The Impact of an Interest Rate Freeze on Residential Mortgage Backed Securities

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Abstract

This paper analyses effects of an interest rate freeze in subprime mortgages on residential mortgage backed securities (RMBS). In particular, we study shifts in the underlying portfolio's discounted cashflow distributions as well as changes in the payment profile of RMBS-tranches. We show that the positive effects of a rate freeze, e.g. less foreclosures and a stabilizing housing market, can outweigh the negative effect of lower interest income such that investors might be better off.

Keywords: Interest Rate Freeze, Subprime Mortgages, Residential Mortgage Backed Securities (RMBS)

JEL classification: G21, G15

1 Introduction

Starting in mid 2007, rising delinquency and foreclosure rates in the US subprime mortgage market triggered a severe financial crisis which spread around the world. Although subprime mortgages that were granted to borrowers with weak credit record and often require less documentation, only account for about 15 percent of all outstanding US mortgages, they were responsible for more than 50 percent of all mortgage loan losses in 2007.[1] Most of the subprime losses were caused by high foreclosure rates on hybrid adjustable rate mortgages (ARM). These loans offer fixed initial interest rates at a fairly low level, which are replaced by higher rates linked to an interest rate index after two or three years. Thus, borrowers face a significant payment shock after the interest reset which increases the probability of delinquencies. In previous years, rising real estate prices and, thus, increasing home owner equity enabled mortgage associations to waive part of delinquent interest payments in exchange for an increase in nominal value of the mortgage or to renegotiate the mortgage. But during the last year the trend in real estate prices has reversed in many regions of the United States leading to "negative equity" of many borrowers, i.e. their real estate values are lower than their outstanding debt. Therefore they often default.[2]

After some discussions with loan and savings associations as well as regulators, the US government proposed a 5-year interest rate freeze on subprime ARM on December 6th, 2007. This interest moratorium should lower the financial burden on borrowers and, thus, prevent another wave of losses on these loans.[3] Although this proposal did not become effective, it raises several interesting questions about the economic effects: Who benefits from an interest moratorium? Who bears the costs? Does an interest moratorium mitigate the crisis?

[1] See *International Monetary Fund* (2008).

[2] Mortgage loan contracts in the United States often exclude personal liability such that borrowers do not face any further financial burden when they default.

[3] According to the *IMF* (2008), $ 250 billion subprime mortgages are due to reset in 2008.

Of course, subprime borrowers benefit from the interest rate relief which lowers their financial burden. Hence there will be fewer delinquencies and fewer foreclosures. This, in turn may take pressure from the housing market and help to avoid a further downturn on house prices. As pointed out in the *Wall Street Journal* on December 7th, 2007:"*The initiative could help stabilize falling home prices and rising foreclosure rates...*".

The effect on the lenders is less clear. On the one hand, they receive lower interest on a significant portion of mortgage loans. On the other hand, they might benefit in a twofold way. First, the number of defaults potentially declines. Second, the average loss given default (LGD) might be lower when house prices stabilize.

But the impact of an interest-rate freeze is not limited to borrowers and lenders. More than half of all subprime mortgages that were granted in recent years were sold in residential mortgage backed securities (RMBS). In these RMBS transactions cash flows from the underlying mortgage pool are allocated to tranches with different seniority: several rated tranches and an equity tranche. Due to a priority of payments scheme the equity tranche absorbs most of the losses whereas the senior tranche exhibits only low risk. Part of the RMBS tranches were purchased by outside investors, i.e. foreign banks, non-mortgage banks, insurance companies or hedge funds who did not take part in the negotiations on the interest rate moratorium. These investors are affected by a rate freeze in a twofold way: On the one hand, investors holding rated tranches loose part of their loss protection since in a true-sale RMBS usually (part of) the interest paid on the underlying mortgage loans is used to cover losses which otherwise might hit the rated tranches. On the other hand, investors also benefit from the potentially lower default rates and LGDs in the portfolio. The combined effects may cause a reallocation of cash flows and losses among creditors which will be studied in this paper. In particular, we analyse the impact of an interest rate moratorium on the default rate of the underlying mortgage pool as well as the redistribution effects from lower interest payments in combination with lower portfolio losses.

The payments on mortgage portfolios and consequently also on the respective RMBS tranches are stochastic and depend on several variables. First, we set up a basic model to capture the repayment behavior of a single mortgage loan. We use the regional house price index as the systematic factor driving the default rate as well as the loss given default. Additionally, the interest rate to be paid on a mortgage loan influences its default probability. Here, we assume each increase in the payment obligations of a debtor to raise the default probability. After calibrating this basic model we investigate the potential consequences of the interest rate freeze on the discounted cashflow distribution of the underlying portfolio. Additionally, we investigate how the allocation of cashflows and losses among different tranches is affected. Due to the complex structure of the allocation that in particular depends on the timing of cashflows and losses we use a Monte Carlo simulation for this study.

Throughout the paper we look at two sample portfolios: a typical subprime RMBS portfolio and another portfolio representing the US mortgage market as a whole. For both portfolios we assume a true-sale RMBS transaction with four differently rated tranches and an equity piece. We use a benchmark scenario without crisis elements to calibrate the sizes and loss protection of the tranches to the respective rating. This scenario includes an interest rate step-up after year two for subprime and alt-A mortgage loans.

Subsequently, we derive the portfolio payment distributions and the resulting tranche characteristics in a crisis scenario that is meant to reflect the current situation in the United States. In particular, the average house prices are assumed to have decreased by ten percent over the first two years of the RMBS transaction. As we show, the crisis leads to a significant reduction of the expected discounted cash flows of the respective portfolios: ten percent for the subprime portfolio and six percent for the US market portfolio. In roughly one third of the simulation runs the equity piece does not suffice to cover the losses which means that the rated tranches need to absorb a significant share of the portfolio loss. Consequently, the risk characteristics of all tranches worsen as compared to the benchmark case which makes severe downgrades necessary as observed in the markets.

Starting from the current crisis scenario we investigate the impact of an interest rate freeze. We assume all scheduled interest rate step-ups to be waived which decreases the claims on the RMBS portfolio. Beside this negative effect we consider two positive effects of the freeze. First, we study only the direct effect of an interest rate freeze, which leads to lower foreclosure rates in the underlying portfolio due to the absence of payment shocks to borrowers. In this case our simulation results show that the net change in expected portfolio payments is negative as is the effect on most tranches. The consequences are not uniform for all tranches however: the better the tranche, the less its characteristics deteriorate.

In the second case, we additionally include a positive 'second round' effect on house prices. In particular, the lower number of foreclosures takes pressure off the housing market resulting in a "neutral" house price trend, i.e. an expected change of zero, instead of the expected additional decrease. Given this combined impact, our results indicate that the positive effects are able to (over-)compensate for the loss due to the interest rate freeze. Consequently, all rated tranches benefit in this scenario. Whereas the equity tranche slightly improves for the US market portfolio, it deteriorates significantly for the subprime portfolio. Therefore we conclude that an interest rate freeze on mortgage loans that are securitised does not only improve the debtor situation, but might also render investors in RMBS tranches better off at the expense of the equity tranche.

The remainder of this paper is structured as follows. First we comment on related literature. Section 3 describes the set-up and calibration of our simulation model. In section 4, we analyse the effects of a mortgage crisis on our sample mortgage portfolios and also on RMBS-tranches backed by these portfolios. Furthermore, we investigate the consequences of an interest rate freeze on portfolio and tranche characteristics. Section 5 concludes.

