Multiple Tranches, Information Asymmetry and the Impediments to Mortgage Renegotiation

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Abstract

This paper examines how the creation of asset-backed security tranches disperses ownership of an asset–the pool of mortgages–subsequently impeding renegotiation of the underlying delinquent loans. I describe how multiplicity of tranches worsens the agency problem between a residential mortgage servicer and the mortgage-backed security deal sponsor, leading to a sub-optimal rate of loan modification. Using within-deal variation in the number and structure of tranches, I find that delinquent loans in pools collateralizing fewer tranches are more likely to be renegotiated. The results provide evidence for one channel through which mortgage securitization inhibited loan modifications during the Great Recession.

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1 Introduction

The years prior to the financial crisis witnessed a large increase in the origination of household credit, and mortgage debt in particular, followed by a rapid and widespread increase in delinquencies (Mayer et al. (2009), Palmer (2015)). Agency problems in the origination of mortgage loans were identified as one of the many culprits (Mian and Sufi (2009), Keys et al. (2010a), Keys et al. (2010b), Purnanandam (2011)). However, the design of the mortgage markets suggests that there exist problems of information asymmetry between market participants even after credit has been extended.

This paper examines one specific post-origination agency problem in the mortgage market and its effect on household outcomes. An inherent feature of private-label residential mortgage backed securities was the creation of multiple tranches, or bonds, collateralized by a single asset—a pool of mortgages. I ask whether the resulting dispersion of collateral ownership ultimately affected the rate at which individual mortgages in the pool were renegotiated upon becoming delinquent.

As Ganong and Noel (2017) and Agarwal et al. (2017) show, mortgage modifications helped lift liquidity constraints on borrowers, allowing them to better smooth consumption and avoid foreclosure. While mortgage delinquencies have subsided, the agency problems discussed in this paper remain. Additionally, the secondary mortgage market is seeing the reintroduction of complex products which create multiple tranches of derivatives on underlying Fannie Mae and Freddie Mac mortgage pools (see FHFA (2015) for a description of Fannie Mae and Freddie Mac's Credit Risk Transfer Program).

My results show that delinquent mortgages in securitized loan pools collateralizing a higher number of residential mortgage-backed security (RMBS) tranches are renegotiated with a lower probability compared to those in loan pools collateralizing fewer tranches. These results cannot be explained by characteristics of the borrower or the mortgages, local economic activity and features of the RMBS deal (for e.g. initial subordination levels of the tranches, or time-varying practices of the mortgage servicer, among others). While Piskorski et al. (2010) and Agarwal et al. (2011) document that securitized loans were modified at a lower rate than those that were held on banks' balance sheets they remain agnostic about the specific mechanism behind their estimated effects.[1]

[1] Kruger (2017) establishes a similar result, and further concludes that differences in pooling and servicing agreements explain only a small portion of the observed differences between securitized and on-balance sheet loans. Adelino

My results explain about a third of the effect of securitization captured by Piskorski et al. (2010).

I begin by building a simple conceptual framework to highlight how the creation of multiple tranches interacts with the principal-agent relationship between the RMBS deal sponsor (who represents the interest of the bond-holders and structures the deal) and the mortgage servicer (who monitors and manages the loan pools post-origination). The servicer has private information about the optimal amount of loan modification, with loan modifications being costly to implement. The deal sponsor designs a contract to elicit the servicer's private information.

The contract also creates a role for multiple investors who, ex-post, can coordinate to audit the servicer (Thompson (2011)). This audit mechanism (Townsend (1979)) acts as a disciplining device, tightening the servicer's incentive compatibility constraint. I assume that the larger the number of tranches, the more costly it is to audit the servicer, and consequently, the lower is the probability that the servicer is audited.[2] This captures, in a reduced form manner, the coordination frictions in the spirit of Diamond (1984) and Holmstrom (1982). The weaker the ability to discipline the servicer, the higher the rents that need to be conceded to him. If the concession needed to induce truth-telling on the part of the servicer is too high, the sponsor may provide insufficient incentives, which leads to below optimal rates of loan modification. This discussion gives rise to the main hypothesis that the higher the multiplicity of tranches, the lower the probability that a delinquent loan is renegotiated.

I test this hypothesis on a sample of delinquent residential mortgages in private-label securitizations. There are two challenges to identifying the effect of multiple tranches on loan renegotiation. First, one needs to construct a measure of the multiplicity of claim-holders to a particular loan pool. Secondly, there are several elements of the structure of an RMBS deal which may affect outcomes of delinquent mortgages, yet are either unobservable, or pose a challenge to quantify. As highlighted by the framework, the contracting between the deal sponsor and the servicer is an important determinant of loan modifications. While it is challenging to codify the contents of these contracts, they must be accounted for in the empirical methodology.[3]

et al. (2013a), Adelino et al. (2013c) do not find an effect of securitization on mortgage renegotiation.

[2] A sample of excerpts (included in Internet Appendix Section C) from Pooling and Servicing Agreements (i.e., the contract between the sponsor and the servicer) show that in many cases, a certain number of bond-holders need to be in agreement in order to amend the document, or change the servicer. Thompson (2011) makes a similar observation.

[3] Other features of the deal may also influence the rate of loan modification. For example, different deals have varying levels of credit enhancements.

The first challenge is overcome by using two measures of tranche multiplicity. I use the data to determine a mapping between the loan pools of a mortgage backed securitization deal and the tranches that the loan pools collateralize. The first measure simply counts up the tranches that have claims to a particular loan pool. The second measure is based on the Herfindahl Hirschman Index methodology and varies on the interval $(0, 1]$.[4] This measure aims to take into account the relative sizes of the tranches that are associated with a particular loan pool. It captures more of the observed variation in the structure of RMBS tranches.

I overcome the second challenge by using deal fixed effects to control for all deal-level unobservables that stay constant over time. Thus, identification is obtained from comparing loans in a pool that collateralized few tranches to observably identical loans in another pool—within the same deal—that collateralized many tranches. Note that the contract that governs the incentives of the servicer is in place at the deal level. To the extent that this contract does not vary significantly over time, controlling for the deal fixed effects allows me to control for the contents of this contract. Additionally, I am able to use a servicer fixed effect to control for all servicer-specific unobservables (for e.g. servicer's infrastructure, competence, size, etc.) that may influence the probability of loan modification. Further tests are performed to mitigate concerns that omitted variables—and unobserved loan quality in particular—are driving the results.

First, consistent with the predictions of the framework, I find that a higher number of tranches predicts a lower probability of loan modification, conditional on a mortgage being 60+ days delinquent. A one standard deviation increase in the count of tranches that have claims to a particular loan pool predicts a 91 bps lower probability of loan modification. Once I use the HHI based measure, I find that moving from the 25th to the 75th percentile of this measure (i.e., decreasing multiplicity) predicts a 120 bps increase in the probability of loan modification.[5] One can draw a parallel between these results and those of Piskorski et al. (2010) and Agarwal et al. (2011). An unsecuritized loan held on a bank's balance sheet would correspond to one in a loan pool collateralizing a single tranche. These authors find that loans on banks' balance sheets have lower foreclosure rates and higher modification rates compared to securitized loans. My results corroborate their

[4] Sufi (2007) uses a similar approach in his study of syndicated loans.

[5] These results are confirmed in a proportional hazard rate specification as well. Moreover, I find that the estimated effect is stronger when I restrict the sample to mortgages which did not have complex features (Amromin et al. (2018)) such as Negative Amortization or Interest Only payments.

evidence by showing that a loan pool collateralizing fewer tranches was more likely to see its loans modified.

Often the servicer has a significant amount of discretion over how the terms of the mortgage might be changed. The conceptual framework lends some insight into how the servicer's choice of modification type (conditional on deciding to renegotiate the loan) will be affected by the multiplicity of tranches. The larger the number of tranches, the more likely the servicer is to implement a loan modification that is beneficial to him while being potentially harmful to borrowers and investors. I focus on two dimensions of the mortgage contract which are most salient to borrowers. Specifically, I hypothesize that higher multiplicity will be associated with more aggressive use of increases in the mortgage balance (which increases the base of the servicers' fee, but increases the probability of negative equity). A priori, the effect of multiplicity on decreases in the mortgage's monthly payment is ambiguous.[6] There is weak evidence for this hypothesis suggesting that the effect of multiplicity manifests itself largely through the servicer's decision to renegotiate or not.

In summation, the results show that agency problems in the intermediation and post-origination monitoring of mortgage debt impede renegotiation of delinquent loans. Failure to renegotiate loans and lower monthly payments does not relax a borrower's liquidity constraint, leaving him worse off. Korgaonkar (2017) and Maturana (2017) suggest that such frictions also prevent investors from realizing gains from renegotiation, particularly when collateral values have declined substantially.[7] The originate-to-distribute model continues to be prevalent in the U.S. mortgage market, and so do the agency problems that arise with it. Understanding potential frictions in the system contributes to the discussion on how best to design U.S. mortgage markets so as to maximise welfare in times of rising delinquency rates.

My work relates to a few different strands of the existing literature. The literature on agency problems in mortgage securitization begins with an examination of how the originate-to-distribute model of lending affected incentives to screen borrowers, and how it affected the subsequent performance of the originated loans (Keys et al. (2010b), Purnanandam (2011)). Others focused the

[6] Eberly and Krishnamurthy (2014), Korgaonkar (2017) and Ganong and Noel (2017) describe how modifications that reduced monthly payments were most helpful to delinquent borrowers in the recent financial crisis. Haughwout et al. (2016) shows that modifications that increased the mortgage balance were not particularly useful in staving off foreclosure.

[7] To be clear; Korgaonkar (2017) shows that while gains to investors were limited on average, he also documents the presence of positive gains for high loan-to-value ratio mortgages and mortgages in MSAs experiencing substantial declines in house prices.

analysis on the role that various entities played in the structuring of mortgage-backed securities, and whether the contractual arrangements between them gave rise to suboptimal lending (Demiroglu and James (2012), Jiang et al. (2014)).

