



A model of mortgage losses and its applications for macroprudential instruments[☆]



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ABSTRACT

We develop a theoretical model of mortgage loss rates that evaluates their main underlying risk factors. Following the model, loss rates are positively influenced by the house price level, the loan-to-value of mortgages, interest rates, and the unemployment rate. They are negatively influenced by the growth of house prices and the income level. The calibration of the model for the US and Switzerland demonstrates that it is able to describe the overall development of actual mortgage loss rates. In addition, we show potential applications of the model for different macroprudential instruments: stress tests, countercyclical buffer, and setting risk weights for mortgages with different loan-to-value and loan-to-income ratios.

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1. Introduction

Loss rates on mortgages have increased substantially in the US and many other countries during the financial crisis. At the same time, financial institutions were heavily exposed to the mortgage market when the crisis started. Fig. 1 displays the relationship between mortgages and charge-off rates in the US. As we can see, mortgages increased strongly as long as charge-off rates were low. Therefore, the banks' exposure was at its peak when the bubble burst and charge-off rates suddenly increased strongly. As a result, many banks suffered high losses or even failed. In 2009 the FDIC recorded 140 bank failures for the US. As a comparison, in 2008 there were 25 bank failures and from 2002 to 2007 only 21.

One reason for this was that financial institutions underestimated the risk associated with mortgages. The development of the lending standards of banks and their mortgage supply¹ indicates that financial institutions base their risk assessment on the past performance of mortgages rather than on the main economic risk drivers. Among others, these risk drivers are the income of borrowers and the development of house prices.

Another reason for the extent of the crisis was that also banking regulation and capital requirements did not adequately capture the build-up of risks in the mortgage market and the resulting systemic impact. As a reaction, we see increasing international efforts (especially by the Financial Stability Board, the BIS and the IMF) to enhance macroprudential instruments in order to identify and monitor systemic risks and to limit the build-up and/or the impact of these risks.² The process is still ongoing; however, key methodologies to identify systemic risks are constructing aggregated indicators for systemic imbalances like the credit-to-GDP ratio and conducting macro stress tests. The most prominent macroprudential instrument is the countercyclical capital buffer, under which banks have to hold more capital in boom phases and can use the buffer to cover losses in a downturn phase. A further

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¹ Lown and Morgan (2006) show that lending standards (as measured by the Loan Officer Opinion Survey of the Federal Reserve) are a key driver of loans.

² See e.g. Financial Stability Board (2011).

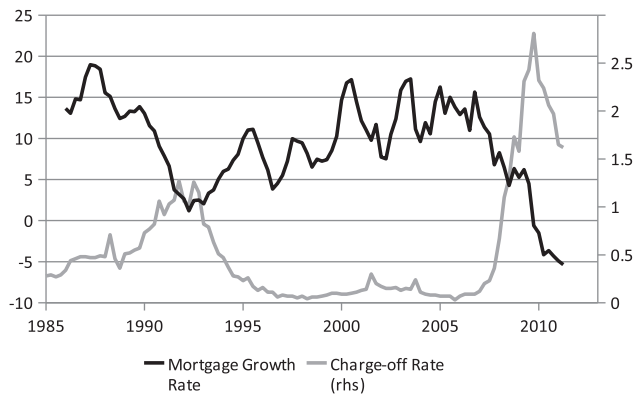


Fig. 1. Mortgages and charge-off rates in the US.

instrument is the limitation of loan-to-value and loan-to-income ratios, which are important parameters for banks to influence the risk profile of their mortgage loan portfolio.

Various papers evaluate the driving forces behind mortgage defaults and the resulting losses. [Campbell and Cocco \(2011\)](#), for example, examine default risks and develop a model where households maximize their discounted future utility from consumption and housing. They finance their house by a mortgage and decide in each period whether or not to default on the mortgage. The authors assume that the mortgage lender has no recourse to the defaulter's income or savings. Following their model, households decide to default when their home equity turns negative, meaning the value of the house becomes smaller than the outstanding mortgage loan. However, the authors also show that if borrowing constraints are less binding (due to a higher income), households might decide not to default even when home equity is negative.

[Deng et al. \(2000\)](#) argue that a mortgage borrower has two separate options: a prepayment option and a default option. The authors develop a unified model of these two options and show that the simultaneity of the two options can help to explain borrower behavior. However, since in many countries there are prepayment penalties and lenders have recourse to defaulters' income, the results are mainly relevant for some US states like California.