2 Literature Review

Our paper is closely related to the empirical study by *Cagan* (2007) analysing the impact of an interest rate reset in adjustable rate mortgages (ARM). Based on a dataset of ARMs originated between 2004 and 2006, he estimates that 59% of these mortgages face a payment increase of more than 25% after the initial period with low rates. He anticipates that in total approximately 13% of adjustable-rate mortgages will default due to the interest rate reset, which corresponds to 1.1 million foreclosures over a total period of six to seven years. This increase in default rates is not equally distributed across all mortgages but depends on the size of the interest rate step-up and the loan-to-value ratio. Additionally, the author estimates that each one-percent fall in national house prices causes an additional 70,000 loans to enter reset-driven foreclosure. Given a house price drop of 10% he projects that more than 22% of ARMs will default due to the interest rate reset. This underlines the impact of a policy reaction to scheduled interest rate step-ups in the present market environment.

Ashcraft and Schuermann (2008) discuss the securitization of subprime mortgages. First they provide a detailed analysis of the key informational frictions that arise during the securitization process and how these frictions contributed to the current subprime crisis. They also document the rating process of subprime mortgage backed securities and comment on the ratings monitoring process. They conclude that credit ratings were assigned to subprime RMBS with significant error which has led to a large downgrade waves of RMBS tranches in July 2007.[4] In the course of our analysis we will also comment on this rating issue and show that in our crisis scenario severe downgrades are necessary.

[4]In fact there was a second downgrade wave in the beginning of 2008 on which the authors do not comment.

Several further research articles provide general information about subprime loans and the current mortgage crisis. *Chomsisengphet/Pennington-Cross* (2006) comment on the evolution of the subprime market segment. In particular, some legal changes in the beginning of the 1980s, which allowed to charge higher interest rates and higher fees on more risky borrowers and which permitted to offer adjustable rate mortgages, enabled the emergence of subprime loans. The Tax Reform Act in 1986 allowing interest deductions on mortgage loans made high loan-to-value (LTV) ratios financially more rewarding and, thereby, subprime mortgages more attractive. In the beginning of the 1990s the increasing use of securitizations as funding vehicles triggered rapid growth in the subprime mortgage market. Between 1995 and 2006 the volume in this market segment increased from $ 65 billion to more than $ 600 billion and also the share on the total mortgage market significantly increased.[5] At the same time the percentage of the outstanding subprime loan volume being securitized went up from about 30% to around 80%.[6] *Dell' Ariccia et al.* (2008) show that the rapid expansion of the subprime market was associated with a decline in lending standards. Additionally, they find that especially in areas with higher mortgage securitization rates and with more pronounced housing booms lending standards were eased. Lower lending standards can thus be identified as one reason for the subprime mortgage crisis.

According to the *IMF* (2008), subprime borrowers typically exhibit one or more of the following characteristics at the time of loan origination: weakened credit histories as indicated by former delinquencies or bankruptcies, reduced repayment capacities as indicated by low credit scores or high debt-to-income ratios and incomplete credit histories. Given this very broad definition subprime borrowers are not a homogeneous group. For example, Countrywide Home Loans,

[5] See also *Kiff/Mills* 2007.

[6] See also *Keys et al.* (2008).

Inc. distinguishes four different risk categories of subprime borrowers.[7] These subcategories may depend on the borrower's FICO (Fair Isaac Corporation) credit score, which is an indicator of the borrowers credit history, the Loan-To-Value (LTV) ratio of the mortgage loan.and the debt-to-income ratio.[8] Analysing a data set of securitized loans from 1995 to 2004, *Chomisengphet/Pennington-Cross* (2006) find strong evidence for risk-based pricing in the subprime market. In particular, interest rates differ according to credit scores, loan grades and loan-to-value ratios.

Using a dataset of securitized subprime mortgages from 2001 to 2006, *Demyanyk/Hemert* (2007) compare the characteristics of different loan vintages in order to identify reasons for the bad performance of mortgages originated in 2006, which triggered the subprime mortgage crisis. Their sample statistics show that the average FICO credit score increased from 620 in 2001 to 655 in the 2006 vintage, which corresponds to the observation that the market expanded in the less risky segment. During the same period average loan size increased from \$ 151,000 to \$ 259,000 whereas the average loan-to-value (LTV) ratio at origin stayed approximately the same at 80%. Applying a logit regression model to explain delinquencies and foreclosure rates for the vintage 2006 mortgages, *Demyanyk/Hemert* (2007) identify the low house price appreciation as the main determinant for the bad performance. Also *Kiff/Mills* (2007), who comment on the current crisis, see the slow down in house prices as the main driver for the deterioration in 2006 vintage mortgage loans. Furthermore they emphasize that although the average subprime borrower credit score increased during the last years, also LTV and debt-to-income ratios increased, which made the mortgages more risky.

Gerardi et al. (2007) analyse a dataset of homeownership experience in Mas-

[7] See www.cwbc.com or *Chomsisengphet/Pennington-Cross* (2006).

[8] *Kiff/Mills* (2007) classify a mortgage as subprime if the LTV is above 85% and/or the debt-to-income ratio exceeds 55%.

sachusetts. They find that the 30 day delinquency rate shows rather limited variance as it fluctuates between 2 and 2.8 % of borrowers. Further, there is no significant correlation to the change in house prices. In contrast, they find a strong negative correlation between foreclosure rates and the house price index over the whole sample period from 1989 to 2007. In particular, *Gerardi et al.* point out that the house price decline starting in summer 2005 was the driver of rising foreclosure rates in 2006 and 2007. These findings show that the house price index drives the portion of delinquent mortgages that are foreclosed rather than the number of delinquencies themselves.

Estimating cumulative default probabilities they further find that subprime borrowers default six times as often as prime borrowers. This corresponds to *Pennington-Cross* (2003) who also compares the performance of subprime to prime mortgage loans and finds that the latter are six times more likely to default and 1.3 times more likely to prepay. Analysing the determinants of default he concludes that for both - prime and non-prime loans - decreasing house prices as well as increasing unemployment rates increase credit losses.

All these empirical studies indicate a strong relationship between mortgage loan defaults and house price appreciation in the subprime market. This corresponds to the theoretical literature on mortgage loan default. According to option pricing theory a borrower, who is not personally liable, should default when the associated put option is in the money, e.g. when the mortgage debt exceeds the house value. Therefore we will use the house price index as the main determinant of default in our simulation model.

3 Model Set-Up

Our analysis is based on a cashflow simulation model. Mortgage loans are more likely to default when they are in “negative equity”, i.e. when the current real estate value is lower than the outstanding debt. This event is usually triggered by a downturn in the house price. Therefore we use a macro factor representing the regional house price index as the systematic determinant of default. We assume the regional house price index to have a nationwide and a regional component. The house price at default further determines the loss incurred in a distressed sale following a foreclosure.

Payment shocks due to interest rate resets can cause additional foreclosures, especially when house prices have already declined. We account for this by adding a function depending on changes in payment obligations to the idiosyncratic debtor component of our model.