The literature then considered whether the originate-to-distribute model of lending had any impact on the way mortgage delinquencies were resolved. Agarwal et al. (2011), Piskorski et al. (2010), Adelino et al. (2013c) and Adelino et al. (2013b) examine whether delinquent loans in securitized pools were modified at a different rate compared to those that were held on banks' balance sheets. While they predominantly find that securitized loans were less likely to be modified, they remain agnostic on the specific channel through which this occurred. Others examined specific mechanisms at play; such as variation in Pooling and Servicing Agreements (Kruger (2017)), or the senior-subordinated structure of private-label residential MBS (Huang and Nadauld (2017)). My paper corroborates the evidence of the earlier literature and provides evidence of an additional mechanism through which the effects of securitization manifest themselves.

This paper also complements a growing theoretical literature on the misalignment of post-origination incentives in the residential mortgage market. Mooradian and Pichler (2016) characterize the optimal contract between the servicer and a MBS investor and the corresponding equilibrium outcome. They show how the contract changes with the degree of diversification in the mortgage pool. Kuong and Zeng (2017) study the interaction between the MBS security design and the contract between the deal sponsor and the servicer. They conclude that deal sponsors commit to higher foreclosure rates to signal the quality of the junior tranche that they retain in the model. My paper argues that renegotiation was below the optimal level due to dispersed ownership of the underlying collateral.

2 Background

I begin by describing the relevant features of mortgage securitization and by discussing the agents on whom the analysis will focus. A securitization deal involves the collection of many individual mortgage loans into mortgage pools. The mortgage pools are eventually held by the securitization trust. A deal sponsor incorporates the securitization trust, which funds the purchase of the loan pools by issuing rated residential mortgage backed securities (RMBS).[8]

2.1 Multiple tranches in residential MBS

Creating residential mortgage backed securities involves creating multiple claims to the cash flows from an underlying pool of loan collateral. A securitization transaction typically involves two or more loan pools, which provide the underlying collateral. Figure 1 diagrammatically depicts a typical Residential Mortgage Backed Security transaction. This particular transaction is the MASTR Adjustable Rate Mortgages Trust 2004-11. It was an Alt-A deal of size $709 million dollars.

As can be seen in Figure 1, there are two loan pools underlying this deal. The blue boxes denote the AAA rated tranches in this deal. The tranches denoted with "1-A" are collateralized exclusively by loan pool 1. The tranches denoted by "2-A" are collateralized exclusively by loan pool 2. The two groups of AAA rated securities depicted are different on two dimensions. Firstly, there is variation in the number of tranches in each stack. Secondly, there is variation in the size of each tranche relative to its stack. For example, the largest tranche in the 1-A stack, 1-A-1, is about 50% of the size of the stack, while 2-A-1 is about 90% of the size its stack. The tranches in green are collateralized by both loan pools.

Here, I also note that the structuring of mortgage-backed securities induces complexities beyond increasing the number of claims to the underlying collateral. Namely, it establishes the priority with which each tranche receives cash flows from the loan pools. In Section 7 I show that the effect of multiplicity of tranches is orthogonal to this seniority structure of the MBS.

2.2 Servicer

The sponsor appoints a servicer at the inception of the deal to manage the cash flows from the loans. Securitization deals are often structured as Real Estate Mortgage Investment Conduits (REMICs) to take advantage of the tax benefits that come with such an arrangement. To receive these benefits, the deal sponsor cannot actively manage the loan collateral. Thus, he appoints a mortgage servicer to do so. For example, the servicer in the deal depicted in Figure 1 was Wells Fargo.

[8]The securitization trust and the deal sponsor can be separate entities. To simplify the analysis, I will assume they are the same entity. The sponsor can be thought of as a representative of the disparate group of RMBS investors.

The primary role of the servicer involves little of his own discretion. He receives interest and principal from mortgage borrowers and allocates them to the tranches as per their seniority. However, the servicer has to call upon his discretion to manage mortgages that have become delinquent; that is, when the borrower misses monthly payments.

If a borrower stops making mortgage payments, the servicer has to step in to advance these amounts to the bond-holders and prevent disruptions in the cash flow to the tranches. Such advances are the major cost to the servicers and may be recovered if the delinquency cures, or if the mortgage is liquidated. A servicer who has made advances has a senior claim to any cash flows from a cured mortgage post-delinquency, or from any liquidation proceeds. Therefore, in effect, advances constitute an interest-free loan made from the servicer to the MBS bond-holders.

If the borrower continues to remain delinquent, the servicer has to determine whether to foreclose upon the borrower or renegotiate the mortgage. Alternatively, the servicer can simply wait for the borrower to "self-cure". The servicer may have significant leeway in deciding how the terms of the mortgage are to be altered (e.g., change in interest rate, principal balance, term to maturity, etc.).

The servicer and the sponsor sign a contract called the Pooling and Servicing Agreement (PSA) which describes the servicing principles, the servicer compensation, and any limitations to the servicer's discretion to renegotiate loans.[9]

The conceptual framework that follows narrows the focus onto two key features of this setting. Firstly, there exists, due to institutional reasons and prevailing securities law, a separation of ownership (tranche-holders) and control (mortgage servicer) of the underlying collateral pool. Secondly, there are not one but multiple "owners" of a particular pool of underlying collateral.

3 Conceptual framework

The conceptual framework describes how multiplicity of tranches worsens an agency problem between the sponsor and the servicer, thus lowering the likelihood that a delinquent mortgage gets

[9]Note that the trust is established by the deal sponsor, and the PSA is in place at the closing of the RMBS deal. Broadly speaking the PSA contains general guidelines and servicing principles to be followed, a description of what the agent may or may not do in certain situations, and an outline of the compensation scheme. Often there may be multiple servicers appointed under a single deal to manage different sets of loans. There are, to my knowledge, only two studies that document the heterogeneity across PSAs in Subprime RMBS deals. Hunt (2009) documents the contents of 65 PSAs. Kruger (2017) considers the contents of a sample of 37 PSAs to understand whether they impede loan modifications. He finds that they do not explain a substantial amount of the difference between the rate of modification between securitized loans and loans held on banks' balance sheets.

renegotiated.

3.1 Setup

I model a pool of mortgages (a continuum of loans with measure 1) that have become seriously delinquent, i.e., the borrower has missed two or more monthly payments. For each mortgage in the pool, let V denote the expected value of the mortgage if it is not renegotiated. Let M represent the expected value of the loan if it is renegotiated.[10] To simplify the analysis, I will assume that $M > V$.[11]

I model the interaction between the deal sponsor (principal) and the mortgage servicer (agent). I assume that there is no information asymmetry between the deal sponsor and investors. The sponsor and investors are aligned in this regard. The sponsor, like the investors, wishes to maximise the cash flows that arise from this pool of delinquent mortgages. To begin with I abstract away from the role of investors. After highlighting the information asymmetry between the sponsor and servicer, I augment the model with a role for multiple investors.

The servicer is one of two types — g_H or g_L. The servicer is of type g_H with probability p and of type g_L with probability $1-p$. g_H and g_L are also parameters of the model and are ordered such that $g_H > g_L$. The first assumption imposes some structure on the servicer's cost function.

Assumption 1. *The servicer's cost of modifying a fraction, ϕ, of the pool of delinquent mortgages will be given by the mapping $C : [0,1] \times \{g_H, g_L\} \rightarrow \mathbb{R}_+$. The cost function $C(\phi, g) > 0$ has the following properties:*

1. $C_\phi(\phi, g) > 0$; $C_{\phi\phi}(\phi, g) > 0$; $C_{g\phi}(\phi, g) > 0$
2. $\lim_{\phi \rightarrow 0} C_\phi = 0$
3. *Additionally, parametrize as follows:* $C(\phi, g) = gC(\phi)$

[10] V represents the present value of the expected cash flows if the mortgage is not renegotiated. It incorporates the probability of self-cure. Similarly, M represents the present value of the expected cash flows if the mortgage is renegotiated. It incorporates the probability that the modified loan re-defaults and ultimately still ends up in foreclosure.

[11] Maturana (2017) documents that mortgage modifications in private-label residential mortgage backed securities markets reduced losses for MBS investors. In contrast, Korgaonkar (2017) finds that on average, the expected gains from mortgage modification were limited. However, mortgages with high loan-to-value ratios and those that had experienced large declines in property price did have positive expected gains.

The servicer's costs are determined by the servicer's type and the fraction of the delinquent loan pool that is renegotiated. The higher the fraction of the loan pool modified, the higher are the servicer's costs. For simplicity, I assume that $(1 - \phi)$ of the mortgages are foreclosed upon. The cost function is convex in ϕ, and is parametrized such that the marginal cost of loan modification is higher for the type g_H servicer. The next assumption defines the dimension on which there is information asymmetry.

Assumption 2. *The servicer privately observes his type.*

In other words, the marginal cost of loan modification is the servicer's private information. I assume that the servicer knows his type after the loan origination, but before the mortgage delinquency. These assumptions about the servicer's type are a reduced-form way of modeling the idea that the servicer has superior information about the fraction of loans to be renegotiated to achieve the first best outcome. After all, it is the servicer—not the sponsor or investors—who closely monitors the borrowers.

