries are lower when fixed-interest-rate loans are the dominant type of mortgage contracts. A fixed-interest type of loan may insulate borrowers from the negative effect of higher interest rates, thus leaving their ability to pay back mortgages unaffected. Interestingly, these two characteristics of the mortgage market seem to amplify the beneficial effect of restrictive macro-prudential policies. Put differently, a higher MPI is associated with a lower incidence of defaults with the effect being stronger for longer maturities (see Figure 10) and fixed-interest-rate loans (see Figure 11).

Figure 8. Mortgage defaults and average mortgage maturity
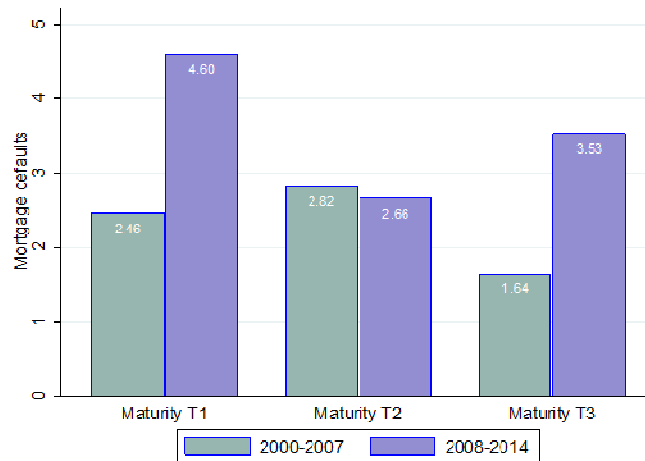


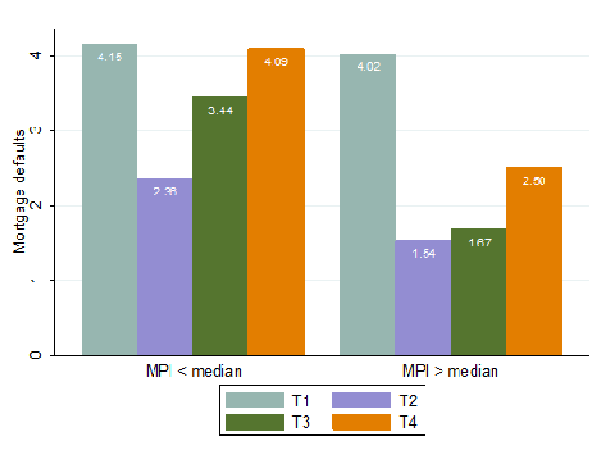*Notes:* The figure plots the cross-country average mortgage default rates when the country specific average maturity is either in the first, or second, or third tercile (where the terciles are computed at the panel level). The average defaults are computed across countries in the sample for the period before and after the beginning of the financial crisis, conditional on the value of the mortgage maturity.

Figure 9. Mortgage defaults and loan type
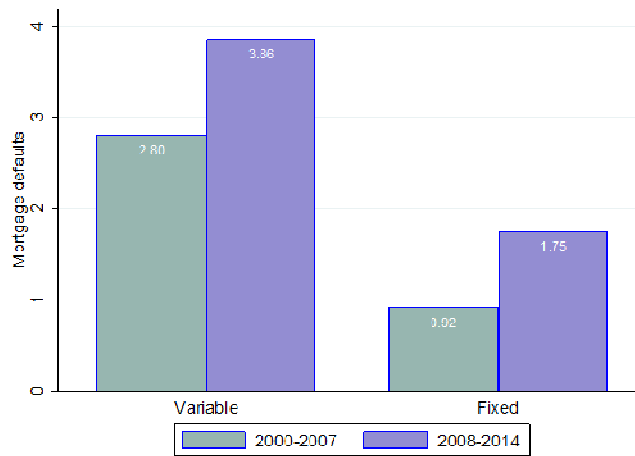


*Notes*: The figure plots the cross-country average mortgage default rates conditional on the predominant interest rate type in the mortgage contracts. The average defaults are computed for countries in the sample with fix (variable) interest rates and for the period before and after the beginning of the financial crisis.

Figure 10. Mortgage defaults, average mortgage maturity, and macro-pru policy index (MPI)



*Notes*: The figure plots the cross-country average mortgage default rates when the macro-pru policy index (MPI) is below and above its median, respectively (where the median is computed at the panel level). The average defaults are computed across countries in the sample conditional on the country specific average maturity (i.e., the first, or second, or third, or fourth quantiles, where the quantiles are computed at the panel level).

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Figure 11. Mortgage defaults, loan type, and macro-pru policy index (MPI)
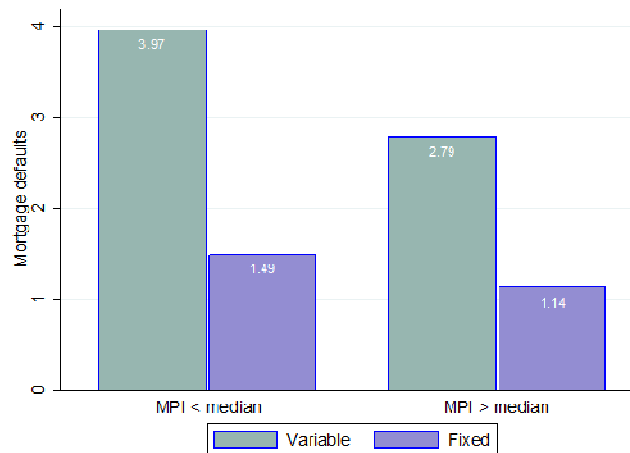


*Notes*: The figure plots the cross-country average mortgage default rates when the macro-pru policy index (MPI) is below and above its median, respectively (where the median is computed at the panel level). The average defaults are computed across countries in the sample conditional on the loan type (i.e., fixed vs. variable).

Finally, we illustrate how average mortgage default rates relate to the degree of lender recourse on borrowers. Full recourse seems to be weakly associated with lower default rates (Figure 12). But the association becomes stronger in countries with better institutional arrangements (Figure 13). As illustrated in Figure 13, recourse procedure deters defaults in countries with high institutional quality, but it is associated with more defaults in countries with low institutional quality. This observed pattern points to the importance of institutional features, such as judicial efficiency and bankruptcy regulation, arguably attributes of institutions without which the recourse procedures per se may prove less efficient.

# Figure 12. Mortgage defaults and degree of recourse
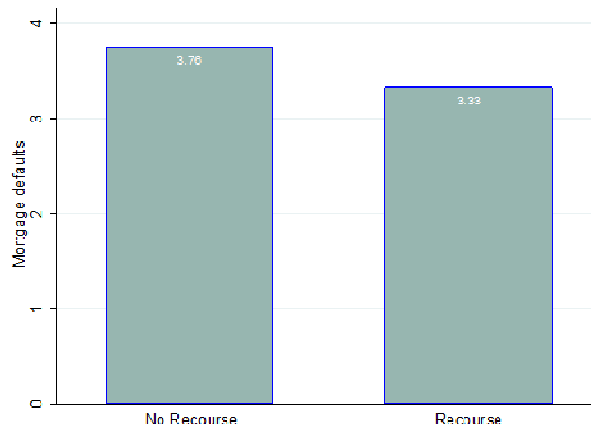


*Notes*: The figure plots the cross-country average mortgage default rates conditional on the degree of lender recourse on borrowers. The average defaults are computed for countries in the sample with full and no (or partial) recourse procedures.

# Figure 13. Mortgage defaults, degree of recourse and Institutional Quality index (IQ)
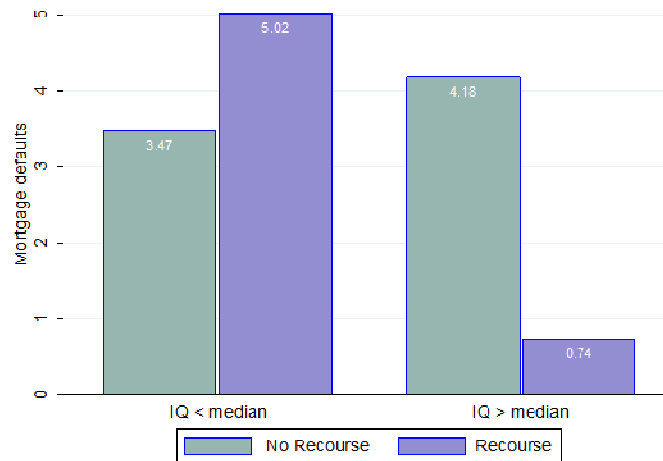


*Notes*: The figure plots the cross-country average mortgage default rates when the institutional quality index (IQ) is below and above its median, respectively. The average defaults are computed conditionally on the degree of lender recourse on borrowers.