3.1 Simulation Model

RMBS are usually backed by mortgage loans from different regions. This regional diversification reduces the variance of the repayment distribution of the mortgage portfolio and thereby helps to make the rated tranches less risky. For each region we assume the regional house price index (HPI) to be the main driver of the foreclosure rate. Further, for each region k we decompose the percentage change of the HPI in year t into an overall positive long-term trend c and a deviation from this trend driven by a nationwide factor M_t and an orthogonal regional factor $B_{k,t}$:

$$\Delta HPI_{k,t} = c + a \cdot (\sqrt{\rho_M} M_t + \sqrt{\rho_k} B_{k,t}) = f(M_t, M_{t-1}, B_{k,t}, B_{k,t-1}) \qquad (1)$$

Unconditionally, M_t and $B_{k,t}$ are assumed to be standard normally distributed. Empirical evidence suggests however, that house price changes display a strong positive autocorrelation.[9] Therefore we incorporate a first-order autocorrelation of 0.5 for each factor. Thus, conditional on M_{t-1}, M_t has a mean of $0.5 \cdot M_{t-1}$ and a standard deviation of $\sqrt{0.75}$. The same holds for the regional factors.

[9] In an empirical study based on 15 OECD countries *Englund and Ioannidis* (1997) estimate an average first-order autocorrelation coefficient of 0.45.

ρ_M and ρ_k account for correlations of house price changes across and within regions. We calibrated the nationwide and regional correlations to $\rho_M = 0.1$ and $\rho_k = 0.2$ and the scaling factor to $a = 0.1$. This implies unconditional standard deviations of 5.5% (3.7%) for annual regional (nationwide) house price changes which is in line with empirical evidence.[10] The unconditional mean annual change of the HPI equals the long-term trend c on both, the regional as well as the national level.

For the loans in the underlying mortgage pool we distinguish five debtor groups by credit quality: Prime, Alt-A, Subprime 1, Subprime 2 and Subprime 3. These groups can be interpreted as representing the FICO score and further characteristics like payment history and bankruptcies of the borrowers.[11] The assumed expected default probabilities for the different debtor groups and maturities are shown in the credit curves in Table 2 in the appendix. The numbers correspond to empirical evidence (see e.g. *Gerardi et al.* 2007).

In each simulation run a path of annual group migrations is computed for each loan in the portfolio. For debtor i located in region k this path depends on a series of latent migration variables $L_{i,k,t}$, $t = 1, \ldots, 7$. In this respect our simulation model resembles a migration model for the assessment of collateralized loan obligations where debtors can "migrate" between different rating groups.[12]

[10]There exist different house price indices for the US. For example, Freddie Mac's Conventional Mortgage Home Price Index (CMHPI-Purchase Only) shows a standard deviation of 3.8% (nationwide) and 5.2% regionally, since 1975.

[11]There exist no general classification scheme of mortgage loans except for the distinction between Prime, Alt-A and Subprime. Nevertheless it is common to further subdivide the subprime category into several grades (see *Chomsisengphet/Pennington-Cross* 2006).

[12]In general, either migration models or factor models are used to model loan defaults. E.g. in the literature on securitization, *Franke/Krahnen* (2006) simulate rating transitions whereas *Hull/White* (2004) use a one-factor model and *Duffie/Garleanu* (2001) as well as *Longstaff/Rajan* (2008) apply multi-factor models in their analysis. We use a mixture of these two approaches.

At each annual payment date t, we derive the latent variable

$$L_{i,k,t} = \frac{1}{a}(\Delta HPI_{k,t} - c) + \sqrt{1 - \rho_M - \rho_k} \cdot \varepsilon_{i,t} \quad \text{with } \varepsilon_{i,t} \text{ iid } \mathcal{N}(0,1)\ . \qquad (2)$$

If the value of the latent variable $L_{i,k,t}$ lies above (below) a certain threshold, which corresponds to the quantile of the standard normal distribution associated with the migration probabilities in the so-called migration matrix, the mortgage is upgraded (downgraded) to the respective debtor category. Panel A of table 2 shows the unconditional expected annual migration probabilities for years without changes in interest obligations as well as the corresponding multi-year cumulative default probabilities. The numbers are chosen to match the empirical findings on prime and subprime default rates of *Geradi et al.* (2007). Since these numbers are estimated from a time series between 1987 and 2007, they already incorporate the positive long-term trend in house prices. Therefore we subtract the long-term trend c from our house price changes such that only the deviation from the expected (positive) long-term growth during the last years enters the latent variable.

As can be seen in equations (2), ρ_M and ρ_k also account for correlation of loan defaults across and within regions. Given our calibrated numbers, 30% $(= 0.1 + 0.2)$ of the default risk is due to sysematic risk in house price changes and 70% are due to idiosyncratic risks. The idiosyncratic component is given by $\varepsilon_{i,t}$, which includes borrower specific shocks like unemployment, illness or divorce.

Due to our assumption of positive autocorrelation in house price changes, our latent variable is not necessarily standard normally distributed, but only normally distributed and the distribution changes from date to date. Hence, our migration model is an extension to classical migration models where always standard normally distributed migration variables are drawn. In particular, we endogenize migration thresholds accounting for the fact that downward migrations and also defaults are less (more) likely in an environment with positive (negative) house price changes.

To capture an increase in the probability of default due to a payment shock resulting from an increase in interest obligations, we subtract a deterministic term from our latent variable in the year of an interest rate step-up, such that

$$L_{i,k,t} = \frac{1}{a}(\Delta HPI_{k,t} - c) + \sqrt{1-\rho_M-\rho_k} \cdot \varepsilon_{i,t} - b_i(r_{i,t} - r_{i,t-1}) \quad , \qquad (3)$$

where $r_{i,t}$ denotes the contractual interest rate of loan i in year t. The impact factor b_i determines the magnitude of this shock and is calibrated for each debtor group separately: We chose b_i such that the number of additional defaults due to an interest rate reset matches the forecast made in Cagan (2008) for the corresponding percentage interest rate step-up and loan-to-value ratio.

In our subsequent simulations we assume an interest step-up in year three by 1% for all Alt-A loans and by 2% for all Subprime loans. Together with the assumed impact factors (see Table 3) this assumption implies higher downgrade and also higher default probabilities in year 3 as shown in the stressed one-year migration matrix given in Panel B of Table 2. Applying this stressed migration matrix in the year of the interest rate freeze, significantly increases multi-year default probabilities even though migration probabilities are assumed to return to the 'normal' case in the following years.

For simplicity we consider interest only mortgages, i.e. in each year, in which the mortgage stays in one of the five debtor categories, only interest payments are made whereas the total nominal value is due at final maturity.[13] The interest rate consists of a variable base rate and a spread component. The amount of the spread is determined by the debtor category of the mortgage at the beginning of the transaction. In case of default we assume the real estate to be sold in a

[13]According to *Ashcraft/Schuermann*(2008) only about 20 percent of mortgage loans in MBS pools are interest only. Other loans mostly pay annuities, which mainly comprise interest payments in the first years, and may even contain a grace period of two to five years in which only interest is paid. Since we only consider a seven year RMBS transaction, our assumption seems to be reasonable.

distress sale with a discount of q percent of the current market value. Given the HPI of date t defined as:

$$\begin{aligned} HPI_{k,0} &= 1 \\ HPI_{k,t} &= \prod_{\tau=1}^{t}(1+\Delta HPI_{k,\tau}) \end{aligned} \tag{4}$$

the percentage loss given default of a mortgage in region k at date t is then derived as

$$LGD_{i,k,t} = 1 - \underbrace{(1-q)}_{\text{percentage proceed in distressed sale}} \cdot \underbrace{\frac{1}{LTV} HPI_{k,t}}_{\text{1/LTV at date } t} \tag{5}$$

Thus, we implicitly account for a positive correlation between foreclosure rates and loss given defaults. Due to the definition of our latent variable, a decline in HPI triggers higher default rates and at the same time implies higher loss given defaults.