At $t = 0$, the deal sponsor offers a contract to the servicer that incentivizes him to truthfully reveal his type. In equilibrium, the contract will be accepted by the servicer, who reports his type at $t = 1$. The contract between the sponsor and the servicer specifies, as a function of the servicer's report, the transfer to be made to the servicer, $t(\widehat{g})$, and fraction of the delinquent loan pool to be modified, $\phi(\widehat{g})$. Invoking the Revelation Principle, I restrict my attention to contracts in which the servicer truthfully reports his type. Thus, let K denote the set of incentive compatible and feasible contracts, i.e. choice of pairs $(\{t_H, \phi_H\}, \{t_L, \phi_L\})$ which satisfy the following constraints:

$$
\begin{aligned}
t_H - g_H C(\phi_H) &\geq t_L - g_H C(\phi_L) \; (ICH) \\
t_L - g_L C(\phi_L) &\geq t_H - g_L C(\phi_H) \; (ICL) \\
t_H - g_H C(\phi_H) &\geq 0 \; (PCH) \\
t_L - g_L C(\phi_L) &\geq 0 \; (PCL)
\end{aligned}
$$

The contract here takes a rather simple form. Outside the model, the Pooling and Servicing Agreements (PSAs) between the servicer and the sponsor can be rather complex (Kruger (2017), Hunt (2009)). While I abstract from this complexity in the model, I address this feature of residential mortgage securitization when discussing the empirical methodology in Section 5. Additionally, to capture potential liquidity constraints of the sponsor, assume that there exists some Θ such that $t(g) \leq \Theta$ must hold.[12] Additionally, let $U_i = t_i - g_i C(\phi_i)$ represent the rents conceded to the servicer of type i.

When writing the contract, the deal sponsor wants to maximize the cash flows that are generated by the pool of delinquent borrowers. The cash flows, described by the function $Z(\phi)$, will depend on the fraction of the delinquent loan pool that is modified.

$$Z(g) = \phi(g)M + (1 - \phi(g))V$$

Given this function, and the private information of the servicer, the sponsor solves the following problem:

$$\begin{aligned} \max_{\{t_H,\phi_H\},\{t_L,\phi_L\}\in K} & pZ(g_H) + (1-p)Z(g_L) \\ & -pt_H - (1-p)t_L \end{aligned}$$

where the set of contracts to be chosen from, K, incorporates the constraints delineated above - ICH, ICL, PCH, PCL.

3.2 Solution

3.2.1 Full information benchmark

First, I obtain the solution to the first-best, full-information benchmark case wherein the sponsor knows the servicer's type. The solution to the first-best problem will be given by the two first order conditions (FOCs):

$$\begin{aligned} C'(\phi_H^{FB}) &= \frac{1}{g_H}[M - V] \\ C'(\phi_L^{FB}) &= \frac{1}{g_L}[M - V] \end{aligned}$$

[12] The investment vehicles used to securitized mortgages were often thinly capitalized and bankruptcy-remote. Additionally, if most of the mortgages in a loan pool begin to go delinquent, there may not be sufficient cash to complete the transfer to the servicer.

These conditions imply that $\phi_L^{FB} > \phi_H^{FB} > 0$. The high-type servicer would be asked to modify fewer loans than the low-type servicer. Under full information, $U_L^{FB} = U_H^{FB} = 0$, and no rents are conceded to the servicer. The servicer is simply reimbursed for performing the optimal amount of loan modification. Next, I impose the incentive compatibility constraints and characterize the contract under Assumption 2.

3.2.2 Asymmetric information (Optimal Contracting)

The second-best rate of loan modification will be characterized by the two FOCs:

$$C'(\phi_H^*) = \frac{p}{g_H - (1-p)g_L}[M - V] \quad (1)$$

$$C'(\phi_L^*) = \frac{1}{g_L}[M - V] \quad (2)$$

The details of the derivation have been relegated to Internet Appendix Section A. These first order conditions imply that $\phi_L^{FB} = \phi_L^* > \phi_H^{FB} > \phi_H^* > 0$. Under assumption 2, and the sponsor's contract choice, the low-type servicer reveals his type and modifies ϕ_L^* of the loan pool, which equals ϕ_L^{FB}. However, the contract asks the high-type servicer to modify a smaller portion of the delinquent loan pool as compared to the first-best case. $U_H^* = U_H^{FB} = 0$, and no rents are conceded to the high-type servicer. The high-type servicer does not have an incentive to misreport his type, and thus can be pushed to his participation constraint. However, to reveal the truth, the low-type agent must be provided some rents, and $U_L^* > U_L^{FB} = 0$. These rents are a function of ϕ_H^* and thus the sponsor optimally chooses $\phi_H^* < \phi_H^{FB}$. Information asymmetry between the sponsor and the servicer forces a distortion away from the first-best level of loan modification.

3.3 Multiple investors

The information asymmetry between the sponsor and servicer induces sub-optimal rates of loan modification. The more binding the incentive-compatibility constraint of the low-type, the larger the rents he needs to report truthfully. In this section, I augment my framework with a simple audit mechanism to describe how the multiplicity of tranches, and investors, interacts with this agency problem between the sponsor and servicer.

Assume that there have been N tranches created for N investors. N will simply be an additional parameter of the model. In this framework, the investors have no role in writing the contract between the servicer and the sponsor. However, they do play a role ex-post.

Following the servicer's announcement of his type and the completion of his action, the investors coordinate to audit the servicer's report. To incorporate the audit mechanism the contract will also specify the probability of audit as a function of the servicer's report ($\gamma(\widehat{g})$), and a punishment if the reported type is found to be different from the servicer's true type $P(g, \widehat{g}) \leq l$. Additionally, there is a cost of auditing that is subtracted from the pool's cash flows. The next assumption describes the cost function $\chi(\gamma, N)$.

Assumption 3. *$\chi_\gamma > 0$, $\chi_N > 0$ and $\chi_{\gamma N} > 0$. Additionally, $\chi(0, N) = 0 \ \forall N$.*

Assumption 3 says that the cost of auditing is increasing in the number of investors and the probability of audit. The third part of the assumption states that the larger the number of investors, the higher the marginal cost of the audit. Finally, a zero probability of audit will have a zero cost, no matter the number of investors. This structure captures, in a reduced-form manner, the frictions to coordination as N increases. The larger the number of investors, the more costly it is for them to coordinate to discipline the servicer ex-post. Thompson (2011) describes how in order to take an action against the servicer —for example, force them to transfer servicing rights—the majority of the RMBS investors have to be in agreement (I show a few examples of such a clause in Internet Appendix Section C[13]). This is particularly difficult when there is a larger number of disparate investors whose identities are unknown to one another. Such frictions to coordination may also arise from free-rider problems such as those described in Diamond (1984).

The solution to the contracting problem is now characterized by Equations 1 and 2 plus an additional first order condition:

$$\chi_\gamma \left(\gamma_H^*, N\right) = \frac{1-p}{p} l \tag{3}$$

For details of the derivation, please see Internet Appendix Section A. This first order condition pins down the optimal probability of audit if the servicer reports that he is a high-type.[14] Under the audit mechanism, the second best outcome (ϕ_H^*, ϕ_L^*) can still be achieved. However, due to the disciplinary threat of the ex-post audit, the rents conceded to the low-type servicer are now lower

[13] The examples show that, depending on the deal, 25% to 66% of certificate-holders would have had to be in agreement to effect any change and discipline the servicer.

[14] See that it is optimal for the investors to never audit if the servicer reports a low-type. Hence $\gamma_L^* = 0$.

by $\gamma_H^* l$.

However, Equation 3 implies that at higher N, the probability of audit γ_H^* is lower. As N increases and $\gamma_H l$ decreases, more and more rents need to be conceded to the low-type servicer. This suggests that the higher the number of investors, the worse is the agency problem between the sponsor and the servicer and the more rents that need to be conceded to induce truth-telling. Failure to provide sufficient incentives (for e.g., if the deal faces liquidity constraints, $t(g) \leq \Theta$) will lead to a suboptimal level of loan modification, ϕ_H^*, by both servicer types.

A deal sponsor may wish to create multiple tranches for various reasons. Oldfield (2000) describes how the potential for market segmentation and price discrimination encourages the sponsor to tranche the cash flows and create differentiated securities for heterogenous investors. DeMarzo (2005) suggests that a "risk diversification" effect motivates tranching, as it allows an informed RMBS Sponsor to create a low risk, high-rating debt security that has enhanced liquidity. As long as the benefit of creating additional tranches exceeds the cost from the worsening agency problem, the sponsor will continue to do so. However, as the model highlights, this will not be without consequences for the households who, as a result of tranche multiplicity, do not receive loan modifications.

3.4 A note on empirical implementation

A key aspect of the framework is the number of investors, N. In the empirical tests that follow, while I do not directly observe the identity of the mortgage-backed security owners, I use the number of tranches collateralizing a particular loan pool as a proxy for the number of investors.

The underlying assumption is that investors heterogenous in their risk-return preferences will choose tranches to maximise their utility. Thus, many different investors, each with similar preferences, may own a single MBS tranche. In this case, my measures of tranche multiplicity will underestimate the number of investors.

Alternatively, if a single investor owns many different tranches, I will overestimate the number of investors. However, for the results to be substantially biased it must be that, conditional on observables, there is a non-zero covariance between the mis-measurement and the outcome variable. While I cannot entirely rule this out, it does impose a rather strong assumption as will become clear when discussing the regression specification in Section 5.

4 Hypotheses

The framework shows that multiplicity of tranches (higher N) tightens the incentive compatibility constraint and increases the rents that need to be conceded to the servicer to implement the constrained first-best level of loan modifications. Piskorski et al. (2010) first highlighted the role of dispersion of ownership inherent in securitization - "securitization creates dispersion in property rights—cash flow rights on a mortgage are held by several bondholders with varying seniority of claims. This raises concerns that complex capital structure, brought about by securitization, may create a coordination problem amongst investors making it harder for servicers to alter mortgage contracts". The framework developed shows how such "dispersion of ownership", inherently tied to the multiplicity of tranches, interacts with the agency problem between the sponsor and servicer to influence the rate of loan modification. This motivates the first hypothesis.