*3.6 Correlations across the main variables and mortgage default rates*

Table 2 shows the correlation between the variables used in our analysis. As shown in column (1), the correlations between the explanatory variables and the mortgage default rates have the expected sign (i.e., in line with the patterns documented in sections 3.2 – 3.5). However, these correlations are not very high (all below 0.50). The highest correlations are for the institutional quality index (-0.47), unemployment (0.38), house price changes (-0.34), and interest spread (0.31). This suggests that the quality of institutions and variables describing macro-economic conditions are closely correlated with default rates. Furthermore, there is a low (negative) correlation between default rates and most other variables—the macro-prudential index (-0.16), average maturity (-0.03), recourse procedures (-0.12), loan type (-0.17) and bank funding type (-0.04)—with the exception of tax deduction which is positively correlated with defaults (0.08). This indicates that a restrictive macro-prudential environment, longer mortgage maturity, a fixed interest rate for mortgages, and banks' reliance on retail funding are (weakly) correlated with default rates.

Before we turn to the econometric estimates, Table 3 shows the expected relationship between the variables introduced in this section and mortgage defaults.

Table 2. Correlation matrix

| | Mortgage defaults | Unemployment | Interest spread | House prices | LTV | Macro-pru instruments | MPI | IQ index | Maturity | Re-course | Loan type | Funding type | Tax deduction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mortgage defaults | 1.00 | | | | | | | | | | | | |
| Unemployment | 0.38 | 1.00 | | | | | | | | | | | |
| Interest spread | 0.31 | 0.34 | 1.00 | | | | | | | | | | |
| House prices (%) | -0.34 | -0.30 | -0.26 | 1.00 | | | | | | | | | |
| LTV index | -0.09 | -0.11 | 0.01 | 0.08 | 1.00 | | | | | | | | |
| Macro-pru instruments | -0.10 | -0.30 | 0.01 | 0.10 | 0.24 | 1.00 | | | | | | | |
| MPI | -0.16 | -0.15 | -0.03 | 0.06 | 0.58 | 0.22 | 1.00 | | | | | | |
| IQ index | -0.47 | -0.37 | -0.03 | 0.04 | 0.15 | 0.14 | 0.24 | 1.00 | | | | | |
| Maturity | -0.03 | -0.22 | -0.06 | -0.09 | 0.08 | 0.36 | 0.01 | 0.31 | 1.00 | | | | |
| Recourse | -0.12 | 0.14 | 0.11 | -0.09 | 0.02 | -0.12 | 0.06 | 0.21 | -0.18 | 1.00 | | | |
| Loan type | -0.17 | -0.04 | 0.01 | 0.13 | 0.04 | 0.09 | -0.04 | -0.14 | -0.15 | -0.05 | 1.00 | | |
| Funding type | -0.04 | 0.25 | 0.14 | -0.04 | -0.04 | -0.16 | -0.09 | -0.22 | -0.20 | 0.03 | 0.35 | 1.00 | |
| Tax deduction | 0.08 | -0.06 | 0.01 | -0.16 | -0.01 | 0.09 | -0.05 | -0.04 | 0.30 | -0.15 | -0.10 | 0.18 | 1.0 |

*Note:* This table shows the pairwise correlations among all the variables used in the regression analysis, computed on a panel basis over the whole sample period 2000-2014.

Table 3. Expected signs of variables considered

| Variable | Expected sign | Explanation |
|---|---|---|
| **Macroeconomic** | | |
| Unemployment | + | Defaults are more likely if a larger share of population is unemployed |
| House prices | - | Defaults are less likely when house prices raise |
| Interest spread | + | Defaults are more likely when financial constraints (i.e., cost of debt less savings) become more acute |
| **Macro-prudential** | | |
| Macro-pru policy index (MPI) | - | Defaults are less likely in a restrictive macro-prudential environment (with policies aimed at housing sector) |
| Macro-pru instruments index | - | Defaults are less likely in a restrictive macro-prudential environment (with policies aimed at banking activities) |
| LTV index | - | Defaults are less likely when LTV regulation tightens (i.e., maximum LTV ratio is lowered) |
| **Institutional** | | |
| Legal rights | +/- | Defaults are more (less) likely when the rights of borrowers (lenders) are better protected |
| Rule of law | - | Defaults are less likely in countries that adhere to the rule of law |
| Property protection | - | Defaults are less likely when the physical property is better protected |
| Investor protection | - | Defaults are less likely when investors (i.e. lenders) interests are better protected |
| Creditor rights | - | Defaults are less likely when lenders rights against defaulting borrowers are better protected |
| Institutional quality index (IQ) | - | Defaults are less likely in presence of better institutions |
| **Mortgage market** | | |
| Maturity | - | Defaults are less likely for longer maturities (which reduce periodic payments) |
| Loan type | - | Defaults are less likely for fixed-rate mortgages (which are associated with less volatile periodic payments) |
| Tax deduction | + | Defaults are more likely when interest payments are tax deductible (which leads to higher household leverage) |
| Recourse | - | Defaults are less likely in countries with recourse legislation (as it provides more rights to lenders in case of borrowers default) |
| **Interactions** | | |
| MPI * IQ | - | Defaults are less likely in restrictive macro-prudential environments with better institutions |
| MPI * Maturity | - | Defaults are less likely when borrowers are less leveraged (because of restrictive macro-prudential policies) and have affordable periodic payments (because of longer maturities) |
| MPI * Loan type | - | Defaults are less likely when borrowers are less leveraged (because of restrictive macro-prudential policies) and have less volatile periodic payments (because of fixed-rate mortgages) |
| MPI * Tax deduction | - | Defaults are less likely when borrowers are less leveraged (because of restrictive macro-prudential policies) and have affordable periodic payments (because of tax deductibility of interest payments) |
| IQ * Recourse | - | Defaults are less likely in countries with efficient judicial systems (an attribute of better institutions) that provides more rights to lenders (via the recourse legislation) |

## 4. Methodology and results

*4.1 Methodology*

In this section, we use our panel dataset to analyze the potential factors affecting mortgage defaults. We start the analysis by focusing on macroeconomic and macro-prudential variables and proceed with expanding the model by including additional variables describing institutional quality and the credit market. We employ the within estimator whenever the model includes only time-varying variables and interactions and switch to random effects whenever we investigate non-time varying variables.

The baseline model is as follows:

$$ln\,(M_{it}) = \alpha + \beta MP_{it-1} + \gamma' Z_{it-1} + \tau_t + \mu_i + \varepsilon_{it}\,, \tag{1}$$

where the indices $i$ and $t$ stand for country and time, respectively, $ln\,(M_{it})$ is the logarithm of the mortgage defaults rate, $MP$ is a macro-prudential policy index, $Z$ is a vector of macroeconomic controls (i.e., unemployment, house price changes and interest rate spread). The macro-prudential measure $MP$ is either an overall macro-prudential index or an index capturing changes in the regulatory loan to value ratio.

The model includes country fixed effects $\mu_i$ to control for unobserved time-invariant differences across countries that might affect mortgage defaults and time fixed effects $\tau_t$ to control for common time trends. We assume a one or two period lag for all regressors with two objectives in mind: (i) we want to mitigate potential reverse causality between mortgage defaults and some of the variables, and (ii) we want to control for the delayed effect that some of the explanatory variables (like macro-prudential policies) might have on mortgage defaults. The model is estimated with the within estimator (FE) and we employ robust standard errors to account for heteroskedasticity and autocorrelation in the residuals.

We extend the baseline model by including other factors or interaction terms which we hypothesize to be associated with mortgage defaults. In the first extension, we explore the role of institutional quality and test whether it is significantly associated with a reduction in mortgage default rates. Since our proxies for institutional quality are non-time-varying, we employ random effects (RE) to estimate the effect of institutional quality:

$$ln\,(M_{it}) = \alpha + \beta MP_{it-1} + \gamma' Z_{it-1} + \delta\,IQ_i + \tau_t + \varepsilon_{it}\,. \tag{2}$$

Next, the institutional quality index (IQ)—based on the first principal component analysis of five institutional attributes—is interacted with macro-prudential policy variables to assess whether the effects of macro-prudential policies on mortgage defaults vary with the quality of institutions. Since the interaction term is time varying, we estimate the model with the fixed effects (FE) estimator:

$$ln\,(M_{it}) \;=\; \alpha \;+\; \beta MP_{it-1} + \gamma' Z_{it-1} + \theta\,IQ_i MP_{it-1} + \mu_i + \tau_t + \varepsilon_{it}\,. \qquad (3)$$

We use a similar specification to test interactions between the macro-prudential indexes and mortgage market variables. In that case, *IQ* in equation (3) is replaced by variables such as average loan maturity, interest rate type, and tax deduction.