Having derived the annual portfolio cash flows we can calculate the sum of discounted cash flows net of any transaction costs (DC_n) for each simulation run n:

$$DC_n = \sum_{t=1}^{T} \frac{CF_{n,t}}{(1+r_f)^t} - PV(TC) \tag{6}$$

where $CF_{n,t}$ denotes the portfolio cashflow at date t and $PV(TC)$ the present value of annual transaction costs. Dividing this figure by the initial portfolio volume we get a proxy for the relative value of the underlying portfolio. We perform 10,000 simulation runs and determine the distribution of this portfolio value as well as several statistics like mean, standard deviation and 99%-quantile.

Given the simulated portfolio cash flows at each annual payment date we subsequently derive tranche payments. We assume that all losses (interest and principal) are first covered by the excess spread of the transaction, i.e. the difference between the interest income from the underlying portfolio and the interest payments to the rated tranches net of transaction costs, and then by reducing the nominal value of the equity tranche. Further, we assume the existence of a reserve account which means that if the excess spread of one period is not wiped out by period losses, the excess cashflow is collected in this account earning the risk-free rate and providing a cushion for future losses.[14] The holder of the equity tranche does not receive any payments until maturity when he receives the remaining cashflow of the transaction. If the equity tranche has been reduced to zero due to previous losses, the face value and subsequently the interest claim of the lowest rated tranche is reduced to cover the losses. If this tranche claim has already been reduced to zero, the next tranche is used to cover the losses, etc.

3.2 Sample Transactions

Throughout our analysis we consider two illustrative sample portfolios: one representing a typical subprime mortgage portfolio and another representing the US mortgage market as a whole. The former only includes Alt-A and subprime mortgage loans. The latter is more diversified with the majority (60%) being prime mortgage loans. 25% fall in the Alt-A category and five percent each in the three subprime classes giving a total subprime share of 15% for the portfolio which roughly resembles the subprime portion in the US mortgage market. The explicit portfolio compositions are given in Table 3 in the appendix.

Each mortgage is assumed to pay the risk-free rate, which is assumed to be constant at 4%, plus a spread ranging between 150 and 400 basis points which is determined by the debtor category as shown in Table 3. Further we assume that mortgage loans with an initial subprime (Alt-A) rating include an interest rate step-up of 2% (1%) after two years, i.e. all spreads are increased by 200 bps (100 bps) after this initial period.[15] The long-term trend is house prices is assumed to

[14]According to *Ashcraft/Schuermann* (2008) excess spread is at least captured for the first three to five years of a RMBS deal, which justifies the assumption of a reserve account.

[15]This step-up is assumed to be fixed at loan origination and is independent of possible downward migrations until the reset date.

be $c = 3\%$, the loan-to-value ratio at origin is 90% for each mortgage[16] and the discount in case of a distressed sale is $q = 30\%$.[17] Additionally we assume that mortgages are equally distributed across five different regions.

First we simulate payments for both portfolios in the benchmark case, i.e. without any crisis. Thus, in year 3 the latent variable $L_{i,k,t}$ for each loan is stressed by the impact factor of the current debtor category times the scheduled interest rate step-up which causes an increase in expected cumulative default rates as shown in Panel B of Table 2. Since there is no step-up for prime loans, the expected default rates of these loans stay the same.

Columns 3 in Tables 4 and 5 present some statistics describing the portfolios' repayment distribution. For both, the subprime as well as and the US mortgage market portfolio the expected value of discounted cash flows (net of transaction costs) clearly exceeds the nominal value in the benchmark case. In both cases the exceedance equals more than two times the standard deviation of discounted cash flows. For the subprime portfolio the average value of the discounted portfolio payment stream after deducting all fees is 113.41% of the initial face value. Since we use the risk-free rate for discounting, this number corresponds to a yearly average premium of 1.9% on top of the risk-free rate. The standard deviation is 4.94% over seven years. In case of the representative portfolio the expected discounted value in the benchmark case is 105.52%, yielding an average premium of 0.8% p.a., with a standard deviation of 2.37% over seven years.

Subsequently, we simulate payments of two residential mortgage backed security (RMBS) transactions which are backed by the sample portfolios and have

[16] *Gerardi et al.* (2007) report a mean LTV ratio of 83% and a median of 90% in the last three years.

[17] *Pennington-Cross* (2004) provides a survey study on the discount in case of a distressed sale and finds that foreclosed property appreciates on average 22% less than the area average appreciation rate. Given that foreclosures also lead to additional costs, we will assume a discount of 30% on the current market value in our simulation analysis. *Cagan* (2007) also states that foreclosure discounts of 30% are quite usual.

a maturity of seven years. We assume that four rated tranches AAA, AA, A and BBB are issued that earn the usual market spreads as shown in Table 3. Additionally, we assume annual transaction costs of 1%, which are paid before any interest payment to the tranches.

We calibrate tranche sizes such that their default probabilities in the benchmark scenario are roughly in line with the historical averages given by Standard & Poor's for the respective rating classes and a seven year maturity. The resulting tranche sizes are also shown in Tables 4 and 5.[18] The calibrated tranche structures are in line with typical RMBS structures observed in the market.[19]

4 Analysis of Mortgage Crisis

4.1 Crisis Scenario

Having calibrated our model to the benchmark case we now turn to modelling the crisis scenario. In particular we assume that the sample transaction was set-up two years ago (e.g. in 2006) with tranche sizes as derived before. Further we assume that in the first two years we observe two subsequent negative realisations of the nationwide factor together with mixed house price trends in the five different regions. The specific assumptions concerning the macro-factor realisations are given in Table 1. Comparing the derived values for the regional house price indices after two years, our assumptions seem to capture the current subprime crisis quite well. In region 1 we see a strong decline in the HPI of more than 20 percent within two years, but we also observe nearly stable or even increasing HPIs in other regions. Figure 1 shows the expected average house price development over seven years that is implied by our assumptions.

[18] A slightly different tranche structure would arise when using the expected loss rating from Moody's. But it should be noted that tranches with the same rating have nearly the same expected losses in our benchmark case.

[19] see *Ashcraft/Schuermann* 2008

Table 1: *Definition of the Crisis Scenario*

Columns 2 and 3 depict the assumed nationwide and regional factor realisations in year 1 and 2. Columns 4 and 5 give the corresponding regional HPI after one and two years. The last three columns show the mean of the distribution for the third year, the corresponding expected change in regional house prices and the corresponding expected HPI after three years.

Factor	Year 1	Year 2	HPI_1	HPI_2	μ_3	$E(\Delta HPI_3)$	$E[HPI_3]$
M	-2	-2	*0.97*	*0.94*	-1	*-0.1%*	*0.94*
B_1	-2	-2	0.88	0.77	-1	-4.6%	0.73
B_2	-1	-1	0.92	0.85	-0.5	-2.4%	0.83
B_3	0	0	0.97	0.93	0	-0.1%	0.93
B_4	1	1	1.01	1.02	0.5	2.1%	1.04
B_5	2	2	1.06	1.12	1	4.3%	1.16

Given the realisations of the macro-factors in the first two years, we again simulate portfolio cash flows and tranche payments. Due to the assumed autocorrelation, the negative trend (as well as the positive trend) in regional house price indices affect the realisations of the latent variable in the following years. For illustration the mean of the macro factors for the third year as well as the corresponding expected cumulative HPI up to year 3 are shown in Table 1.