Hypothesis 1. *All else being equal, the more the number of tranches on a particular pool of mortgages, the lower the probability of loan modification conditional on delinquency.*

In addition, I also explore the effect of multiple tranches on the type of loan modification implemented by the servicer. While this remains outside the scope of the framework, I form my second hypothesis by examining how the agency problem between sponsor and servicer may interact with the existing design of the pooling and servicing agreements. The main component of a servicer's compensation is the servicing fee. Among his main costs of maintaining delinquent mortgages are the advances made to MBS bond-holders (since advances essentially constitute an interest-free loan to investors). These two features of the servicers' contract are common to all RMBS deals. Given discretion over the choice of modification type, a servicer will prefer to implement a loan modification that increases the loan balance, which is the basis for the servicing fee. He does so by either capitalizing missed payments into the balance, or by increasing the balance and converting a portion of it into interest free debt. Once the borrower is reclassified as current on the loan, the servicer can begin to recoup any funds advanced. However, these types of modifications lead to a higher rate of redefault as documented by Haughwout et al. (2016). If the home enters foreclosure, a servicer with outstanding advances has a senior claim to any liquidation proceeds and thus recovers his advances with a high probability.

Following the logic of the framework, increasing the number of tranches makes the servicer—conditional on modifying the loan—more likely to implement a modification that is privately beneficial but does little to help increase cash flows to investors. Increasing mortgage balances is such a modification.

The servicer could also modify the loan by reducing the monthly payments that the borrower has to make. If implemented, the servicer would recover their advances at a slower rate due to smaller monthly payments. On the other hand, such modifications tend to be more successful in keeping the borrower out of delinquency (see Ganong and Noel (2017)). This implies that a servicer stands to earn a longer stream of future income from the servicing fee. Therefore the effect of multiplicity on the change in monthly payments as a result of loan modification is ambiguous. The above discussion motivates my second hypothesis.

Hypothesis 2. *All else being equal, the more the number of tranches on a particular pool of mortgages, the larger the increase in the outstanding balance as a result of loan modification. The effect of tranche multiplicity on the change in the monthly payment due to loan modification is ambiguous.*

5 Empirical strategy

In order to test the hypotheses above, I need a measure of tranche multiplicity that flexibly captures the variation in deal structure. This measure will then have to be coupled with the appropriate empirical framework that controls for potential confounding variables.

5.1 Measures of tranche multiplicity

5.1.1 Count of tranches mapping to each loan pool

As a first measure of multiplicity, I take the simplest approach, which is to count the tranches that have claims to each individual loan pool in a particular RMBS deal. Therefore, for the example described earlier in Figure 1, the count for loan pool 1 would be 8 and the count for loan pool 2 would be 6.

More formally, the measure is constructed as follows. Assume that a deal has J tranches given by the set $T = \{T_1, \ldots, T_J\}$ collateralized by K loan pools given by the set $P = \{P_1, \ldots, P_K\}$. The data provides a mapping $M(P_k) = \{T_j \in T | T_j \text{ receives cash flows from } P_k\}$ which determines the tranches of a deal that receive cash flows from the loan pool P_k. The measure of tranche-count is then simply $|M(P_k)|$. I standardize the variable so that it has mean 0 and variance 1. I plot the distribution of the resulting measure in Internet Appendix Figure B.1

5.1.2 Herfindahl Hirschman Index (HHI) based measure

One shortcoming of the measure delineated above is that simply considering the count of tranches does not capture the rich variation in deal structure.[15] To construct a measure that captures not only the number of tranches but also their relative size, I follow an approach similar to the Herfindahl Hirschman Index. Sufi (2007) uses this approach to measure concentration of lenders in syndicated deals.

Essentially the Index is a weighed average of the the face value of each tranche that has a claim to the loan pool, where the weights are equal to the share of the tranche's face value among all tranches that have claims to the loan pool. First, let us construct a simple example based on the structure of MASTR Adjustable Rate Mortgages Trust 2004-11. Table 1 summarizes the debt structure. Column 1 lists the tranches of the deal, Column 2 denotes the loan pool collateralizing each tranche, Column 3 denotes the class balance of the tranche at deal closing.

The total balance of tranches that have claims to loan pool 1 is \$361 million, and the total balance to tranches with claims to loan pool 2 is \$418 million. As column 4 shows, tranche 1-A-1 has a weight of 0.4 with respect to loan pool 1 (\$145 million/\$361 million). Similarly, tranche 2-A-1 has a weight of 0.76 with respect to loan pool 2. Taking a sum of the squared weights that appear in Column 4 and 5, I obtain a HHI based measure of multiplicity of tranches for pool 1 and pool 2 respectively. The measure is 0.27 for pool 1 and 0.6 for pool 2. This suggests that loan pool 2 has a lower multiplicity of tranches.

In terms of the pools, tranches and mapping $M(P_k)$ described above, the measure of multiplicity $C(P_k)$ is calculated as:

$$C(P_k) = \sum_{T_j \in M(P_k)} \left(\frac{V_{T_j}}{\sum_{T_j \in M(P_k)} V_{T_j}} \right)^2$$

where V_{T_j} is the principal balance at origination of the tranche T_j.

[15] Consider the earlier example. Suppose, hypothetically, that the "1-A" stack now had only two tranches, each equal in size to the other. Even though stacks 1-A and 2-A would have the same number of tranches, stack 2-A has one tranche which is dominant.

Figure 2a below depicts the distribution of this measure. The measure $C(P_i) \in [0,1]$ has mean 0.43 and standard deviation 0.23. The lower the measure the higher the multiplicity of tranches, and the more dispersed the "ownership" of the underlying collateral. This will be the preferred measure of tranche multiplicity. Figure 2b shows how this measure of multiplicity evolves over time. Loan pools in deals that closed in 2003 had an average $C(P_k)$ of about 0.5. By 2007, loan pools had a $C(P_k)$ measure of about 0.3 on average, a 40% increase in tranche multiplicity.

5.2 Estimation frameworks

Having constructed these measures of tranche multiplicity, I incorporate them into the empirical design described below. Note that the use of such pool-level measures of deal structure (as opposed to tranche-level measures such as the level of subordination) facilitates a loan-level analysis. A single mortgage can be unambiguously assigned to a particular loan-pool. Due to the complex waterfall of RMBS, it is challenging to assign cash flows from an individual mortgage to a particular tranche. The linear probability model specification used to test Hypothesis 1 and 2 is:

$$Y_{ikd} = \alpha + \gamma_d + \psi_s + \eta_{CBSA \times t} + \beta_1 \cdot Multiple_k + \beta_2' X_i + \epsilon_{ikd} \tag{4}$$

where the dependent variable is an indicator for whether a loan i from loan pool k of RMBS deal d that was at least 60+ days delinquent was modified (in the case of testing Hypothesis 1) or for whether a loan received a particular type of modification (to test Hypothesis 2). $Multiple_k$ measures multiplicity of tranches and is equal to either the count of tranches or $C(P_k)$, the Herfindahl based measure of multiplicity. X_i are loan and borrower level control variables. $\eta_{CBSA \times t}$ are CBSA by delinquency date (year-quarter) fixed effects.[16]

The conceptual framework implies that an important driver of loan modifications is the contracting between the servicer and the sponsor, i.e., the Pooling and Servicing Agreement. A reading of the PSA contracts reveal that they make reference to all the loans in a particular RMBS deal that are monitored by the servicer, and that the contracts are not specific to a given loan pool or MBS tranche. Therefore, in order to control for the contents of this contract, Equation 4 includes

[16] I control for whether the property was Owner Occupied or not; the presence of private mortgage insurance, whether there was a second lien present on the property, CLTV at origination, CLTV at origination squared, Log of the original appraised value, the interest rate, the age of the loan (in months) at delinquency, and a set of indicators for loan contract features (ARM, IO, Negative Amortization, Balloon, Prepayment Penalties).

γ_d, a deal fixed effect. Including this fixed effect also controls for other unobserved features of the RMBS—for example, initial credit-enhancement levels, the existence of tranches with fixed and variable yields, the existence interest-only and principal-only tranches, among others.

Pooling and Servicing Agreements are, however, specific to a particular mortgage servicer who monitors the loans in a loan pool. Given that servicers exert significant discretion over the decision to renegotiate the loan and vary in their servicing practices (Reid (2015)), or more generally in their operational characteristics (Agarwal et al. (2017)), I control for servicer fixed effects, ψ_s. The most stringent specification will control for a deal-by-servicer fixed effect. I also consider alternative configurations of the relevant fixed effects.

The use of the deal fixed effect implies that the identification of β_1 comes from comparing the modification outcomes of delinquent loans *within the same deal* but in loan pools that have different degrees of multiplicity of tranches (similar to Adelino et al. (2017)). In short, the identifying assumption can be summarized as: $Cov(Multiple_k, \epsilon_{ikd} \mid X_i, \gamma_d, \psi_s, \eta_{CBSA \times t}) = 0$.[17] Internet Appendix Table B.1 documents the relationship between $Multiple_k$ and pool-level averages of mortgage characteristics at origination. It shows that there are observable differences across loan pools with different tranche multiplicities. These differences are controlled for by including X_i, γ_d, ψ_s and $\eta_{CBSA \times t}$ in the regression specification.

However, differences across loans and loan pools on unobservable dimensions might violate the identifying assumption. For example, loans in pools with more tranches might be of worse quality that those in pools with fewer tranches, with this "soft information" not being captured by X_i and the fixed-effects. Such omitted variables may bias the estimate of β if they are also correlated with tranche multiplicity. While such unobservable differences cannot be explicitly ruled out, Section 6.1.2 performs a series of tests to mitigate these concerns. While my main result will be obtained using a sample of mortgages that have become 60+ days delinquent, the robustness tests employed in Section 6.1.2 will use the sample of all originated loans. I perform tests which examine differences across loan pools in the rate at which mortgages entered delinquency in the first place.

[17] Therefore, for measurement error in $Multiple_k$ to bias the results, it must be correlated with unobservable determinants of mortgage modification, conditional on controlling for loan and borrower level characteristics, time varying unobserved heterogeneity at the CBSA level and time-invariant unobserved heterogeneity across deals, and across mortgage servicers.