Finally, we explore the effects of recourse (*RP*) as well as the interaction between the institutional quality index and the recourse dummy. This interaction captures the fact that the role of recourse procedures in deterring defaults crucially depends on the efficiency of the judicial process (an attribute of the institutional quality indicator). As both variables are time-invariant, we employ random effects (RE) in order to be able to estimate the effect of these variables on mortgage default rates.

$$ln\,(M_{it}) = \alpha \;+\; \beta MP_{it-1} + \gamma' Z_{it-1} + \zeta RP_i + \pi\,IQ_i RP_i + \tau_t + \varepsilon_{it}\,. \qquad (4)$$

*4.2 Results*

Table 4 presents the results of fixed effects (FE) regressions for 26 countries over the period 2000-2014 in which the macro-economic variables and the proxies for macro-prudential policies are included as regressors. In line with the results of previous studies, our findings suggest that higher unemployment is significantly associated with an increase in mortgage defaults, while higher house prices have a negative association with defaults. From a theoretical perspective, defaults are more likely when house prices decline because, on the one hand, the ability to finance consumption out of housing wealth declines, and on the other, negative equity may create incentives for strategic default.

The coefficient on the lagged interest rate spread is positive, but is estimated imprecisely. Jappeli et al. (2008) report similar results for their interest rate variable. Our results suggest that it may take time for financial constraints (proxied by the interest rate spread) to materialize in affordability problems, or put differently, an increase in interest rate spread does not have an immediate impact on mortgage

delinquencies.[17]

In column (2) the MPI is added as explanatory variable. Our expectation is that defaults are less likely if macro-prudential policy is tightened (i.e., the index goes up). The coefficient on our first proxy for macro-prudential policy is negative and significant. This indicates that a unit increase in the MPI is associated with a decrease in the mortgage defaults ratio of 11.8%. As an alternative we employ the cumulative macro-prudential index from Cerutti et al. (2017a). As the results in column (3) show, the coefficient on this proxy for macro-prudential policy is also significantly negative. This broader index captures the effects of cumulative changes in prudential regulations on banking activities (i.e., housing and non-housing activities) at a given point in time. Thus, this significant association between the index and mortgage defaults is suggestive for the long-term impact of prudential regulations.[18,19]

Finally, the results for our proxy for changes in the regulatory LTV ratios (from Cerutti et al., 2017a) presented in column (4) suggest that the relationship between this particular instrument and mortgage defaults is significant. The magnitude of the effect is large and indicates that the LTV ratio has a strong association with mortgage defaults. This result is in line with the findings of Wong et al. (2011) which highlight the importance of LTV caps in reducing the responsiveness of mortgage default risk to volatility in property prices.[20] Due to its discrete character, one has to be careful in interpreting the economic significance of our estimates. Our results suggest that when the regulatory policy with respect to the LTV ratio tightens (i.e., the LTV cap goes down), which translates into a change for our LTV index from 0 to 1, the default rates decrease by 30%. A one-unit increase in the LTV index represents here a large change, as this is equivalent with approximately 3 standard deviations of the variable.

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[17] We therefore considered more lags for the interest rate spread. It turns out that for longer time lags our proxy for financial constraints is significantly associated with mortgage defaults (results available on request).

[18] We considered the cumulative version of the MPI index (compiled in a similar fashion as the cumulative Macro-pru instruments index). Our results remain the same: the coefficient is negative and significant, albeit only at the ten percent level (results available on request).

[19] A potential limitation of our analysis is that the macro-prudential policy index and mortgage defaults may have a reverse causal relationship, as policy might be changed in anticipation of increasing defaults. However, as our estimated coefficient on the MPI is negative and the bias is likely to be positive (because the MPI will increase in response to higher mortgage defaults), macro-prudential policies may have a stronger negative impact on mortgage defaults than suggested by our estimates.

[20] We also interacted our macro-prudential variables with macro-economic variables to examine whether the responsiveness of mortgage defaults to changes in house prices or macroeconomic fluctuations is conditioned by macro-prudential policies. We did not find support for this (results available on request).

Table 4. Macro-prudential policy and mortgage defaults

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Unemployment | 0.062** | 0.057** | 0.034 | 0.059** |
| | [0.027] | [0.026] | [0.027] | [0.027] |
| House price changes | -0.029*** | -0.029*** | -0.031*** | -0.030*** |
| | [0.008] | [0.008] | [0.007] | [0.008] |
| Interest spread | 0.013 | 0.009 | 0.015* | 0.012 |
| | [0.009] | [0.010] | [0.009] | [0.009] |
| MPI | | -0.118* | | |
| | | [0.059] | | |
| Macro-pru instruments | | | -0.178*** | |
| | | | [0.056] | |
| LTV index | | | | -0.303** |
| | | | | [0.117] |
| Constant | 0.074 | 0.156 | 0.643 | 0.138 |
| | [0.339] | [0.334] | [0.392] | [0.345] |
| | | | | |
| Observations | 220 | 220 | 220 | 220 |
| $R^2$ | 0.386 | 0.402 | 0.464 | 0.413 |
| Number of countries | 26 | 26 | 26 | 26 |
| Model | FE | FE | FE | FE |
| Adj. $R^2$ | 0.337 | 0.352 | 0.419 | 0.364 |

*Notes*: This table shows panel FE results for mortgage defaults using data for 26 countries over the period 2000-2014. The dependent variable is expressed in logs. We use one-period lagged values of all the regressors. Country fixed effects and time fixed effects (yearly dummies) are included in all specifications. We use robust standard errors in parentheses to correct for serial correlation and heteroskedasticity. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Given that by construction, the MPI is better suited for analyzing cross-country heterogeneity in the usage of prudential tools (including LTV caps) applied to the housing sector, for the reminder of the paper we use the MPI as our main proxy for regulation. We therefore keep model (2) of Table 4 as our baseline specification and extend it with the other proposed determinants of mortgage defaults.

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| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Unemployment | 0.055*** | 0.057*** | 0.039* | 0.055** | 0.054** | 0.041* |
| | [0.021] | [0.017] | [0.022] | [0.022] | [0.021] | [0.021] |
| House price changes | -0.037*** | -0.044*** | -0.034*** | -0.033*** | -0.033*** | -0.039*** |
| | [0.009] | [0.010] | [0.008] | [0.008] | [0.008] | [0.009] |
| Interest spread | 0.005 | 0.013 | 0.013 | 0.009 | 0.009 | 0.010 |
| | [0.009] | [0.008] | [0.008] | [0.009] | [0.009] | [0.008] |
| MPI | -0.172** | -0.218** | -0.178** | -0.161** | -0.165*** | -0.164** |
| | [0.070] | [0.108] | [0.075] | [0.065] | [0.061] | [0.068] |
| Legal rights | -0.196* | | | | | |
| | [0.103] | | | | | |
| Rule of law | | -7.843*** | | | | |
| | | [1.676] | | | | |
| Property protection | | | -0.809*** | | | |
| | | | [0.299] | | | |
| Investor protection | | | | -0.199 | | |
| | | | | [0.179] | | |
| Creditor rights | | | | | -0.399 | |
| | | | | | [0.253] | |
| IQ index | | | | | | -0.433*** |
| | | | | | | [0.149] |
| Constant | 1.580** | 5.576*** | 5.611*** | 1.529 | 0.989* | 0.244 |
| | [0.633] | [1.094] | [1.876] | [1.123] | [0.582] | [0.328] |
| | | | | | | |
| Observations | 210 | 208 | 220 | 220 | 220 | 204 |
| Number of countries | 24 | 24 | 26 | 26 | 26 | 23 |
| Model | RE | RE | RE | RE | RE | RE |
| $R^2$ | 0.345 | 0.612 | 0.464 | 0.302 | 0.326 | 0.435 |

*Notes*: This table shows panel RE results for mortgage defaults using data over the period 2000-2014. The dependent variable is expressed in logs. We use one-period lagged values of all the time variant regressors. Yearly dummies are included in all specifications. We use robust standard errors in parentheses to correct for serial correlation and heteroskedasticity. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5 shows the random effects (RE) estimation results if we add several institutional variables. We expect that better institutions—like high judicial efficiency making it easier for banks to enforce their rights—to reduce the level of mortgage defaults. We use several proxies for institutional quality.[21] In column (1) we add the legal rights index. The results suggest that better legal rights have a negative and significant association with mortgage defaults. As shown in column (2), also a higher score on the rule of law index is associated with fewer defaults. Columns (3)-(5) show the estimates for our three proxies for the protection of property. In all cases, our

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[21] We considered more proxies for institutional quality (see the robustness section).

results suggest that better protection of property rights is associated with a lower level of mortgage arrears. This holds for the index for the protection of physical property, for the index for investor protection, and for the index of the strength of creditor rights.