For the two portfolio settings the resulting portfolio and tranche characteristics given this crisis scenario are depicted in Tables 4 and 5. The crisis leads to a sharp drop in the expected level of the national house price index after seven years from 1.23 to 1.03 (appr. 16%) which translates into significantly lower discounted cash flows. In fact, our simulation results show that the house price index and the portfolio cashflows are positively correlated with 0.8. Whereas the expected discounted cashflow of the subprime portfolio stays above the nominal issuance volume, the expected discounted cashflow of the US mortgage market portfolio drops below $ 100 million indicating that there is no premium left for originator. Figures 2 and 3 show that the crisis causes a severe first order stochastic dominance deterioration in the distributions of discounted cashflows of both portfolios.

The shift in the distribution of discounted cashflows causes all tranches to exhibit much higher default probabilities and expected losses such that it would be necessary to downgrade them several rating notches. For example the AAA tranches of both RMBS would now receive a BBB rating and the BBB tranches would only get CCC+ ratings. In general, the effect of the crisis on the tranches' risk characteristics is slightly stronger for the US mortgage market portfolio. Here the default probabilities and expected losses are roughly 15 times higher than before whereas for the subprime portfolio the numbers only increase by a factor of about 12.

The main part of the decrease in expected payments is allocated to the equity tranche. For the subprime portfolio the expected present value of equity tranche payments decreases by \$ 10.1 million which corresponds to about 91% of the total portfolio decrease of \$ 11.1 million. For the US portfolio the situation is similar. The expected discounted cashflow to the equity tranche decreases by \$ 4.7 million - about 76% of the total portfolio decrease. Nevertheless the decline in expected discounted portfolio cashflows is rather moderate, only 10% for the subprime portfolio and 6% for the US mortgage marekt portfolio. This is due to the fact that both portfolios are assumed to be well diversified concerning the regional allocation with some regions expecting still a positive house price trend.

4.2 The Impact of an Interest Rate Freeze

Departing from the crisis scenario described in the previous subsection we now analyse the effects of an interest rate freeze on both sample RMBS. In particular, we assume that the interest step-up after two years is cancelled such that all mortgage loans continue to pay the low initial rates. The direct effect of this freeze will be twofold. On the one hand, lower interest rates reduce the portfolio payment claims and, thus, negatively affect payments to the issued tranches. On the other hand, an interest rate freeze takes pressure from borrowers such that there will be less foreclosures which in turn lowers the foreclosure costs. We study this trade-off of direct effects first.

In the second part of this section we investigate different scenarios of house price reactions following the freeze. In fact the lower number of foreclosures may have a positive feedback effect on house prices. We find that a relatively moderate stabilization of house prices renders the net effect on most tranches positive.

4.2.1 Pure Interest Rate Freeze

As noted before, the interest rate freeze does not only lead to less interest payments from the portfolio, but has also a positive effect on the portfolio default rate. In particular, there are less downward migrations and also less defaults in the year of the scheduled interest rate step-up because the stress component of all Alt-A and subprime debtors in year $t = 3$ disappears (see equation 2) due to unchanged payment obligations. Thus, the cumulative default rates as shown in Panel A of Table 2 are realised on average as compared to the higher default probabilities in the benchmark case as depicted in Panel B of the same Table. In effect, by avoiding downgrades the interest rate freeze does not only decrease default rates after three years but also results in lower cumulative default probabilities in subsequent years.

We simulate portfolio repayments and tranche characteristics for this scenario. The results are shown in Figures 2 and 3 and Tables 4 and 5. Although the interest rate freeze lowers the default rate of the underlying portfolio, this positive effect is not enough to compensate for the decline in interest payments from years three to seven. In fact, the freeze leads to a deterioration in the distributions of discounted cashflows. For the US mortgage market portfolio we see a first order stochastic dominance deterioration with the expected discounted portfolio cashflow being further reduced by $ 1 million. Also all RMBS tranches further deteriorate as compared to the crisis scenario. The former AAA tranche which would have to be downgraded to BBB due to the crisis now only receives a BBB- rating. Again a substantial share of the additional loss is allocated to the equity tranche (appr. 41%).

For the subprime portfolio we see an additional loss of $ 2.5 million due to the interest rate freeze and also a first-order stochastic dominance deterioration in the distribution. In accordance with this observation all RMBS tranches suffer additional losses from the interest rate freeze. Here the equity tranche takes 84% of the additional expected loss.

4.2.2 Interest Rate Freeze and Positive Feedback Effect

As shown in the previous subsection, the first round effects of an interest rate freeze are not sufficient to attenuate the crisis but lead to a further deterioration. Therefore we now also take second round effects into account. In particular, we assume that the decrease in foreclosure rates will take pressure from the housing market such that the negative trend in the regional house prices is mitigated or even reversed.[20] This in turn will lead to a positive effect on foreclosure rates.

In the previous scenarios, persistent trends in the house price index are implemented by positive autocorrelation in the house price index. Therefore the downturn in years one and two leads to an expected downturn in year three, i.e. the conditional mean of the variable describing changes in the house price index is negative. Combined with the regional components, this yields expected house price changes of -4.6%, -2.4%,-0.1%,2.1% and 4.3% for the respective regions, nationwide -0.1% (see Table 1) which is substantially below the long-term mean of 3%. We now assume the negative trend in nationwide house prices to be stopped

[20]Cagan (2007) finds significant additional foreclosure discounts in regions with high foreclosure rates. This indicates limited buyer capacities unable to absorb the excess supply without additional discounts.

and further that also the negative regional trend components in regions 1 and 2 are offset by the interest intervention. This gives expected house price changes equal to the long-term trend of 3% for regions 1, 2 and 3 and an expected increase of 5.2% respectively 7.5% for regions 4 and 5 in year 3. We implement this by ignoring any positive autocorrelation from year two to three in the nationwide factor as well as in regions 1 and 2 which had negative factor realization in year 2. The resulting development of the expected house price index (averaged over the five regions) over seven years is shown in Figure 1.

The results for this scenario are again shown in Figures 2 and 3 and Tables 4 and 5. Due to further feedback effects in subsequent years resetting the house price trends in year three increases the average HPI at the end of year seven by appr. 9 percentage points as compared to the crisis scenario, i.e. from 1.03 to 1.12. Consequently, the portfolio value is increased as compared to the previous scenario, which only covers the first round effects without any feedback in the housing market.

For the subprime portfolio the expected discounted cashflow is now only slightly below the value in the crisis scenario without an interest rate freeze. Looking at the portfolio characteristics and the cumulative distribution of discounted cashflows in this positive feedback scenario is only slightly second-order stochastically dominated by the crisis scenario with all lower quantiles being substantially improved. Consequently, all rated RMBS tranches benefit concerning the default probabilities and also the expected losses. Looking at the expected loss, the performance of the AAA-tranche even comes close to the benchmark scenario meaning that no significant downgrade would be necessary (only to AA+) and also concerning the default probability this tranche would now receive a AA- instead of a BBB rating in the crisis scenario. In this case the costs of the interest rate freeze are completely borne by the owner of the FLP, who suffers an additional loss of $ 1.1 million as compared to the crisis scenario.