5.3 Data

In order to perform the tests outlined in the previous section, I require mortgage data that satisfies a few key requirements. First, the data needs to deliver the mapping from individual mortgages to mortgage pools; and subsequently the mapping from mortgage pools to RMBS tranches. Additionally, I require detailed data on loan performance, including the dates of, and types of loan modifications implemented. Finally, to control for observable characteristics and mitigate concerns of omitted variable bias, I require information on borrower and loan characteristics, and the identify of the mortgage servicer.

Therefore, the main source of data used is ABSNet Loan. ABSNet Loan aggregates data from Residential Mortgage Backed Securitization (RMBS) trustee reports, and covers the majority of Private Label RMBS issuances. This data is augmented with data on the origination balance and rating of the MBS bond tranches. The baseline sample will consist of loans that went at least 60+ days delinquent before January 2009. I use this restriction to ensure that the effects of government interventions, such as the HAMP program, do not confound my results. I also obtain the name of the servicer for each loan in the pool. The final sample consists of about 3,500 deals and 2,700,000 mortgages originated between 2002 and 2007.

Table 2 shows us summary statistics for the sample of loans used in the regressions. Since these loans are those that go at least 60+ days delinquent, one sees that the borrowers were not as credit worthy, with a FICO score of about 625. Additionally, about 22% of the loans in this sample receive some form of modification. This rate of modification considers all modifications occurring at any length of time following the delinquency.[18] It does not restrict to only modifications made within the first or second year of the loan modification. About 57% of the loans see the mortgage foreclosed upon at any point following delinquency. Note that this figure includes loans that were modified and then subsequently foreclosed upon. On average, the loans are about a year and a half old by the time they become seriously delinquent.

[18] Loans in the sample may be modified multiple times. If a loan is modified multiple times, the average length of time between modifications is on average 9 months. If the mortgage has been modified more than once, the data aggregates these multiple modifications. For example, I create the indicator variables for the various modification types by comparing the loan features (outstanding balance, monthly payment, interest rate) prior to the first modification and following the last modification recorded for each particular mortgage in the dataset. Among modified mortgages, the median number of modifications is 1. 75% of modified mortgages received 2 or fewer modifications, and 90% of modified mortgages received 3 or fewer modifications.

In addition to the sources above, I use house price indices from Zillow to control for county-level changes in house prices.

6 Results

Having established a way to measure tranche multiplicity and outlined the regression frameworks, I now test the hypotheses I have outlined above.

6.1 Multiplicity and loan modification

6.1.1 Baseline result: Linear probability model

Table 3 shows the results from estimating the specification in Equation 4. Columns (1) to (4) show the results using the Tranche Count as the measure of tranche multiplicity. Columns (4) to (8) implement the regressions with the $C(P_k)$ as the measure of tranche multiplicity. Column (1) indicate that a 1 standard deviation increase in the count of tranches increases the probability of loan modification by 91 basis points. Column (5) suggests that moving from the 25th percentile of the HHI-based measure to the 75th percentile (i.e. less dispersed ownership of the tranches) predicts an increase in the probability of loan modification by about 120 basis points. As a point of comparison, the in-sample probability of loan modification conditional on delinquency is about 21.4%.[19]

The above tests use a sample of loans that have become 60+ days delinquent. If a delinquent loan is not renegotiated, it either self-cures, or soon enters foreclosure. Of the loans that were not modified 72% eventually entered foreclosure. Consistent with this, Internet Appendix Table B.2 shows that, conditional on a loan entering 60+ days delinquency, higher tranche multiplicity predicts a higher probability of subsequent entry into foreclosure.

These specifications use deal fixed effects, and thus hold constant various elements of the deal structure such as the credit-enhancement features, or the contents of the pooling and servicing agreement between the sponsor and the servicer. Servicer fixed effects control for unobservable differences across mortgage servicers. Since there are multiple servicers used for a given RMBS

[19] As seen in Internet Appendix Table B.6, multiplicity of tranches does not affect the efficacy of loan modifications as measured by the redefault rate following loan modification.

deal, Columns (2) and (6) refine the identification by comparing two loans within the same RMBS deal that also had the same servicer.[20]

While the result remains robust to this specification, the literature documents that servicers' incentives and ability to monitor and renegotiate loans may vary both in the time-series and the cross-section. For example, some servicers may have had more capacity to respond to the sharp increase in delinquencies relative to others. Aiello (2017) documents how financially distressed servicers were more likely to foreclose upon borrowers rather than renegotiate mortgages. Columns (4) and (8) use servicer by delinquency date fixed effects to control for all time-varying unobserved heterogeneity across mortgage servicers. This does not change the result. The structure of the deal may also vary over time, as mortgages terminate through prepayment and default and the resulting cash flows are assigned to the various tranches (as described by Huang and Nadauld (2017)). Columns (3) and (7) control for deal by delinquency date fixed effects to ensure that the main result remains robust to these considerations. Overall, the results support Hypothesis 1 and demonstrate that the multiplicity of tranches does indeed hamper loan modifications.

6.1.2 Robustness to unobserved loan quality

The fixed-effects analysis above controls for unobservable differences across servicers, and across different residential mortgage-backed security deals. However, there may also exist loan-level differences in mortgage characteristics and quality that remain unobservable. To allay concerns that such differences drive the result, I perform a series of tests which use data on all originated mortgages in my sample of RMBS deals; that is, they also includes those mortgages that never became delinquent.

First, I test whether a mortgage originated and placed in a loan pool with higher tranche multiplicity was more or less likely to become delinquent compared to a similar mortgage from a loan pool with fewer tranches. I regress an indicator for whether a mortgage became 60+ days delinquent within 12, 24 or 36 months on the same set of observable characteristics and fixed effects

[20] To further illustrate this point, I separately estimate the $\hat{\beta}_1$ coefficient on each of the servicers among the top 10 in the sample. The top 10 servicers account for 62% of the loans in the sample. As observed in Internet Appendix Figure B.2, the coefficient on $C(P_k)$ is positive and statistically significant for 7 of the top 10 servicers. The coefficient on Tranche Count is negative and statistically significant for 6 of the top 10 servicers in the sample. While the effect of multiple tranches is heterogenous across servicers, the direction of the effect is consistent with the estimate from the pooled regression.

that appear in Equation 4 (except that I now use CBSA by origination date fixed effects). Table 4a shows the results. While loans in pools with higher tranche multiplicity were slightly more likely to become delinquent, the effect is economically very small. For example, a 1 S.D. increase in tranche multiplicity predicts a 0.008 higher probability of 60+ days delinquency within 36 months. This is about 3% of the average rate of entry into delinquency within 3 years (0.252).

A stronger test of the unobserved differences across loans and loan pools can be performed by examining the residuals from the above regressions. The residuals characterize entry into delinquency unexplained by the observable characteristics and fixed effects. To perform this test, I form two sets of residuals for every measure of delinquency considered. One vector of residuals is formed using a regression that includes $Multiple_k$ as a regressor, and a second vector is formed using a regression which excludes this variable. I then perform a Kolmogorov-Smirnov test comparing the resulting residual distributions, with the results appearing in Table 4b. In every case, I am unable to reject the null hypothesis that the two distributions are identical. This strongly suggests that $Multiple_k$ is unlikely to capture unobservable differences across mortgages.

Finally, I use the residuals constructed above as an additional regressor in Equation 4, where the sample of mortgages is once again those that were 60+ days delinquent. Including these residuals as an additional regressor is a reduced form way of controlling for any unobserved differences across mortgages. Table 5 demonstrates that the results remain robust to their inclusion.

In addition, I also estimate Equation 4 on various subsamples of the data, restricting attention to loans that might be considered of a higher quality and loans where the origination decision is less likely to have been made primarily on the basis of "soft" or unobservable information. I consider three different subsamples, Full Documentation loans, loans with balances below the conforming loan limit, and 30 Year Fixed Rate Mortgages. The results of these regressions appear in Table 6. Looking at Columns (1) to (8) indicates that the coefficients on $Multiple_k$ are comparable to the baseline results presented in Table 3. This is suggestive evidence that the results are not simply driven by a particularly risky group of borrowers.

6.1.3 Controlling for characteristics of the loan pool

While the regression framework thus far orthogonalizes the effect of $Multiple_k$ from characteristics of the individual mortgages, it does not rule out that the result may be driven by the correlation between $Multiple_k$ and other characteristics at the more aggregate loan-pool level. In Internet Appendix Table B.3 I include some of these pool-level covariates.[21] To capture historical loan pool losses and prepayments, I control for the percentage of the loan-pool's balance at deal inception which remains active as at quarter of delinquency t, and for the change in the total balance of active loans over the previous 3 months. To control for the intensity of servicing required for the loan pool (Agarwal et al. (2017)), I control for the percentage of the loan-pool balance that is in delinquency, and the change in the total loan-pool balance in delinquency over the previous 3 months. Finally, I control for the geographical diversification of the loan pool at deal origination (Mooradian and Pichler (2016)). The results remain robust to the inclusion of these additional control variables.

6.1.4 Proportional hazards model

In addition to the linear probability model above, I estimate a proportional hazards specification to test Hypothesis 1, which accounts for the right-censoring of mortgage data. I use the framework from Palmer (2015). The latent variable is time to modification. The instantaneous probability of modification at time t for loan i, of loan pool k in deal d, year of serious delinquency c and zip-code z will be given by:

$$\lambda(X_{ikdyz}(t), t) = exp(X'_{ikdyz}(t)\beta)\lambda_0(t)$$

where $\lambda_0(t)$ is the baseline hazard function that only depends on time since serious delinquency, t. The specification for the covariates is:

$$X'_{ikdyz}(t)\beta = \phi_y + \gamma_d + W'_i\theta + \mu \times \Delta HPChange_z(t) + \eta \times C(P_k)$$

where ϕ_y are year of serious delinquency fixed effects, γ_d are deal-level fixed effects, W_i are a set of borrower and loan level control variables as at origination or serious delinquency. The only time varying variable in $X_{icz}(t)$ is the House Price Change ($\Delta HPChange_z(t)$) over the past three months for zip-code z which is computed using Zillow House Price Index data. I estimate this specification on a 5% random sample of seriously delinquent mortgages.