[Haughwout et al. \(2008\)](#) evaluate possible reasons for the strong increase in early mortgage defaults in the US in 2006 and 2007. In their empirical estimation they use credit risk variables like loan-to-value ratios and debt service-to-income ratios as well as variables that capture the economic conditions like regional unemployment rates or house prices. Their results indicate that both, bad credit standards and bad economic conditions, contributed to the increase in defaults, with economic conditions having the largest impact. However, the empirical model only predicts less than half of the strong increase in early defaults after 2006.

While most studies focus on default rates of mortgages, [Qi and Yang \(2009\)](#) evaluate different influence factors of the loss given default. Their empirical study is based on a large pre-crisis loan level data set and indicates that the current loan-to-value ratio is the single most important determinant of the loss given default.

The aim and main contribution of this paper is to develop a theoretical model of mortgage loss rates which should serve as a foundation for macroprudential instruments like countercyclical buffers. We develop a theoretical model of mortgage losses by [Hott \(2011\)](#) further in order to be able to calibrate loss rates and to transform it in ways that make it applicable for macroprudential instruments.

In the theoretical model, banks provide mortgages to *a priori* identical households. A heterogeneous development of the households' income and house prices leads to the default of some

households in the following period. In order to demonstrate the empirical relevance of the model, we calibrate it for two countries that experienced pronounced real estate crises within the past 25 years but had a different development: the US and Switzerland. The results of the calibration are used to demonstrate the ability of the model to estimate the impact of stress scenarios on mortgage losses, to calculate the size and development of countercyclical buffers, and to set standards for risk weights on mortgages with different loan-to-values and loan-to-incomes.

The paper is organized as follows: in the next section we develop the theoretical model, in Section 3 we calibrate the model, Section 4 shows potential applications of the model for macroprudential instruments, and Section 5 offers some concluding remarks.

2. The model

In this section we develop a theoretical two-period model that enables us to calculate loss rates for mortgage loans. The basic setting of the model is very similar to [Hott \(2011\)](#): in period $t = 1$ banks provide mortgages to *a priori* identical households. In period $t = 2$ each household receives a random labor income and defaults if this labor income plus the value of the house is too low to fulfill the mortgage duties. In contrast to [Hott \(2011\)](#), however, we assume that the constant loan-to-value of mortgages is less than 100%. In addition, we consider unemployment, maintenance costs for houses, foreclosure costs, and a heterogeneous development of house prices. By introducing these additional features, the model becomes more realistic and, hence, more suitable for describing actual loss rates on mortgages.

2.1. Basic assumptions

2.1.1. Houses

There are S_1 *ex ante* identical houses and in period $t = 1$ the price of house i is $P_1^i = P_1$, where $i = 1, \dots, S_1$. Therefore, the value of the entire housing stock is $S_1 P_1$. Further, we assume that houses are subject to depreciation and that owning a house leads to maintenance costs. The sum of the depreciation and the maintenance costs (as a fraction of the house price) is assumed to be $1 > \rho' \geq 0$.

In period $t = 2$ the price of house i is assumed to be uniformly distributed between $(1 - \delta)P_2$ and $(1 + \delta)P_2$, where P_2 is the average house price in $t = 2$ and $\delta > 0$ is the maximum relative deviation from this average price. Therefore, in $t = 2$ the value of the existing housing stock is $S_1 P_2$.

2.1.2. Mortgages

In period $t = 1$ banks provide mortgages to households at the interest rate $m_1 > 0$. Since banks cannot *ex ante* differentiate between different households and different houses, this mortgage rate is identical for each household. The loan-to-value (LTV) of a mortgage that is granted is the constant l , where $0 < l < 1$.³ Therefore, in period $t = 1$ the amount of all mortgages is $l S_1 P_1$. The maturity of each mortgage loan is assumed to be one year. This implies that households have to refinance their mortgage every year. However, after this year the LTV of the old mortgage is different for each mortgage borrower and between $l P_1 / (1 + \delta) P_2$ and $l P_1 / (1 - \delta) P_2$.

When a mortgage borrower defaults, the house goes into the ownership of the bank. We assume that the foreclosure and change in ownership causes costs. These foreclosure costs are assumed

³ [Iacoviello \(2005\)](#) and [Kiyotaki and Moore \(1997\)](#) also assume fixed LTV ratios when evaluating the link between real estate prices and output. [Campbell and Cocco \(2011\)](#) show that in the US, LTV ratios were relatively stable between 1984 and 2008.

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