Finally, column (6) shows the results for our institutional quality index, which is the first principal component of the five variables used above (see Appendix C for details). This index varies from -3 (= low quality) to 3 (=high quality). The results suggest that a unit increase in the index is associated with a decrease in mortgage defaults by 43%. This finding reflects the importance of institutional arrangements in deterring mortgage delinquencies.

Table 6 presents the results of FE regressions when institutional quality and several characteristics of the mortgage market are interacted with macro-prudential policies. Column (1) of Table 6 shows the estimation for the interaction of the macro-pru policy index MPI and our proxy for institutional quality.[22] The results suggest that the association between macro-prudential regulation and mortgage defaults is stronger in countries that have better institutions. In other words, the effect of tougher macro-prudential policies (that reduce household leverage and ultimately deter defaults) is amplified in an institutional environment with an efficient judicial system, with better protection of lenders' rights and better enforcement capabilities.

The second column of Table 6 suggests that restrictive macro-prudential policies in countries that have mortgage contracts with longer maturities are associated with lower incidence of mortgage arrears. This result complements the findings of Aristei and Gallo (2012) who show that the maturity of mortgages reduces the probability of mortgage delinquency in the Italian mortgage market. The intuition for this result is that the combination of a restrictive macro-prudential environment, which may limit household indebtedness, with longer maturities, which make periodic mortgage payments more affordable to borrowers, is conducive to repayment.

Column (3) shows the interaction effect of macro-prudential policy and a dummy for the flexibility of the interest rate on the mortgage (the dummy is one if most loans have a fixed interest rate in a given country and zero otherwise). The evidence suggests that in countries with fixed-interest mortgages, restrictive macro-prudential policies are significantly negatively associated with mortgage arrears. This most

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[22] We considered longer lags for the interacted variables. We report here the significant associations only (which start from the second lag onwards) pointing to the fact that it takes time for macro-prudential measures to have a significant impact on mortgage arrears (when controlling for heterogeneity in institutional quality and mortgage market characteristics). Using the first lag for the interaction obtains similar negative (but not statistically significant) coefficients.

likely captures the effect of a reduction in the volatility of payment obligations on defaults. First, a restrictive macro-prudential environment reduces the amount that can be borrowed. In addition to that, households not only borrow less, but they are able to fix their payment obligations over a certain period of time, thus reducing the volatility of their payment obligations.[23]

Column (4) presents the estimation results for the interaction of macro-prudential policy and a dummy for tax-deductibility of interest payments (the dummy is one if some form of tax-deductibility is allowed and zero otherwise). The results suggest that in countries with mortgage interest deductibility, restrictive macro-prudential measures are (weakly) associated with lower delinquency rates. While there is empirical evidence on the relationship between mortgage interest deduction and higher house prices (or higher households leverage), our results point to a novel effect: in the presence of restrictive borrowing constraints (i.e., stricter macro-prudential policies), the tax-deductibility of the interest payments increases borrowers' ability to pay by reducing their periodic payments.[24]

Finally, column (5) shows the interaction effect of macro-prudential policy and a dummy for the bank-funding model (the dummy is one if most funding is retail and zero otherwise). Non-retail funding may lead to higher leverage in the banking sector (Hahm et al., 2011) and higher banking leverage has often been associated with more risk-taking (e.g., lax lending standards). We therefore expect that defaults are less likely in case of retail funding. It turns out that the coefficient of this interaction is indeed negative, but it is not statistically significant.

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[23] The volatility of payment obligations caused by changes in the interest rates (and its subsequent impact on mortgage delinquencies) is expected to be higher in countries where variable-rate mortgages are prevalent. However, we did not find a significant relationship between mortgage arrears and the interaction between interest rate spread and loan type. This result is in line with the findings of Gerlach-Kristen and Lyons (2015) who also did not find support for the impact of monetary policy on mortgage arrears.

[24] More than half of the countries in our sample allow for some form of tax deductibility. However, the amount that can be deducted varies substantially across countries. We also examined whether tax deductibility has a direct relationship with mortgage defaults. Although our results suggest that deductibility increases mortgage defaults, it turned out that this result was driven by just two countries (i.e., Greece and Ireland) and we therefore conclude that it is not a robust relationship.

Table 6. The impact of the interaction of mortgage market variables and macro-prudential policy on mortgage defaults

| VARIABLES | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Unemployment | 0.050** | 0.052* | 0.058** | 0.054** | 0.056** |
| | [0.024] | [0.026] | [0.026] | [0.026] | [0.026] |
| House price changes | -0.035*** | -0.028*** | -0.029*** | -0.028*** | -0.032*** |
| | [0.008] | [0.008] | [0.008] | [0.008] | [0.008] |
| Interest spread | 0.007 | 0.007 | 0.008 | 0.006 | 0.005 |
| | [0.010] | [0.010] | [0.010] | [0.010] | [0.010] |
| MPI | -0.094** | -0.097** | -0.125** | -0.106** | -0.112* |
| | [0.045] | [0.045] | [0.060] | [0.044] | [0.062] |
| MPI * IQ index | -0.065** | | | | |
| | [0.026] | | | | |
| MPI * Maturity | | -0.004* | | | |
| | | [0.002] | | | |
| MPI * Loan type | | | -0.243*** | | |
| | | | [0.066] | | |
| MPI * Tax deduction | | | | -0.178* | |
| | | | | [0.095] | |
| MPI * Funding | | | | | -0.059 |
| | | | | | [0.051] |
| Constant | 0.186 | 0.261 | 0.161 | 0.218 | 0.176 |
| | [0.340] | [0.348] | [0.335] | [0.336] | [0.354] |
| | | | | | |
| Observations | 201 | 217 | 217 | 217 | 207 |
| R$^2$ | 0.437 | 0.418 | 0.407 | 0.417 | 0.417 |
| Number of countries | 23 | 26 | 26 | 26 | 24 |
| Model | FE | FE | FE | FE | FE |
| Adj. R$^2$ | 0.384 | 0.368 | 0.356 | 0.315 | 0.307 |

*Notes*: This table shows panel FE results for mortgage defaults using data over the period 2000-2014. The dependent variable is expressed in logs. Country fixed effects and time fixed effects (yearly dummies) are included in all specifications. We use one-period lagged values for the regressors, except for the interactions with MPI where we use two lags. We use robust standard errors in parentheses to correct for serial correlation and heteroskedasticity. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 7 presents three RE regressions to further examine the effects of recourse and institutional quality, controlling for macroeconomic variables and macro-prudential policy. The first column adds a dummy to the model shown in column (6) of Table 5 which is one for countries with recourse and zero otherwise. A full recourse procedure is expected to increase borrowers' incentives to repay their debt because it gives more rights to the lenders in pursuing borrowers' assets in case of default (Ghent and Kudlyak, 2011; Li and Oswald, 2017). Indeed, the coefficient on the recourse variable is negative and significant.

Column (2) shows the outcomes if the recourse variable is interacted with our institutional quality index. The results confirm the significant relationship between the degree of lender recourse on borrowers and mortgage arrears, in particular for those countries with higher institutional quality. These results are suggestive for the importance of institutional arrangements (in particular those attributes that capture judicial efficiency, bankruptcy regulation and property protection) in alleviating banks' problems related with an increase in mortgage arrears.

Finally, the results in column (3) confirm the results of the FE regressions (reported in column (1) of Table 6) that the impact of stricter macro-prudential regulation on mortgage defaults is significantly stronger in countries that have better institutions.

## 5. Robustness tests

*5.1 Additional controls*

Results are robust to the inclusion of additional macroeconomic control variables such as inflation (data comes from the World Development Indicators database) and credit to households as a percentage of GDP (data comes from the Bank of International Settlements). These results are shown in the first columns of Table 8. It turns out that the coefficients on both variables are insignificant. To further assess the robustness of our core results we also control for some characteristics of the banking sector, such as bank capital to total assets and loan loss provisions ratios (data comes from Global Financial Development database). The results as presented in columns (3) and (4) of Table 8 show that most of these additional controls are not statistically significant. The only exception is loan loss provisions, which is negatively associated with mortgage default rates. Adding these variables does not affect our main findings, except that in column (4) the unemployment rate loses significance, while the interest spread becomes significant (at the 10 percent level).