[21]Note that certain pool-level covariates were available only from the first quarter of 2004 onwards.

The results appear in Tables 7 and 8. Table 7 uses as the regressor of interest the HHI based measure of multiplicity, while Table 8 uses the standardized Tranche Counts. The preferred specification appears in Column (4).[22] Exponentiating the coefficient in Table 7 to obtain the hazard ratio demonstrates that moving from the 25th to the 75th percentile of the HHI distribution (decreasing multiplicity) predicts an increase in the hazard rate of loan modification of 7 percentage points. Similarly, a 1 S.D. decrease in the Tranche Count measure (Table 8) reflects an increase in the hazard rate of loan modification of 11.2 percentage points.

6.1.5 Comparison to other estimates in the literature

Piskorski et al. (2010) estimate the effect of securitization on the hazard rate of foreclosure using a Cox proportional hazards model. They find (Table 5 in their paper) that portfolio held loan is 24 percentage points less likely to be foreclosed upon as compared to a securitized loan (i.e. the "Portfolio" dummy variable has a hazard ratio of 0.759). Estimates from my hazard rate of foreclosure specification (see Internet Appendix Table B.5) shows that a 1 S.D. decrease in the Tranche Count measure predicts that a mortgage is 10.6 percentage points less likely to be foreclosed upon. Similarly moving from the mean $C(P_k)$ of 0.43 to a $C(P_k) = 1$ (i.e. the hypothetical $C(P_k)$ of a portfolio held loan) indicates that the delinquent mortgage is 8.1 percentage points less likely to be foreclosed upon. Thus, the multiplicity of tranches in securitization accounts for about 34% to 44% of the effect captured by Piskorski et al. (2010).

The results indicate that Hypothesis 1 is indeed borne out in the data. Thus, I present evidence for one channel through which the securitization of mortgages affects the rate of loan modifications following borrower delinquency. Moreover, based on the time-series in Figure 2b, loans originated toward the end of the housing boom would have been even more exposed to this channel. Thus, the increasing complexity of residential mortgage-backed securitization deals did not come without consequence to borrowers when the housing crisis broke.

[22] The preferred specification excludes CBSA fixed effects to keep the model parsimonious. Looking across Column (1) and Column (2), the inclusion of CBSA fixed effects does not influence the estimated coefficient $\widehat{\eta}$.

6.2 Does multiplicity of tranches harm investors?

The main result establishes that the higher the number of tranches collateralizing a particular loan pool, the less likely a delinquent mortgage gets renegotiated. Korgaonkar (2017) documents that while on average, expected gains from loan modification appeared to be small, these gains where higher for borrowers that had experienced larger house price declines. Maturana (2017) estimated that mortgage renegotiations reduced realized losses for mortgage-backed security investors, and this was particularly true in geographies where house prices did not rebound following their precipitous decline during the crisis. Multiplicity of tranches would be particularly problematic if it inhibited those loan modifications that were expected to be most beneficial for investors. The following result suggest that indeed this was the case.

Following the methodology of Maturana (2017), I compute for each zip code the log difference between the minimum of the house price index in 2009 and the house price index in December 2012. Then I form three groups. The first group did not see a rebound. The second and third groups are based on the median rebound of the remaining loans. The second group contains the loans that experienced a small rebound, while the third group contains loans that experienced a large rebound. Loan modifications would have been most valuable to investors in group 1. Restricting attention to loans that went delinquent after July 2007 (as per Maturana (2017)) I estimate the regression in Equation 4 separately on each group. The results appear in Table 9. The table suggests that the effect of multiplicity appears to be more acute in zip codes that saw no or a low rebound.

6.3 Multiplicity and the type of loan modification

In the previous section, I observe that mortgages in loan pools with fewer tranches on the underlying collateral were more likely to be modified conditional on being seriously delinquent. Here, I test for the effect of tranche multiplicity on the type of loan modification used. For the tests that follow, I restrict my sample to mortgages that were modified.

First, consider the summary statistics on the types of loan modifications employed. Table 2 documents that 85% of loan modifications involve a change in the monthly payment of the borrower. Of these modified loans, 86% involve a decrease in the monthly payment. The change in the monthly payment will be a function of the change in other terms of the mortgage contracts. For example, 80% of loan modifications involve a change in the interest rate, and 80% involve a capitalization of missed monthly payments into the outstanding balance.[23] The analysis of the type of loan modification used is complicated by the fact that my sample includes a variety of mortgage types. For example, 80% of the mortgages in my sample have adjustable rates, 20% of the loans are interest-only mortgages and 11% have balloon payments. I will control for the mortgage contract type (interest-only, adjustable-rate, etc.) when estimating the regressions.

In order to overcome these complications, I focus on two dimensions of the change in the mortgage contract — the change in the monthly payment and the change in the outstanding balance. These features of a mortgage are the most salient to the borrower. The size of the monthly payment directly enters a household's budget constraint. The size of the mortgage balance determines the value of the default option held by the borrower.

The results of the analysis appear in Table 10 Panel A. I regress each of the dependent variables analysed on the two measures of tranche multiplicity. Firstly, the table suggests that the multiplicity of tranches does not appear to have an effect on the probability of an increase in the mortgage balance or the size of a change in the mortgage balance (i.e. $ln(\text{Post-mod bal.}) - ln(\text{Pre-mod bal.})$). Higher multiplicity of tranches does predict a higher probability of a change in the monthly payment, and in particular, predicts a smaller decrease in the monthly payments (i.e. $ln(\text{Post-mod PMT}) - ln(\text{Pre-mod PMT})$).

Such analysis abstracts from the fact that servicers often changed multiple terms of the mortgage contract. For example, servicers often combined a capitalization of missed payments into the mortgage balance with decreases in interest rates to reduce the monthly payments. Alternatively, some servicers engaged in principal forbearance wherein they increased the outstanding balance, but converted a significant portion of it into interest-free debt (with a balloon payment) to reduce the monthly payments.

To examine such loan modifications, Panel B of Table 10 focuses on loan modifications that either involved a decrease in monthly payments without a subsequent increase in the outstanding balance, or those modifications that involved an increase in the mortgage balance without a subsequent decrease in the monthly payment. The first type of loan modification is particularly helpful to the

[23] Often, loan modifications also involved principal forbearance wherein the principal balance may have been increased, but a portion of it was converted into interest-free debt.

household as it relaxes the budget constraint without driving the borrower closer to, or further into, a negative equity position. The second type of loan modification is particularly harmful to the borrower, and potentially the MBS investors, as it pushes the borrower's default option further into the money without relaxing the budget constraint.

The results show that higher multiplicity of tranches predicts a higher likelihood that servicers use the latter, more harmful, kind of loan modification. These modifications may be privately beneficial to servicers as they increase the basis for the servicing fee, while maintaining the high probability that the servicer can recover any advances made, since the servicer has a senior claim to any proceeds from mortgage liquidation. Overall, there is only weak evidence for Hypothesis 2, suggesting that the effects of tranche multiplicity primarily occur through a servicer's decision about whether to renegotiate the loan or not.

7 Robustness checks

7.1 Government Sponsored Entities and Tranche Multiplicity

The mechanism proposed so far indicates that multiple claim holders find it difficult to coordinate and discipline the agent, i.e. the mortgage servicer. Adelino et al. (2017) highlight that the GSEs were large investors in subprime private-label MBS. Private label securitization deals had certain mortgage pools specifically created to collateralize tranches to be held by the GSEs. For example, in 2004 Fannie Mae purchased $90.8 billion of PLS, while Freddie Mac purchased $121.1 billion. If the GSEs demanded loan pools with less complex (lower multiplicity) tranching structures, the results may be driven by the exertion of their political pressure and market power on servicers' actions. The first set of robustness checks alleviates these concerns.

I follow the algorithm of Adelino et al. (2017) to determine whether a loan pool was used as collateral for tranches purchased by the GSEs (i.e. was a GSE pool).[24] To remain consistent with

[24]In particular, the algorithm exploits the fact that the GSEs are only allowed to acquire mortgages below the conforming loan limit, a fixed dollar amount set annually by the government. The algorithm determines a loan pool to be collateral to GSE-owned bonds if at least 99% of the loans in the loan pool have a balance below the conforming loan limit of the given year at the time of deal closing, and if the number of loans that are not first lien mortgages make up less than 75% of the loan pool. There is some error associated with this. If data is not available on the balance of the loan at the exact month of deal closing I look out up to 6 months after the deal closed. Thus I may be overestimating slightly the number of loans with a conforming loan balance. See Internet Appendix of Adelino et al. (2017) for more details on the algorithm.

their approach, I restrict attention to deals classified as "Subprime" by ABSNet. For this sample, about 30% of loan pools are GSE pools, and about 60% of deals have at least one pool specifically designed for the GSEs. Unconditionally, the correlation between the GSE pool indicator variable, and the HHI-based measure of multiplicity is 0.15. Partialling out deal fixed-effects the correlation rises to about 0.40.

The results appear in Table 11. First Columns 1 and 5 estimate the main result of Table 3 on the sample of "Subprime" deals. Columns 2 and 6 demonstrate that upon including a control variable equal to 1 if the loan is in a GSE Pool, the effect of tranche multiplicity remains statistically significant, although has a smaller magnitude. Given the high correlation between the GSE pool indicator and tranche multiplicity, the preferred test results are in Columns 3 and 7. Here, I exclude all deals with a GSE pool, and show that the effect of tranche multiplicity remains prominent; moving from the 25th to the 75th percentile of $C(P_k)$ predicts an increase in the probability of loan modification by 114 basis points.