For the US mortgage market portfolio less interest payments are lost due to the interest rate freeze because in the portfolio 60% of loans are prime mortgage loans, which do not incorporate an interest step-up. Therefore the positive effect of stopping the house price decline even overcompensates the crisis driven losses such that the expected discounted cashflow of the portfolio in this scenario is higher than in the crisis scenario. Also in this portfolio all rated RMBS tranches profit from this situation compared to the crisis scenario. The higher the tranche, the more it benefits. This is due to a steeper distribution of discounted cashflows making high loss rates less probable. Looking at the cumulative repayment distribution we observe a second order stochastic dominance shift when going from the crisis scenario to this scenario. This also means that the probability of small losses increases due to the lower loss coverage by excess interest which results in lower expected repayments for the equity tranche.

Summarizing, our results indicate that an interest rate freeze may help to alleviate the current crisis. Even though RMBS tranche investors loose a significant portion of their loss protection, this deterioration may be overcompensated by improvements in mortgage payments due to lower foreclosure rates and a positive feedback effect in the housing market. For both portfolios we derive positive net effects on all rated RMBS tranches as compared to the crisis scenario. The higher the tranche, the more it improves. Especially the AAA tranche benefits from the rate freeze. Thus, the RMBS market will benefit from an interest rate freeze which can induce positive spill over effects on other markets. In particular, markets for other structured instruments that contain RMBS tranches may stabilize. Especially special investment vehicles backing their commercial paper funding with senior RMBS tranches may recover.

4.3 Robustness Checks

(i) Assumptions concerning House Price Developments

Our previous results depend on several assumptions concerning house price developments which are motivated by empirical findings. When setting up the *crisis scenario* we started from certain assumptions on negative house price changes during the first two years and when discussing the positive feedback effect of an interest rate freeze we made a specific assumption concerning house price stabilization. Naturally, other house price reactions are also possible.

As robustness checks we derive portfolio and tranche repayments for less favorable assumptions concerning house price stabilization. In particular we assume the negative house price trend only to be partially offset by the interest rate freeze. Instead of zero autocorrelation in year three resulting in an expected cumulative increase of 8.7 percentage points in the average HPI compared to the crisis situation, we now assume that only a half (one fourth) of this effect is realised. Figure 1 shows the expected average house price development for these two scenarios. Tables 4 and 5 display the tranche and portfolio characteristics for these additional scenarios.

As can be seen, a relatively moderate stabilization of 4.3 percentage points until year seven of the transaction (*Robustness 1*) is sufficient to leave the outcomes of the lowest rated (BBB) tranche roughly unaffected and improve all higher tranches. In contrast, a stabilization of only 2.1 percentage points (*Robustness 2*) yields a worse performance of all rated tranches than in the crisis scenario, but the effects are smaller for higher rated tranches.

Given these results we conclude that the qualitative results are quite stable towards changes in the assumption of house price stabilization: Due to lower excess spread, the payments to the equity tranche will be reduced the most and due to lower probabilities of high losses the highest rated tranche will profit most from an interest rate freeze.

Since our results might also depend on our assumption about the long-term trend, $c = 3\%$, in the housing market we repeated our simulations with setting this trend component to zero. But also in this setting, the qualitative results stayed the same.

(ii) Assumptions concerning RMBS-Structure

A further assumption which needs to be critically reviewed is our assumption concerning the payment waterfall for our RMBS tranches. In the previous simulations we always assumed the existence of an unlimited reserve account, which means that the holder of the equity tranche only receives payments at final maturity and that at each annual payment dates all excess cashflows are placed in an extra account which can be used to cover future losses. In fact other reserve account specifications are possible, e.g. a capped reserve account, where all excess cashflows above this cap are paid out to the holder of the equity piece periodically, or even a structure without any reserve account, in which the holder of the equity tranche receives the whole excess cashflow at each payment date.

This assumption mainly influences the calibration of tranche sizes in the benchmark case. In particular, a structure without a reserve account will lead to a much smaller AAA tranche a bigger equity tranche. In this case the effect of the interest rate freeze is less pronounced since the tranche sizes are already calibrated to provide a better protection against interest losses. Nevertheless the qualitative effects stay again the same with the difference that now a more moderate house price stabilization is sufficient to make all rated tranches better off than in the pure crisis scenario.

5 Conclusion

The proposed interest rate moratorium for subprime mortgages is an agreement between two parties - the U.S. government and the originating banks - that affects two different third parties: the mortgage debtors and investors in RMBS tranches. The first group will unambiguously profit from an interest rate freeze. Some of their payment obligations are waived, thus they might avoid default. Additionally they benefit from a stabilizing housing market. The effect on RMBS-tranches is more ambiguous. We show that the interest rate freeze significantly decreases the expected value of the portfolio payment stream. Nevertheless the tranche holders might benefit from this action as long as the positive impulse on the housing market is strong enough. The holder of the equity tranche has to bear the costs of this interest rate moratorium but even he may benefit from the interest rate freeze if the loan portfolio is of good quality and if the positive feedback effect in the housing market is strong enough.

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A Tables

Panel A: Standard Case
Credit Curve

t	1	2	3	4	5	6	7
Prime	0.20%	0.52%	0.94%	1.47%	2.07%	2.75%	3.50%
Alt-A	0.50%	1.11%	1.80%	2.57%	3.41%	4.30%	5.23%
Sub1	1.50%	2.98%	4.44%	5.87%	7.29%	8.69%	10.06%
Sub2	2.50%	4.88%	7.15%	9.31%	11.36%	13.32%	15.19%
Sub3	3.50%	6.71%	9.67%	12.41%	14.94%	17.30%	19.51%

Derived One-Year Migration Matrix

Debtor	Prime	Alt-A	Sub1	Sub2	Sub3	D
Prime	88.0%	6.5%	3.0%	1.5%	0.8%	0.2%
Alt-A	9.0%	82.0%	5.0%	2.0%	1.5%	0.5%
Sub1	3.0%	6.0%	82.0%	5.0%	2.5%	1.5%
Sub2	0.5%	2.5%	6.0%	82.0%	6.5%	2.5%
Sub3	0.2%	0.8%	3.0%	7.5%	85.0%	3.5%
D	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

Panel B: Stressed Migration (Due to Interest Rate Step-Up)
Stressed One-Year Migration Matrix in $t = 3$

Rating	Prime	Alt-A	Sub1	Sub2	Sub3	D
Prime	88.00%	6.50%	3.00%	1.50%	0.80%	0.20%
Alt-A	6.80%	81.51%	6.22%	2.63%	2.08%	0.76%
Sub1	0.66%	1.96%	74.44%	10.45%	6.67%	5.82%
Sub2	0.07%	0.58%	1.96%	84.44%	14.25%	8.69%
Sub3	0.03%	0.15%	0.77%	2.65%	85.13%	11.28%
D	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%

Resulting Credit Curve

t	1	2	3	4	5	6	7
Prime	0.20%	0.52%	0.94%	1.47%	2.07%	2.75%	3.50%
Alt-A	0.50%	1.11%	2.81%	3.62%	4.49%	5.41%	6.36%
Sub1	1.50%	2.98%	8.29%	9.82%	11.32%	12.78%	14.2%
Sub2	2.50%	4.88%	12.67%	14.84%	16.89%	18.83%	20.68%
Sub3	3.50%	6.71%	16.36%	19.00%	21.43%	23.69%	25.80%

Table 2: Assumed Credit Curve and One-Year Migration Matrix
Panel A gives the *credit curve* for different debtor groups. Each entry in the credit curve describes the average probability of default for a given initial debtor group and maturity t. The numbers are chosen in accordance with empirical results (see e.g. *Gerardi et al.* 2007). The standard one-year migration matrix is subsequently matched to this credit curve. Panel B displays our assumed stressed migration matrix for year 3. It is assumed that the interest rate step-up causes significant payment shocks which increase the downgrade probabilities of all non-prime loans in year 3. Even though the migration probabilities in the following years return to the normal level, the expected cumulative default probabilities in every subsequent year are increased as shown in the resulting credit curve in Panel B.