Table 7. Recourse, institutional quality and mortgage defaults

| VARIABLES | (1) | (2) | (3) |
|---|---|---|---|
| Unemployment | 0.063*** | 0.032 | 0.036* |
| | [0.022] | [0.020] | [0.020] |
| House price changes | -0.039*** | -0.040*** | -0.038*** |
| | [0.009] | [0.009] | [0.008] |
| Interest spread | 0.006 | 0.009 | 0.010 |
| | [0.010] | [0.009] | [0.009] |
| MPI | -0.195** | -0.181** | -0.117** |
| | [0.084] | [0.073] | [0.049] |
| IQ index | | | -0.391*** |
| | | | [0.135] |
| MPI * IQ index | | | -0.087*** |
| | | | [0.028] |
| Recourse | -1.062** | -0.995*** | |
| | [0.416] | [0.317] | |
| Recourse * IQ index | | -0.568*** | |
| | | [0.175] | |
| Constant | 0.998*** | 1.203*** | 0.374 |
| | [0.319] | [0.299] | [0.315] |
| Observations | 210 | 204 | 201 |
| Number of countries | 24 | 23 | 23 |
| Model | RE | RE | RE |
| $R^2$ | 0.410 | 0.602 | 0.471 |

*Notes*: This table shows panel RE results for mortgage defaults using data over the period 2000-2014. The dependent variable is expressed in logs. We use one-period lagged values of all the time variant regressors, except for the interaction between MPI and IQ where we use two lags. Yearly dummies are included in all specifications. We use robust standard errors in parentheses to correct for serial correlation and heteroskedasticity. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8. Robustness to additional macroeconomic and banking controls

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Unemployment | 0.044* | 0.049* | 0.057** | 0.021 |
| | [0.025] | [0.024] | [0.023] | [0.028] |
| House price changes | -0.036*** | -0.035*** | -0.036*** | -0.034*** |
| | [0.009] | [0.009] | [0.009] | [0.008] |
| Interest spread | 0.008 | 0.008 | 0.011 | 0.016* |
| | [0.010] | [0.010] | [0.010] | [0.009] |
| MPI | -0.096** | -0.092* | -0.089** | -0.102* |
| | [0.042] | [0.045] | [0.042] | [0.050] |
| MPI x IQ index | -0.059** | -0.068** | -0.053** | -0.066** |
| | [0.026] | [0.028] | [0.025] | [0.031] |
| Inflation | -4.580 | | | |
| | [4.681] | | | |
| Households credit | | -0.004 | | |
| | | [0.015] | | |
| Capital to assets | | | 0.122 | |
| | | | [0.077] | |
| Provisions | | | | -0.006** |
| | | | | [0.002] |
| | | | | |
| Constant | 0.314 | 0.463 | -0.836 | 0.814* |
| | [0.336] | [1.131] | [0.560] | [0.442] |
| | | | | |
| Observations | 201 | 196 | 200 | 181 |
| R-squared | 0.440 | 0.439 | 0.455 | 0.487 |
| Number of id | 23 | 22 | 23 | 23 |
| Model | FE | FE | FE | FE |

*Notes*: This table shows panel FE results for mortgage defaults using data over the period 2000-2014. The dependent variable is expressed in logs. We use one-period lagged values of all the time variant regressors, except for the interaction between MPI and IQ where we use two lags. Fixed effects and yearly dummies are included in all specifications. We use robust standard errors in parentheses to correct for serial correlation and heteroskedasticity. *** p<0.01, ** p<0.05, * p<0.1

Next, we consider alternative proxies for the efficiency of the judicial system. In Table 9 we examine whether our results change if we use the number of procedures required to legally recover debt, number of days required to enforce a contract, the depth of private credit bureaus and public credit registries (as the proportion of adult population for whom there is information about repayment history) as alternative proxies for institutional quality (data comes from World Development Indicators and Work Bank Doing Business databases). We find that the results are very much in line

with our previous findings, although the coefficients on the last two alternative proxies for institutional quality are not significant.

Table 9. Additional institutional variables

| VARIABLES | (1) M1 | (2) M2 | (3) M3 | (4) M4 | (5) M5 |
|---|---|---|---|---|---|
| Unemployment | 0.053** | 0.049** | 0.052** | 0.052** | 0.050** |
| | [0.025] | [0.024] | [0.023] | [0.023] | [0.022] |
| House price changes | -0.036*** | -0.037*** | -0.033*** | -0.034*** | -0.033*** |
| | [0.010] | [0.010] | [0.008] | [0.009] | [0.010] |
| Interest spread | 0.012 | 0.014* | 0.004 | 0.014 | 0.013 |
| | [0.008] | [0.008] | [0.010] | [0.009] | [0.010] |
| MPI | -0.153** | -0.153** | -0.171** | -0.158** | -0.141** |
| | [0.070] | [0.067] | [0.068] | [0.072] | [0.069] |
| No procedures | 0.230* | | | | |
| | [0.119] | | | | |
| Time to enforce WDI | | 0.002* | | | |
| | | [0.001] | | | |
| Time to enforce DB | | | 0.002*** | | |
| | | | [0.001] | | |
| Private coverage | | | | -0.001 | |
| | | | | [0.003] | |
| Public coverage | | | | | 0.013 |
| | | | | | [0.012] |
| Constant | -1.176 | -0.852 | -0.670 | 0.326 | 0.057 |
| | [0.916] | [0.738] | [0.570] | [0.444] | [0.400] |
| | | | | | |
| Observations | 194 | 194 | 220 | 188 | 188 |
| Number of id | 23 | 23 | 26 | 26 | 26 |
| Model | RE | RE | RE | RE | RE |
| R2 | 0.432 | 0.412 | 0.384 | 0.380 | 0.289 |

*Notes*: This table shows panel RE results for mortgage defaults using data over the period 2000-2014. The dependent variable is expressed in logs. We use one-period lagged values for all the time variant regressors. Yearly dummies are included in all specifications. We use robust standard errors in parentheses to correct for serial correlation and heteroskedasticity. *** p<0.01, ** p<0.05, * p<0.1

*5.2 Correlated random effects*

The institutional quality index probably does not have a reverse causal relationship with mortgage defaults, as the underlying institutional variables are not likely to be affected by mortgage defaults and the variables measuring the quality of institutions are time-invariant. However, the institutional quality index might be correlated with the country specific effects. Therefore, we employ the correlated random effects

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specification proposed by Mundlak (1978) as a robustness test. The Mundlak specification estimates random-effects regression models by adding group-means of the regressors that display within group variation. This technique relaxes the assumption in the random-effects estimator that the observed variables are uncorrelated with the unobserved variables. The results shown in Table 10 indicate that our findings based on the random effects estimator are robust: the estimated coefficients found using the Mundlak specification are similar in sign and magnitude as the RE estimates.

Table 10. Correlated RE (Mundlak approach)

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Unemployment | 0.054*** | 0.041* | 0.050*** | 0.036* |
| | [0.019] | [0.021] | [0.019] | [0.020] |
| House price changes | -0.035*** | -0.039*** | -0.035*** | -0.038*** |
| | [0.007] | [0.009] | [0.007] | [0.008] |
| Spread | 0.008 | 0.010 | 0.007 | 0.010 |
| | [0.016] | [0.008] | [0.016] | [0.009] |
| MPI | -0.122** | -0.164** | -0.094* | -0.117** |
| | [0.054] | [0.068] | [0.054] | [0.049] |
| IQ index | -0.288** | -0.433*** | -0.323** | -0.391*** |
| | [0.131] | [0.149] | [0.136] | [0.135] |
| MPI x IQ index | | | -0.065** | -0.087*** |
| | | | [0.027] | [0.028] |
| Observations | 204 | 204 | 201 | 201 |
| Countries | 23 | 23 | 23 | 23 |
| Model | Mundlak | RE | Mundlak | RE |
| $R^2$ | 0.837 | 0.435 | 0.860 | 0.471 |

*Notes*: This table shows panel RE and Mundlak results for mortgage defaults using data over the period 2000-2014. The dependent variable is expressed in logs. We use one-period lagged values of all the time variant regressors, except in the interaction between MPI and IQ where we use two lags. Yearly dummies are included in all specifications. We use robust standard errors in parentheses to correct for serial correlation and heteroskedasticity. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

*5.3 Sample split*

The results reported are robust to the exclusion of one country at a time. The macro-pru policy index remains statistically significant as well as the macroeconomic variables. However, the effects of the MPI are not statically significant if we exclude all Asian countries and estimate the model on a sample containing only EU countries and the US (results available on request). This may be due to the fact that Asian countries had the most active macro-prudential policies in place during the time

frame covered in our study, while EU countries only started to introduce these policies after the crisis.

## 6. Conclusions

Using a newly constructed database for 26 countries over the period 2000-2014, we examine potential explanations for the cross-country and within-country heterogeneity in mortgage defaults. A major advantage of using panel data at the macro level is that several important determinants of mortgage defaults can be taken into account. Some of these variables are time varying (e.g., changes in the macro-prudential policies), while others are not (e.g., institutional attributes, housing market characteristics). For this reason, we employ both fixed and random effect estimators in our empirical analysis.