The presence of these GSE pools sets up another robustness test. Ownership of a loan pool by the GSEs (through ownership of the tranches) proxies for lower creditor multiplicity. Thus, I hypothesize that if a pool is "owned" by the GSEs, multiplicity of tranches should not predict a higher rate of loan modification . I combine the multiplicity measure $C(P_k)$ and the GSE Pool indicator into a single regression. I estimate equation (1) but with:

$$Multiple_k = \begin{matrix} C(P_k) \\ GSEPool_k \\ C(P_k) \times GSEPool_k \end{matrix}$$

or

$$Multiple_k = \begin{matrix} TrancheCount_k \\ GSEPool_k \\ TrancheCount_k \times GSEPool_k \end{matrix}$$

The result of this regression appears in Columns 4 and 8 of Table 11. Additionally, I test the null hypothesis that the effect of tranche multiplicity on a GSE Pool is 0 (i.e., the coefficient on $C(P_k)$

plus the coefficient on $C(P_k) \times GSEPool_k$ is equal to 0). The last row of Columns 4 and 8 presents the p-value of the corresponding F-test, and indicates that I cannot reject this null hypothesis. Together these results corroborate the evidence in Table 3, and reduce concerns that the estimates are driven purely by GSE demand for private-label MBS tranches.

7.2 Distinguishing multiplicity of tranches from seniority

The analysis so far has abstracted away from another dimension on which loan pools differ with regards to their relationship to MBS tranches. The tranches in a MBS deal vary in their seniority. This variation is captured by the tranche-level measure of subordination. The more senior the MBS tranche, the more protected it is from losses and the higher the level of subordination. Different loan pools within a deal will collateralize tranches of different seniority. In this section I assess the extent to which the effect of tranche multiplicity is orthogonal to the effect of tranche seniority (e.g., see Huang and Nadauld (2017)).

To do so, I first obtain a measure of each tranche's initial subordination level. Then, for each loan pool, I compute a weighted average subordination measure. I use the face values of the tranches collateralized by a particular loan pool to construct the weights. The pool level measure of subordination has a correlation of 0.15 with the $C(P_k)$ measure of tranche multiplicity. I then include this measure of tranche seniority as a control variable in the main specification. As can be seen in Table B.8, both the statistical and economic significance of the multiplicity coefficients survive.[25]

8 Conclusion

This paper demonstrates that the pooling and tranching of cash flows inherent in asset-backed securitization impeded the renegotiation of underlying mortgage collateral in the wake of the financial crisis. By worsening the agency problem between the mortgage servicer — who monitors the mortgage collateral – and the deal sponsor — who represents the interest of the dispersed MBS investors — the multiplicity of tranches reduced the rate at which delinquent mortgages were renegotiated.

[25] In results available upon request, I estimate Table 3 using only the sample of deals that did not have cross-collateralization (i.e., a single tranche which maps to two loan pools). The effect of tranche multiplicity has a smaller, yet still statistically and economically significant effect.

Failure to renegotiate the loan leaves a borrower more constrained and less likely to cure from their delinquency. Moreover, it leaves investors worse off, particularly when the borrower has experienced a substantial decline in collateral value (Korgaonkar (2017), Maturana (2017)).

These results are important not only from the perspective of assessing the effect of mortgage-market frictions during a period of elevated mortgage delinquencies, but also with a view towards the future of the market. Post-crisis, delinquencies have remained low. However, the originate-to-distribute model of mortgage lending has persisted, albeit with the government-sponsored entities (GSEs) involved in almost all secondary market activity. Additionally, the GSEs are beginning to introduce derivative products called Credit-Risk Transfers (see FHFA (2015) for a description of these securities) to move credit risk off their balance-sheets. These derivative products will in effect create a complex tranching structure on the GSEs' loan pools.

The results of this paper speak to the effects of asset-backed security complexity in times of rising mortgage delinquency.

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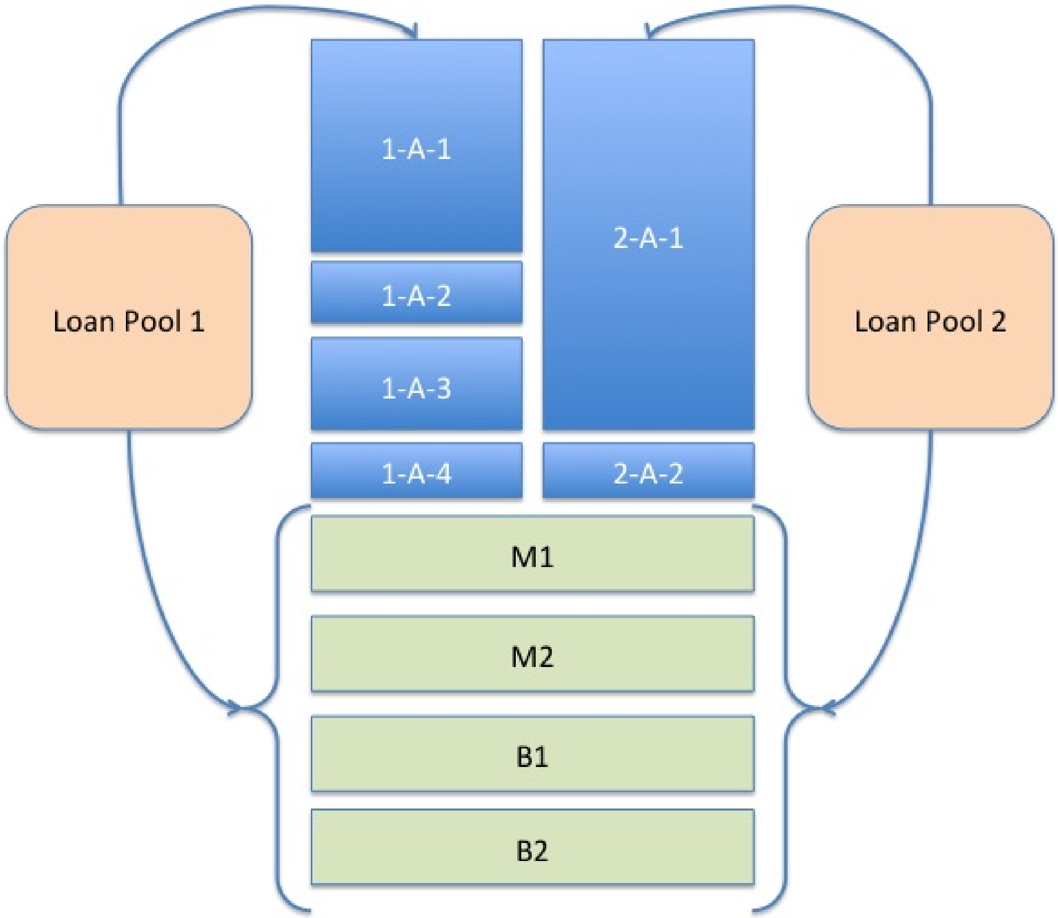
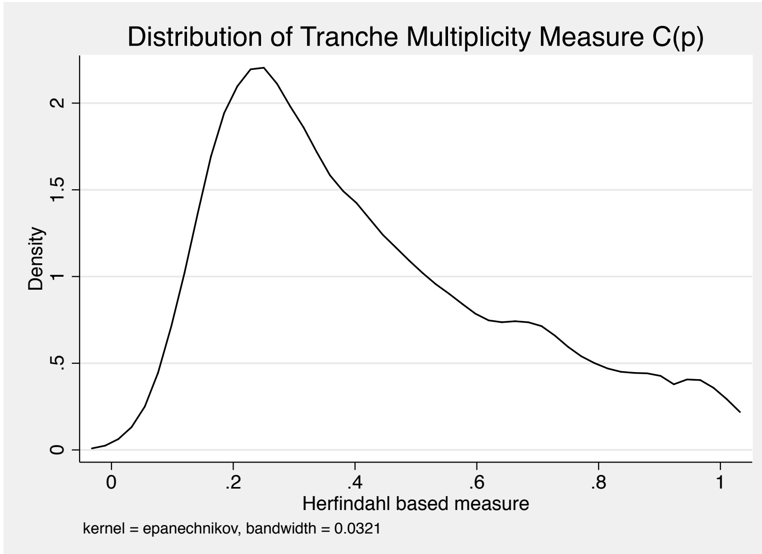
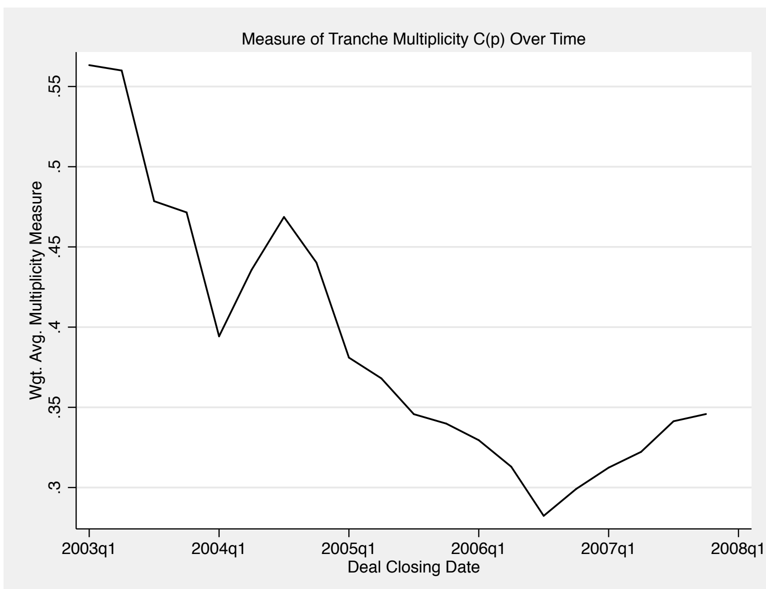


Figure 1: Diagram of typical RMBS transaction (Source: ABSNet)
The diagram above describes the relationship between loan pools and mortgage-backed security tranches for a particular securitization deal in my sample. The size of each box (green or blue) representing the tranches is proportional to the tranches' class balance at origination.