	Subprime Portfolio	US Mortgage Market Portfolio	
Portfolio:			
Initial Volume	$ 100,000,000	$ 100,000,000	
Number of Mortgages	500	500	
Regions	5	5	(100 mortgages each)
initial LTV	90%	90%	
Share of			*Spreads (bps)*
Prime	-	60%	150
Alt-A	20%	25%	225
Subprime 1	30%	5%	300
Subprime 2	30%	5%	350
Subprime 3	20%	5%	400
⊘ Interest Rate ($t = 0$)	7.2%	6.0%	
Interest Rate Step-Up *(after 2 Years)*			Impact Factor (b)
Prime	0%	0%	0
Alt-A	1%	1%	15
Subprime 1-3	2%	2%	30
RMBS-Structure:			*Spreads (bps)*
Tranches	AAA	AAA	30
	AA	AA	50
	A	A	80
	BBB	BBB	150
	Equity	Equity	-
Transaction Costs	1% p.a.	1% p.a.	
Maturity	7 years	7 years	

Table 3: Portfolio Characteristics and Model Assumptions
This table present the assumed portfolio compositions of our two sample portfolios as well as the assumed tranche structure. The depicted spreads are paid in addition to the risk-free rate of 4%.

		Benchmark	Crisis	Crisis & Freeze	Crisis & Freeze Positive Feedback	Crisis & Freeze Robustness 1	Crisis & Freeze Robustness 2
Portfolio Characteristics							
Exp. Discounted CF (in $)		113,409,975	102,307,436	99,816,257	101,822,768	100,889,465	100,295,190
% of initial Volume		113.41%	102.31%	99.82%	101.82%	100.89%	100.30%
Standard Deviation		4.94%	4.121%	2.95%	2.23%	2.68%	2.94%
1%-Quantil		97.28%	90.28%	90.64%	94.38%	92.23%	90.89%
Tranche Characteristics							
Rating	Size	*Default Probabilities*					
AAA	90.30%	0.28%	3.45%	4.49%	0.84%	2.30%	3.76%
AA	2.70%	0.68%	7.61%	11.18%	2.64%	6.00%	9.05%
A	2.70%	1.37%	15.69%	25.20%	7.17%	14.50%	20.71%
BBB	2.70%	4.28%	57.40%	66.75%	48.84%	57.14%	62.27%
		Expected Loss					
AAA		0.01%	0.09%	0.10%	0.02%	0.05%	0.09%
AA		0.38%	4.10%	5.65%	1.18%	3.00%	4.64%
A		0.79%	8.81%	13.13%	3.41%	7.41%	10.77%
BBB		2.12%	22.93%	30.29%	13.55%	20.83%	26.12%
Equity Tranche	1.60%						
Exp. Discounted CF (in $)		13,032,922	2,946,739	852,246	1,886,227	1,363,272	1,101,239
(Multiple of Nominal)		(8.15)	(1.84)	(0.53)	(1.18)	(0.85)	(0.69)

Table 4: Subprime Portfolio - Simulation Results

Each column of this table shows the simulation results for a different simulation scenario: The benchmark scenario (without any crisis) the crisis scenario, the crisis scenario together with an interest rate freeze as well as the crisis scenario with an interest rate freeze and an additional positive feedback effect which resets house price trends after 2 years to zero, or lowers positive autocorrelation by a half (robustness 1) and one fourth (robustness 2), respectively. The first lines show some portfolio characteristics - the expected discounted cash flow net of transaction costs, the standard deviation and the 99%-quantile of the discounted cashflows distribution - are presented. The following lines show the default probabilities and expected losses of the rated tranches. Finally the expected discounted cash flow to the equity tranche is depicted.

		Benchmark	Crisis	Crisis & Freeze	Crisis & Freeze Positive Feedback	Crisis & Freeze Robustness 1	Crisis & Freeze Robustness 2
Portfolio Characteristics							
Exp. Discounted CF (in $)		105,518,706	99,379,076	98,355,172	99,992,374	99,243,656	98,755,055
% of initial Volume		105.52%	99.38%	98.36%	99.99%	99.24%	98.76%
Standard Deviation		2.37%	2.70%	2.43%	1.72%	2.14%	2.39%
1%-Quantil		96.89%	90.92%	90.47%	93.97%	92.04%	90.79%
Tranche Characteristics							
Rating	Size	*Default Probabilities*					
AAA	90.20%	0.27%	3.98%	5.31%	0.93%	2.77%	4.31%
AA	2.90%	0.69%	11.94%	16.25%	3.97%	8.88%	13.24%
A	1.80%	1.34%	21.63%	30.74%	9.00%	18.27%	25.05%
BBB	3.40%	4.46%	61.75%	81.47%	52.53%	67.49%	74.61%
		Expected Loss					
AAA		0.01%	0.08%	0.11%	0.02%	0.05%	0.09%
AA		0.35%	5.64%	7.73%	1.63%	4.08%	6.28%
A		0.75%	12.52%	17.45%	4.63%	9.93%	14.17%
BBB		1.96%	29.23%	40.68%	17.93%	28.37%	34.88%
Equity Tranche	1.70%						
Exp. Discounted CF (in $)		5,217,919	540,557	118,113	404,356	247,985	181,996
(Multiple of Nominal)		(3.07)	(0.32)	(0.07)	(0.24)	(0.15)	(0.11)

Table 5: US Mortgage Market Portfolio - Simulation Results

This table present the same simulation results as in Table 4 but now for the US Mortgage Market portfolio instead of the Subprime Portfolio.