Our results suggest that macro-prudential policies, and in particular lower regulatory LTV ratios, and proxies for institutional quality (such as judicial efficiency, bankruptcy regulation and property protection), are statistically significantly associated with a lower share of mortgage arrears. We also find that the effects of macro-prudential policy and institutional quality on mortgage defaults are mutually reinforcing: average default rates are the lowest in countries with better institutions and restrictive macro-prudential policies.

Our findings also indicate that several mortgage market characteristics are related to cross-country differences in mortgage defaults. Longer maturities, fixed-interest rate contracts, and tax-deductibility of interest payments are correlated with lower default rates in countries with restrictive macro-prudential policies. In addition to that, legislation that allows mortgage lenders to claim borrowers' assets (if the proceedings do not cover the outstanding loan balance), may deter mortgage defaults. We find a strong relationship between the degree of lender recourse on borrowers and mortgage arrears, in particular in those countries with better institutions.

From a policy perspective, our evidence suggests that a mix of policies may be required in order to reduce mortgage defaults. Such a mix should consist of both macro-prudential regulation and improvements in institutional design, in particular improvements of judicial efficiency and bankruptcy regulation. In addition to that, our findings also inform the policy discussion on the need for stricter capital requirements for mortgages. Our results suggest that countries with better institutions and stricter macro-prudential regulation are less in need of those higher risk weights as they face lower levels of mortgage defaults than countries with lower institutional quality and less strict macro-prudential regulation.

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**Online material**

**Appendix A. Mortgage defaults**

Table A.1 Summary statistics for mortgage defaults at the country level

| Country | Mean | Std. Dev. | Minimum | Maximum | N |
|---------|------|-----------|---------|---------|---|
| Australia | 0.50 | 0.20 | 0.20 | 0.79 | 12 |
| Belgium | 1.68 | 1.83 | 0.40 | 5.22 | 15 |
| Brazil | 2.03 | 0.11 | 1.88 | 2.14 | 4 |
| Canada | 0.34 | 0.07 | 0.25 | 0.43 | 15 |
| Czech Republic | 2.39 | 0.75 | 1.58 | 3.41 | 13 |
| Denmark | 0.26 | 0.13 | 0.08 | 0.55 | 15 |
| France | 1.14 | 0.19 | 0.89 | 1.45 | 13 |
| Greece | 12.43 | 9.74 | 3.40 | 28.60 | 10 |
| Hong Kong | 0.40 | 0.50 | 0.01 | 1.33 | 15 |
| Hungary | 8.85 | 4.47 | 3.12 | 13.89 | 6 |
| Ireland | 11.35 | 5.28 | 4.29 | 16.93 | 6 |
| Italy | 2.19 | 0.86 | 1.50 | 3.70 | 10 |
| Malaysia | 3.18 | 1.67 | 1.38 | 5.59 | 7 |
| Mexico | 6.72 | 5.13 | 2.79 | 18.55 | 15 |
| Netherlands | 0.96 | 0.20 | 0.72 | 1.26 | 8 |
| Philippine | 8.10 | 3.68 | 3.06 | 14.98 | 15 |
| Poland | 2.94 | 1.77 | 1.00 | 7.80 | 15 |
| Portugal | 1.66 | 0.47 | 1.07 | 2.73 | 15 |
| Romania | 4.04 | 1.85 | 0.88 | 5.88 | 7 |
| Singapore | 0.62 | 0.37 | 0.30 | 1.38 | 9 |
| Slovakia | 3.13 | 0.24 | 2.95 | 3.59 | 6 |
| Spain | 1.87 | 1.91 | 0.33 | 6.09 | 15 |
| Sweden | 0.08 | 0.09 | 0.01 | 0.24 | 8 |
| Thailand | 5.29 | 4.07 | 2.20 | 14.50 | 12 |
| UK | 1.80 | 0.41 | 1.28 | 2.45 | 8 |
| US | 5.18 | 3.82 | 1.55 | 10.84 | 15 |
| Total | 3.13 | 4.20 | 0.01 | 28.60 | 297 |

Figure A.1 Mortgage defaults and intensity of macro-pru policy index (MPI)
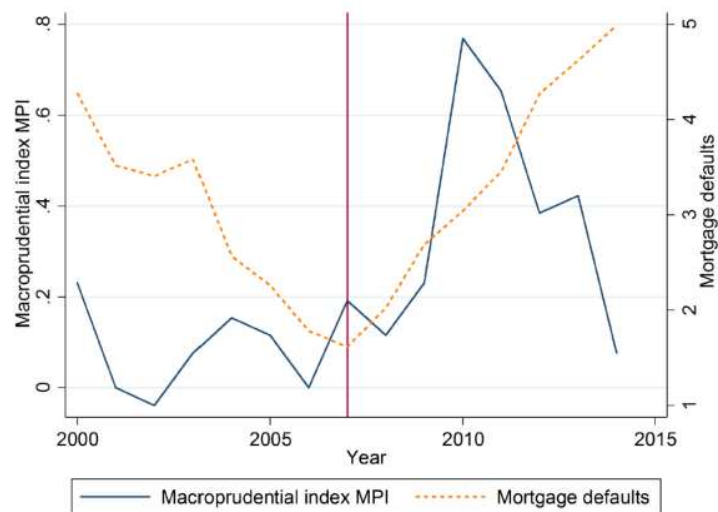


*Notes*: The figure plots the evolution of the cross-country averages for the mortgage default rates and the MPI. The series are obtained by averaging the respective variables across countries for each year in the sample.

## Appendix B. Summary statistics at the country level

Table B.1 Summary statistics per country (macroeconomic and macro-prudential variables)

| Country | Unemployment | Interest spread | House prices (%) | MPI | Macro-pru instruments | LTV index |
|---------|--------------|-----------------|------------------|------|----------------------|-----------|
| **Australia** | **5.47** | **0.36** | **4.99** | **0.13** | **1.53** | **0** |
| Std. Dev | 0.74 | 0.35 | 6.25 | 0.35 | 1.19 | 0 |
| Min | 4.20 | -0.30 | -4.05 | 0.00 | 0.00 | 0 |
| Max | 6.80 | 0.88 | 14.29 | 1.00 | 3.00 | 0 |
| **Belgium** | **7.71** | **1.90** | **7.22** | **0.00** | **-0.93** | **0** |
| Std. Dev | 0.73 | 0.92 | 7.78 | 0.00 | 0.26 | 0 |
| Min | 6.20 | 0.53 | 1.75 | 0.00 | -1.00 | 0 |
| Max | 8.50 | 3.39 | 30.77 | 0.00 | 0.00 | 0 |
| **Brasil** | **8.11** | **1.43** | **14.03** | **0.07** | **3.60** | **0.06** |
| Std. Dev | 1.21 | 1.84 | 7.50 | 0.26 | 3.46 | 0.26 |
| Min | 6.10 | -1.12 | 2.29 | 0.00 | -3.00 | 0 |
| Max | 9.70 | 4.22 | 25.95 | 1.00 | 9.00 | 1 |
| **Canada** | **7.10** | **1.67** | **6.44** | **0.67** | **0.47** | **0.13** |
| Std. Dev | 0.66 | 1.11 | 4.27 | 1.76 | 1.81 | 0.64 |
| Min | 6.00 | 0.03 | -1.68 | -1.00 | -2.00 | -1 |
| Max | 8.30 | 3.73 | 14.43 | 5.00 | 4.00 | 1 |
| **Czech Rep** | **7.06** | **1.99** | **5.58** | **0.00** | **-1.53** | **0** |
| Std. Dev | 1.14 | 0.83 | 7.56 | 0.00 | 0.74 | 0 |
| Min | 4.40 | 1.01 | -4.63 | 0.00 | -2.00 | 0 |
| Max | 8.80 | 3.55 | 19.35 | 0.00 | 0.00 | 0 |
| **Denmark** | **5.49** | **1.21** | **4.14** | **0.13** | **0.87** | **0** |
| Std. Dev | 1.46 | 0.86 | 9.94 | 0.35 | 0.74 | 0.53 |
| Min | 3.40 | -0.60 | -11.59 | 0.00 | 0.00 | -1 |
| Max | 7.60 | 2.22 | 22.15 | 1.00 | 2.00 | 1 |
| **France** | **9.08** | **1.95** | **5.07** | **0.07** | **1.33** | **0** |
| Std. Dev | 0.81 | 0.81 | 7.36 | 0.26 | 1.54 | 0 |
| Min | 7.40 | 0.70 | -4.07 | 0.00 | 0.00 | 0 |
| Max | 10.40 | 3.25 | 16.02 | 1.00 | 4.00 | 0 |