B Figures

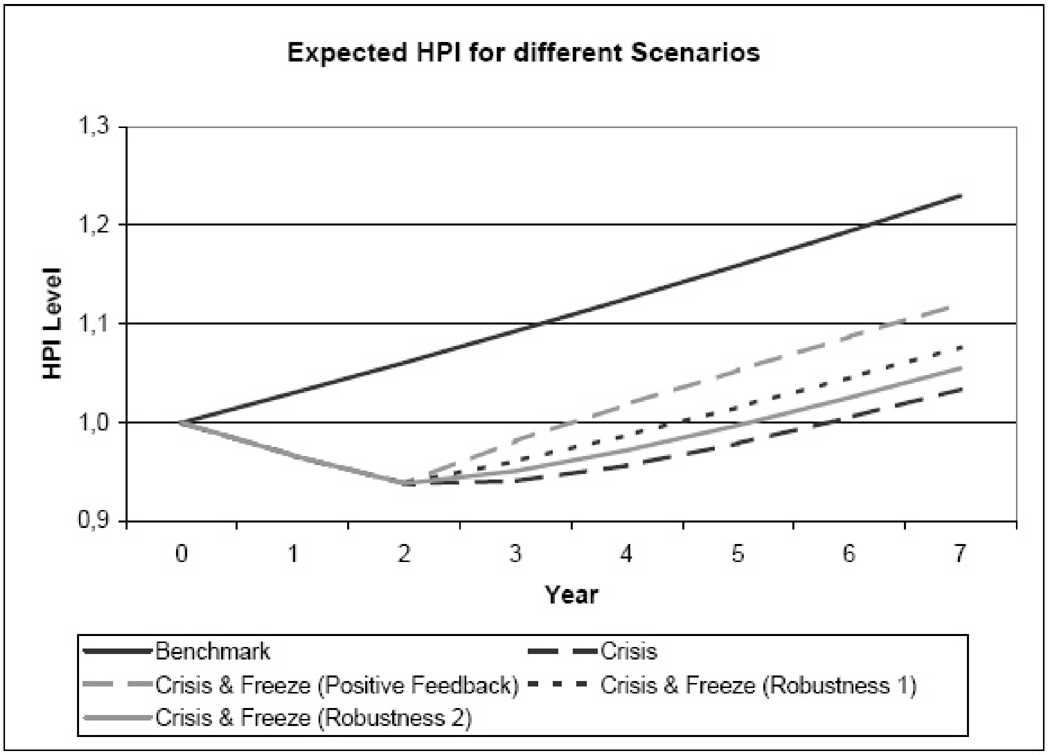

Figure 1: This figure shows the expected development of the House Price Index (HPI) averaged over our five regions for different simulation scenarios: In the benchmark case a long-term house price growth of 3% p.a. is assumed. The crisis scenario is set by fixing macrofactor realisations in the first two years (see Table 1) which cause a severe decline in house prices. Departing from this crisis scenario the positive feedback scenario assumes that there is no autocorrelation between years 2 and 3, such that house prices recover faster from the crisis. The scenarios Robustness 1 and 2 assume a weaker house price stabilization as the autocorrelation is only reduced by a half or one fourth, respectively.

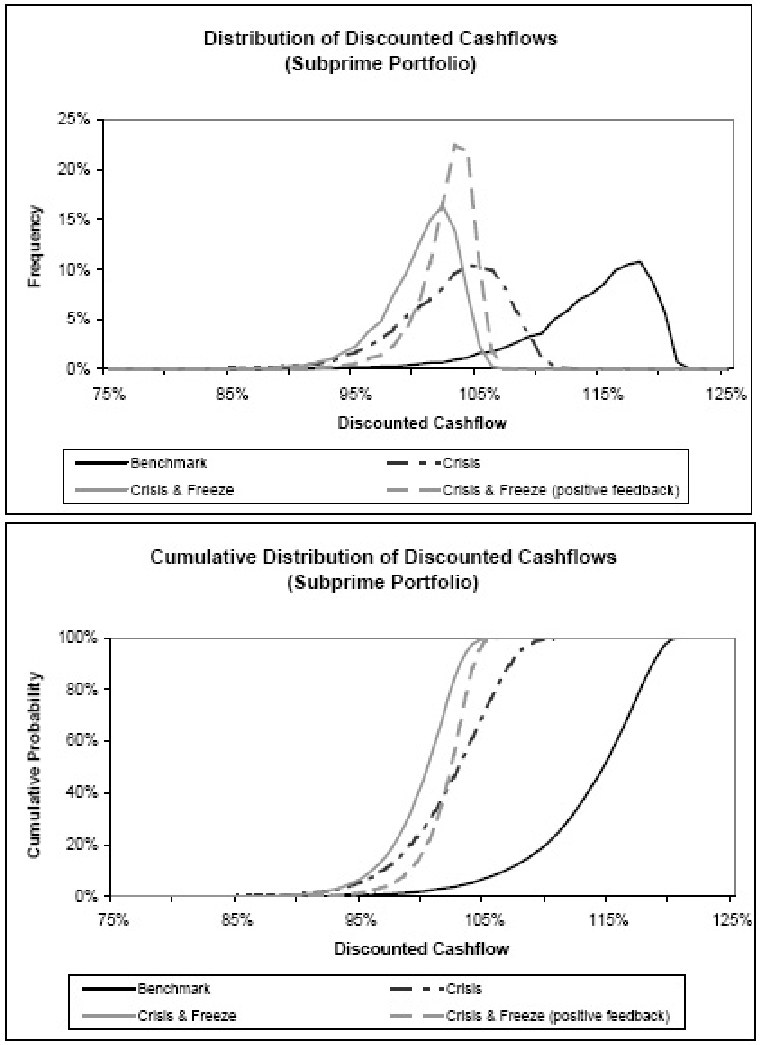

Figure 2: This figure shows the distributions of discounted cash flows (in percent of initial portfolio volume) for the subprime portfolio and four different simulation scenarios.

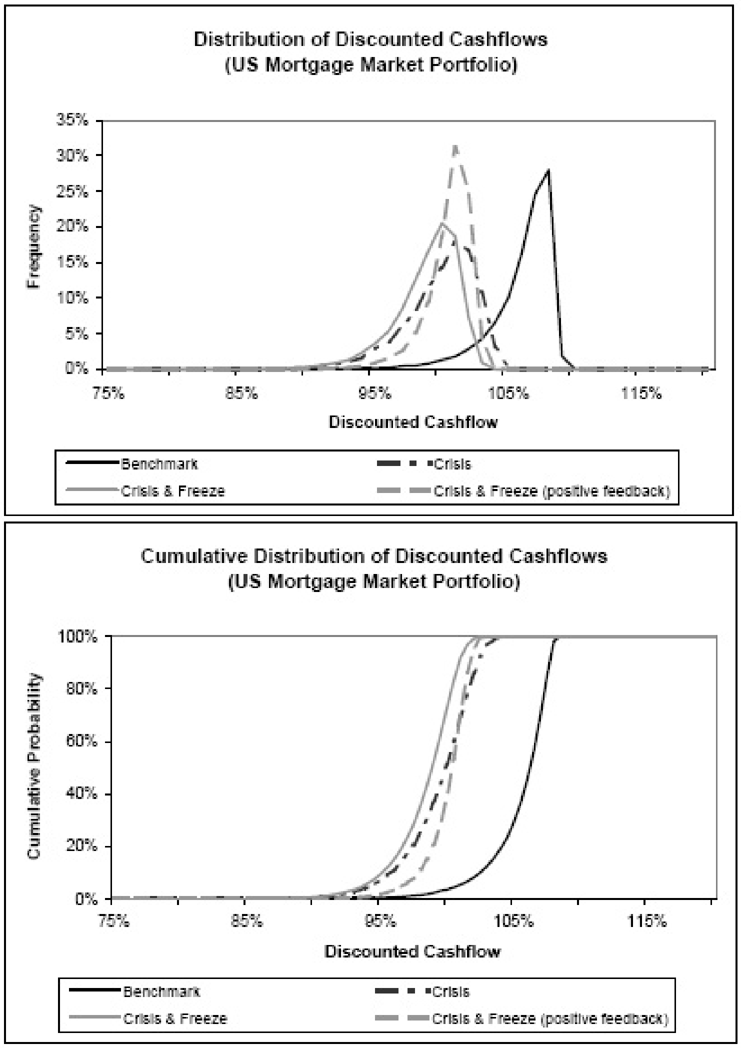

Figure 3: This figure shows the distributions of discounted cash flows (in percent of initial portfolio volume) for the US mortgage market portfolio and four different simulation scenarios.