| Country | Unemployment | Interest spread | House prices (%) | MPI | Macro-pru instruments | LTV index |
|---|---|---|---|---|---|---|
| *Greece* | *13.59* | *5.71* | *0.73* | *0.13* | *-0.93* | *0* |
| Std. Dev | 6.79 | 9.16 | 8.79 | 0.52 | 0.26 | 0 |
| Min | 7.70 | -0.75 | -11.66 | 0.00 | -1.00 | 0 |
| Max | 27.20 | 35.47 | 13.86 | 2.00 | 0.00 | 0 |
| *Hong Kong* | *4.84* | *1.86* | *8.19* | *1.27* | *0.40* | *0.20* |
| Std. Dev | 1.50 | 0.74 | 14.17 | 1.87 | 3.18 | 0.86 |
| Min | 3.20 | 0.87 | -12.28 | -1.00 | -2.00 | -1 |
| Max | 7.90 | 2.58 | 29.52 | 5.00 | 7.00 | 2 |
| *Hungary* | *8.05* | *-0.48* | *2.73* | *0.27* | *-3.13* | *0* |
| Std. Dev | 2.03 | 2.24 | 7.80 | 0.88 | 1.30 | 0.38 |
| Min | 5.70 | -4.27 | -6.26 | -1.00 | -5.00 | -1 |
| Max | 11.20 | 3.73 | 19.28 | 3.00 | 0.00 | 1 |
| *Ireland* | *8.03* | *2.55* | *-2.93* | *0.07* | *1.07* | *0.07* |
| Std. Dev | 4.56 | 2.48 | 12.47 | 0.26 | 1.16 | 0.26 |
| Min | 3.70 | -0.36 | -18.74 | 0.00 | -1.00 | 0 |
| Max | 14.70 | 7.82 | 14.68 | 1.00 | 3.00 | 1 |
| *Italy* | *8.91* | *1.38* | *2.56* | *0.07* | *-0.27* | *0* |
| Std. Dev | 1.94 | 0.97 | 4.94 | 0.26 | 1.10 | 0 |
| Min | 6.10 | 0.32 | -5.35 | 0.00 | -1.00 | 0 |
| Max | 12.50 | 3.51 | 10.07 | 1.00 | 2.00 | 0 |
| *Malaysia* | *3.25* | *0.88* | *5.48* | *0.47* | *1.47* | *0.13* |
| Std. Dev | 0.41 | 0.67 | 3.35 | 0.74 | 2.64 | 0.35 |
| Min | 2.00 | -0.22 | 0.79 | 0.00 | -2.00 | 0 |
| Max | 3.70 | 2.20 | 12.23 | 2.00 | 6.00 | 1 |
| *Mexico* | *3.91* | *-2.87* | *5.03* | *0.07* | *2.00* | *0* |
| Std. Dev | 1.03 | 1.94 | 1.34 | 0.26 | 1.31 | 0 |
| Min | 2.50 | -8.50 | 2.90 | 0.00 | 0.00 | 0 |
| Max | 5.30 | -0.44 | 7.29 | 1.00 | 4.00 | 0 |

| Country | Unemployment | Interest spread | House prices (%) | MPI | Macro-pru instruments | LTV index |
|---------|--------------|-----------------|------------------|-----|------------------------|-----------|
| **Netherlands** | **4.09** | **1.28** | **0.81** | **0.47** | **0.27** | **0.27** |
| Std. Dev | 1.42 | 0.81 | 4.43 | 0.74 | 2.05 | 0.46 |
| Min | 2.10 | -0.40 | -6.57 | 0.00 | -1.00 | 0 |
| Max | 6.90 | 2.46 | 6.33 | 2.00 | 6.00 | 1 |
| **Philippine** | **8.68** | **4.57** | **6.16** | **-0.07** | **2.93** | **0** |
| Std. Dev | 1.99 | 1.65 | 5.83 | 0.46 | 2.25 | 0.38 |
| Min | 7.00 | 2.44 | -2.50 | -1.00 | -1.00 | -1 |
| Max | 11.90 | 7.91 | 14.37 | 1.00 | 8.00 | 1 |
| **Poland** | **13.21** | **-0.62** | **0.44** | **0.33** | **1.60** | **0.07** |
| Std. Dev | 4.69 | 2.89 | 7.51 | 0.62 | 2.06 | 0.26 |
| Min | 7.10 | -6.25 | -5.21 | 0.00 | 0.00 | 0 |
| Max | 19.90 | 2.14 | 18.04 | 2.00 | 6.00 | 1 |
| **Portugal** | **9.07** | **2.93** | **0.97** | **0.13** | **-0.53** | **0** |
| Std. Dev | 4.05 | 3.42 | 2.15 | 0.52 | 0.74 | 0 |
| Min | 3.90 | -0.67 | -3.53 | 0.00 | -1.00 | 0 |
| Max | 16.50 | 12.00 | 4.25 | 2.00 | 1.00 | 0 |
| **Romania** | **7.07** | **0.37** | **-4.25** | **0.27** | **-1.47** | **0.07** |
| Std. Dev | 0.54 | 0.45 | 10.23 | 0.59 | 2.67 | 0.46 |
| Min | 5.80 | -0.21 | -17.13 | 0.00 | -5.00 | -1 |
| Max | 8.10 | 1.08 | 8.74 | 2.00 | 3.00 | 1 |
| **Singapore** | **3.64** | **1.57** | **3.33** | **0.87** | **4.33** | **0.33** |
| Std. Dev | 0.77 | 0.85 | 10.22 | 1.46 | 3.92 | 0.62 |
| Min | 2.80 | 0.09 | -11.70 | -1.00 | 0.00 | 0 |
| Max | 5.20 | 3.10 | 31.15 | 4.00 | 11.00 | 2 |
| **Slovakia** | **14.92** | **1.91** | **3.79** | **0.00** | **-4.53** | **0.07** |
| Std. Dev | 3.01 | 1.54 | 13.36 | 0.00 | 1.60 | 0.26 |
| Min | 9.60 | -0.48 | -12.73 | 0.00 | -6.00 | 0 |
| Max | 19.30 | 4.34 | 29.04 | 0.00 | -1.00 | 1 |
| **Spain** | **15.55** | **1.80** | **3.65** | **0.07** | **-1.27** | **-0.13** |
| Std. Dev | 6.49 | 1.00 | 10.26 | 0.26 | 0.46 | 0.35 |
| Min | 8.40 | 0.24 | -10.02 | 0.00 | -2.00 | -1 |
| Max | 26.30 | 3.39 | 18.52 | 1.00 | -1.00 | 0 |

| Country | Unemployment | Interest spread | House prices (%) | MPI | Macro-pru instruments | LTV index |
|---|---|---|---|---|---|---|
| **Sweden** | **7.02** | **1.36** | **5.89** | **0.20** | **2.40** | **0.07** |
| Std. Dev | 1.19 | 0.76 | 4.00 | 0.41 | 2.35 | 0.26 |
| Min | 5.10 | -0.02 | -1.29 | 0.00 | 1.00 | 0 |
| Max | 8.70 | 2.85 | 11.37 | 1.00 | 8.00 | 1 |
| **Thailand** | **1.35** | **1.77** | **4.25** | **0.13** | **1.93** | **0** |
| Std. Dev | 0.57 | 0.92 | 2.39 | 0.52 | 1.71 | 0.38 |
| Min | 0.70 | 0.57 | 1.76 | -1.00 | 0.00 | -1 |
| Max | 2.60 | 3.56 | 7.42 | 1.00 | 5.00 | 1 |
| **UK** | **6.11** | **1.29** | **6.15** | **0.07** | **0.60** | **0** |
| Std. Dev | 1.30 | 1.71 | 7.08 | 0.46 | 0.99 | 0 |
| Min | 4.70 | -1.12 | -7.81 | -1.00 | 0.00 | 0 |
| Max | 8.00 | 3.74 | 16.96 | 1.00 | 3.00 | 0 |
| **US** | **6.46** | **2.61** | **4.21** | **0.00** | **0.20** | **0** |
| Std. Dev | 1.84 | 1.35 | 9.28 | 0.00 | 0.56 | 0 |
| Min | 4.10 | 0.27 | -15.91 | 0.00 | 0.00 | 0 |
| Max | 9.70 | 3.95 | 15.95 | 0.00 | 2.00 | 0 |
| **Total** | **7.61** | **1.60** | **4.35** | **0.23** | **0.48** | **0.05** |
| Std. Dev | 4.34 | 2.87 | 8.35 | 0.76 | 2.67 | 0.35 |
| Min | 0.70 | -8.50 | -18.74 | -1.00 | -6.00 | -1 |
| Max | 27.20 | 35.47 | 31.15 | 5.00 | 11.00 | 2 |

*Notes*: This table shows summary statistics of the macroeconomic and macro-prudential indexes at the country level. Data on unemployment comes from the World Development Indicators database (World Bank). Data on interest spread (as a difference between government long-term bond yield and the rate of treasury bills) comes from International Financial Statistics (IMF) and FRED Economic Data (St. Louis Fed). Data on house prices is from BIS and the European Mortgage Federation. Data on MPI (the macro-prudential policy index) is from Akinci and Olmstead-Rumsey (2017). Data on Macro-pru instruments (the cumulative macro-prudential policy index) and LTV index are from Cerutti at al. (2017a).

Table B.2 Overview of institutional quality indicators

| Country | Legal rights | Rule of law | Property protection | Investor protection | Creditor rights | Institutional quality index (IQ) |
|---|---|---|---|---|---|---|
| Australia | 9 | 0.8 | 7.1 | 5.7 | 3 | 1.3 |
| Belgium | 6 | 0.8 | 6.4 | 7.0 | 2 | 0.2 |
| Brazil | 3 | 0.5 | 5.5 | 5.3 | 1 | -2.5 |
| Canada | 7 | 0.8 | 7.5 | 8.7 | 1 | 1.2 |
| Czech Rep. | 6 | 0.7 | 6 | 5.0 | 3 | -0.4 |
| Denmark | 9 | 0.9 | 7 | 6.3 | 3 | 1.7 |
| France | 7 | 0.7 | 6.9 | 5.3 | 0 | -0.5 |
| Greece | 4 | 0.6 | 5.1 | 5.3 | 1 | -2.3 |
| Hong Kong | 10 | 0.8 | 7.7 | 9.0 | 4 | 3.0 |
| Hungary | 7 | 0.6 | 5.2 | 4.3 | 1 | -2.0 |
| Ireland | 9 | - | 6.4 | 8.3 | 1 | - |
| Italy | 3 | 0.6 | 5.2 | 6.0 | 2 | -1.7 |
| Malaysia | 10 | 0.6 | 7.7 | 8.7 | 3 | 1.9 |
| Mexico | 5 | 0.5 | 5.1 | 5.7 | 0 | -2.8 |
| Netherlands | 6 | 0.8 | 7.1 | 4.7 | 3 | 0.5 |
| Philippine | 4 | 0.5 | 6.2 | 4.3 | 1 | -2.2 |
| Poland | 9 | 0.7 | 5.7 | 6.0 | 1 | -0.3 |
| Portugal | 3 | 0.7 | 6.2 | 6.0 | 1 | -1.3 |
| Romania | - | 0.6 | 5.8 | 6.0 | 1 | - |
| Singapore | 10 | 0.8 | 8.1 | 9.3 | 3 | 3.1 |
| Slovakia | - | - | 6 | 4.7 | 2 | - |
| Spain | 6 | 0.7 | 5.5 | 5.0 | 2 | -1.1 |
| Sweden | 8 | 0.9 | 7.5 | 6.3 | 1 | 1.0 |
| Thailand | 5 | 0.5 | 6.5 | 7.7 | 2 | -0.6 |
| UK | 10 | 0.8 | 6.9 | 8.0 | 4 | 2.3 |
| US | 9 | 0.7 | 7.2 | 8.3 | 1 | 1.2 |

*Notes*: This table provides an overview of the institutional quality indexes at the country level. Data on Legal rights index comes from the World Bank's Doing Business database. Data on Rule of law index comes from World Justice Project (2015). Data on Property protection index comes from the International property rights database. Data on Investor protection index comes from the World Bank's Doing Business database. Data on Creditor rights index is from Djankov et al. (2007). Institutional quality index (IQ) combines the five attributes of institutional arrangements and represents the first principal component of these attributes.

Table B.3 Overview of mortgage markets characteristics

| Country | Average maturity | Recourse (full) | Loan type | Funding type | Tax deductibility |
|---|---|---|---|---|---|
| Australia | 25 | Yes | Other | Other | No |
| Belgium | 20 | Yes | Fixed | Retail deposit | Yes |
| Brazil | 25 | No | Fixed | Retail deposit | No |
| Canada | 25 | Yes | Other | Retail deposit | No |
| Czech Rep. | 20 | Yes | Other | Retail deposit | Yes |
| Denmark | 30 | Yes | Other | Other | Yes |
| France | 20 | Yes | Fixed | Retail deposit | No |
| Greece | 15 | Yes | Other | Retail deposit | Yes |
| Hong Kong | 15 | Yes | Other | Other | No |
| Hungary | 20 | Yes | Other | Other | No |
| Ireland | 40 | Yes | Other | Retail deposit | Yes |
| Italy | 22 | Yes | Other | Retail deposit | Yes |
| Malaysia | 35 | No | Other | Retail deposit | Yes |
| Mexico | 25 | No | Other | Other | Yes |
| Netherlands | 30 | Yes | Fixed | Retail deposit | Yes |
| Philippine | 30 | Yes | Other | Other | No |
| Poland | 32.5 | Yes | Other | Retail deposit | Yes |
| Portugal | 30 | No | Other | Retail deposit | Yes |
| Romania | 32.5 | . | Other | . | No |
| Singapore | 35 | Yes | Other | Other | Yes |
| Slovakia | 17 | . | Other | . | No |
| Spain | 20 | Yes | Other | Retail deposit | Yes |
| Sweden | 45 | Yes | Other | Other | Yes |
| Thailand | 20 | Yes | Other | Retail deposit | Yes |
| UK | 25 | Yes | Other | Retail deposit | No |
| US | 30 | No | Other | Other | Yes |

*Notes*: This table provides an overview of the mortgage market characteristics at the country level. Data on average maturity of mortgage loans (years), degree of lender recourse (full vs no or partial recourse), loan type (fixed vs. variable rate), and bank funding type (retails vs. other sources such as covered bonds or securitization) come from Cerutti et al. (2015) and European Mortgage Federation (Hypostat report, 2015). Data on tax deductibility comes from Cerutti et al. (2015) and the International Bureau of Fiscal Documentation (Tax research platform).

**Appendix C. Principal component analysis of indicators of institutional quality**

The institutional index is based on five selected indicators of institutional quality, which are aggregated via principal components analysis to build a single index of institutional quality (IQ) that accounts for most variation in the set of five institutional variables. The selection is based on the results of the model, which indicate the relevance of these factors for mortgage defaults. Table C.1 reports the correlations between these institutional variables and Table C.2 shows the eigenvalues for each of the five identified components. The correlations among the selected institutional variables are positive and vary from 0.38 to 0.69, which indicates that they are suitable for principal components analysis.

Table C.1. Correlation institutional variables

| Variable | Legal Rights | Physical Property | Investor Protection | Creditor Rights | Rule of Law |
|---|---|---|---|---|---|
| Legal Rights | 1 | | | | |
| Physical Property | 0.67 | 1 | | | |
| Investor Protection | 0.57 | 0.69 | 1 | | |
| Creditor Rights | 0.52 | 0.42 | 0.38 | 1 | |
| Rule of Law | 0.55 | 0.57 | 0.24 | 0.46 | 1 |

Table C.2. Eigenvalues principal components

| Component | Eigenvalue | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Comp 1 | 3.06 | 2.26 | 0.61 | 0.61 |
| Comp 2 | 0.79 | 0.20 | 0.16 | 0.77 |
| Comp 3 | 0.59 | 0.25 | 0.11 | 0.89 |
| Comp 4 | 0.34 | 0.13 | 0.06 | 0.95 |
| Comp 5 | 0.20 | | 0.04 | 1 |

The proportion indicates the relative weight of each factor in the total variance. The first component explains 61.3% of the total variance and components 1 and 2 account for 77% of the total variance. Following Kaiser's criterion, we retain only the first component since it has an eigenvalue substantially higher than 1 and this component

is our institutional quality index (see column 1 of Table C.2). Table C.3 presents the loadings of each institutional variable on the institutional quality index. Factor loadings are the weights and correlations between each variable and the factor. The higher the loading, the more relevant in defining the factor's dimensionality. A negative value indicates an inverse impact on the factor. We notice that the loadings of each of the variables on the first component are positive and have similar magnitudes, with Legal Rights and Physical Property having the highest loadings.

Finally, the last column in Table C.3 summarizes the Kaiser-Meyer-Olkin measure for sampling adequacy by comparing correlations and partial correlations between variables. The measure has a value of 0.73, which indicates a good sampling adequacy. Therefore, a low-dimensional representation of the data is possible.

Table C.3. Principal components loadings and Kaiser-Meyer-Olkin measure

| Variable | Loadings | Unexplained | KMO |
|---|---|---|---|
| Legal Rights | 0.49 | 0.25 | 0.84 |
| Physical Prop | 0.49 | 0.23 | 0.71 |
| Investor Protection | 0.42 | 0.43 | 0.65 |
| Creditor Rights | 0.39 | 0.51 | 0.84 |
| Rule of Law | 0.41 | 0.48 | 0.66 |
| Overall KMO | | | 0.73 |

**Previous DNB Working Papers in 2017 (continued)**