(a) Distribution of $C(P_k)$ measure



(b) Distribution of $C(P_k)$ measure

Figure 2: Summarizing the $C(P_k)$ measure

Panel (a) presents a kernel density plot depicting the distribution of $C(P_k)$ the HHI-based measure of tranche multiplicity. Panel (b) summarizes the evolution of this measure over time. It computes the weighted average multiplicity measure where the weights are determined by the size of the loan pool.

Table 1: Tranche Structure: MASTR Adjustable Rate Mortgages Trust 2004-11

The table below summarizes the debt structure of securitization deal MASTR Adjustable Rate Mortgages Trust 2004-11. Column 1 lists the tranches of the deal, Column 2 denotes the loan pool collateralizing each tranche, Column 3 denotes the class balance of the tranche at deal closing. The total balance of tranches that have claims to loan pool 1 is $361 million, and the total balance to tranches with claims to loan pool 2 is $418 million. As column 4 shows, tranche 1-A-1 has a weight of 0.4 with respect to loan pool 1 ($145 million/$361 million). Similarly, tranche 2-A-1 has a weight of 76% with respect to loan pool 2. Taking a sum of the squared weights that appear in Column 4 and 5, I obtain a HHI based measure of multiplicity of debt claims for pool 1 and pool 2 respectively.

(1)	(2)	(3)	(4)	(5)
Tranche	**Pools**	**Class Balance**	**Weight for Pool 1**	**Weight for Pool 2**
1-A-1	1	145,078,000	0.40	0
1-A-2	1	16,000,000	0.04	0
1-A-3	1	105,000,000	0.29	0
1-A-4	1	26,000,000	0.07	0
2-A-1	2	318,985,000	0	0.76
2-A-2	2	30,000,000	0	0.07
M-1	Both	40,357,000	0.11	0.10
M-2	Both	15,714,000	0.04	0.04
B-1	Both	7,143,000	0.02	0.02
B-2	Both	5,714,000	0.02	0.01

Table 2: Summary Statistics

The table below presents summary statistics on the sample of delinquent loans used in the analysis. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. Note that Panel C restricts attention to loans that were modified.

Panel A: Loan Outcomes

Variable	Mean	Std. Dev.
Modified	0.217	0.412
Foreclosed	0.572	0.495
Prepaid	0.170	0.375

Panel B: Control Variables

Variable	Mean	Std. Dev.
FICO Score	626.03	63.05
CLTV (Pct. Points)	84.80	12.10
Appraised Val.	281609.50	202599.20
Not Own. Occ.	0.19	0.39
Age at Delinquency	19.29	11.04
Second Lien	0.22	0.41
Rate (pct. Points)	7.80	2.09
Purchase	0.43	0.50
Prepayment Penalty	0.43	0.50
HELOC	0.00	0.00
IO	0.20	0.40
Balloon	0.11	0.32
Neg Am.	0.06	0.23
Low/No Doc	0.41	0.49
ARM	0.79	0.41
PMI	0.08	0.27

Panel C: Types of Modification

Variable	N	% of Mods
Rate Change	488,987	80.77%
Payment Change	512,404	84.63%
Capitalization	486,921	80.43%
Deferral	10,395	1.72%
Principal Forgiveness	112,265	18.54%
Interest Forgiveness	2,204	0.36%

Table 3: Multiplicity of Tranches and the Extensive Margin of Loan Modification

The table below shows the effect of tranche multiplicity on the probability that a delinquent loan in my sample was renegotiated. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan is modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)
Tranche Count	-0.0091***	-0.0098***	-0.0108***	-0.0100***				
	(0.0031)	(0.0033)	(0.0033)	(0.0032)				
Multiplicity (HHI)					0.0353***	0.0361***	0.0383***	0.0382***
					(0.0050)	(0.0051)	(0.0050)	(0.0050)
House Price Change	-0.0533***	-0.0480***	0.0130	0.0264*	-0.0532***	-0.0479***	0.0129	0.0262*
	(0.0180)	(0.0180)	(0.0154)	(0.0145)	(0.0180)	(0.0181)	(0.0154)	(0.0144)
Observations	2,225,128	2,224,566	2,222,003	2,225,543	2,225,128	2,224,566	2,222,003	2,225,543
R-squared	0.1977	0.2019	0.2153	0.1973	0.1978	0.2020	0.2154	0.1974
Borrower & Loan Chars	X	X	X	X	X	X	X	X
CBSA FE			X	X			X	X
CBSA x Quarter FE	X	X			X	X		
Deal FE	X			X	X			X
Servicer FE	X		X		X		X	
Deal x Servicer FE		X				X		
Deal x Quarter FE			X				X	
Serv x Quarter FE				X				X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.214	0.214	0.214	0.214	0.214	0.214	0.214	0.214

Table 4: Robustness to unobservable differences across loan pools

The tables below show the results of tests mitigating concerns about unobservable differences across pools with different tranche multiplicities. Table (a) below shows the effect of tranche multiplicity on the probability that a mortgage becomes delinquent (i.e., when it enters the sample for the tests on modification and foreclosure). The estimation sample consists of all the originated mortgages that reside in the deals used for the main analysis. The dependent variable is an indicator equal to one if the originated mortgage becomes 60+ days delinquent within 12, 24, or 36 months of origination. Multiplicity (HHI) is the inverse measure of multiplicity, while Tranche Count is the standardized count of the number of tranches. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate. Standard errors are clustered at the deal level. (*** $p<0.01$, ** $p<0.05$, * $p<0.1$) Table (b) shows the test statistic and corresponding p-value of Kolmogorov-Smirnov tests. For each of the regressions in Table (a) I construct two sets of residuals; one set from a regression that excludes the measure of tranche multiplicity, and one set from a regression that includes the measure. The Kolmogorov-Smirnov is a test of the null-hypothesis that the two distributions are identical.

(a) The effect of tranche multiplicity on entry into 60+ days delinquency

VARIABLES	(1) P(Del 60+ in 12)	(2) P(Del 60+ in 12)	(3) P(Del 60+ in 24)	(4) P(Del 60+ in 24)	(5) P(Del 60+ in 36)	(6) P(Del 60+ in 36)
Tranche Count		0.003***		0.006***		0.008***
		(0.001)		(0.002)		(0.002)
Multiplicity (HHI)	-0.004***		-0.006***		-0.008***	
	(0.001)		(0.001)		(0.001)	
Observations	13,082,434	13,082,434	13,082,434	13,082,434	13,082,434	13,082,434
R-squared	0.128	0.128	0.209	0.209	0.274	0.274
Borrower & Loan Chars	X	X	X	X	X	X
HPI Change	X	X	X	X	X	X
Deal FE	X	X	X	X	X	X
CBSA by Quarter FE	X	X	X	X	X	X
Servicer FE	X	X	X	X	X	X
Controls	X	X	X	X	X	X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.0764	0.0764	0.172	0.172	0.252	0.252

(b) Kolmogorov-Smirnov Test Results

VARIABLES	(1) HHI P(Del 60+ in 12)	(2) Tranche Cnt. P(Del 60+ in 12)	(3) HHI P(Del 60+ in 24)	(4) Tranche Cnt. P(Del 60+ in 24)	(5) HHI P(Del 60+ in 36)	(6) Tranche Cnt. P(Del 60+ in 36)
KS Test Statistic	0.0004	0.0004	0.0003	0.0002	0.0002	0.0002
p-value	0.2378	0.2951	0.6398	0.8273	0.9283	0.9046
(H_0: Distributions are identical)						

Table 5: Robustness Check: Controlling for Unpredicted Entry into Delinquency

The table below shows the effect of tranche multiplicity on the probability of loan modification, after controlling for unpredicted entry into 90+ days delinquency. The sample of mortgages used in this analysis were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan is modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. Default Residuals are the prediction errors from a first stage regression model (not shown in this Table) estimated on a sample of all loans originated in RMBS deals that closed between 2002 and 2007. The dependent variable in that regression is an indicator for whether the originated loan entered delinquency. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)
VARIABLES	P(Modify)	P(Modify)	P(Modify)	P(Modify)
Tranche Count	-0.0085***	-0.0093***		
	(0.0032)	(0.0034)		
Multiplicity (HHI)			0.0354***	0.0361***
			(0.0050)	(0.0051)
GSE Pool	-0.0638***	-0.0585***	-0.0637***	-0.0584***
	(0.0188)	(0.0188)	(0.0188)	(0.0188)
Default Residuals	-0.0029	-0.0040	-0.0031	-0.0042
	(0.0306)	(0.0299)	(0.0306)	(0.0299)
$(\text{Default Residuals})^2$	0.1277*	0.1292**	0.1274*	0.1289*
	(0.0670)	(0.0658)	(0.0671)	(0.0658)
$(\text{Default Residuals})^3$	-0.0611	-0.0615	-0.0603	-0.0606
	(0.0418)	(0.0412)	(0.0418)	(0.0412)
Observations	2,099,078	2,098,526	2,099,078	2,098,526
R-squared	0.1984	0.2027	0.1985	0.2028
Borrower & Loan Chars	X	X	X	X
HPI Change	X	X	X	X
CBSA x Quarter FE	X	X	X	X
Deal FE	X		X	
Servicer FE	X		X	
Deal by Servicer FE		X		X
Cluster	Deal	Deal	Deal	Deal
Mean of Dep Var	0.214	0.214	0.214	0.214

Table 6: Effect of Multiplicity on Modification by Subsamples

The table below shows effect of tranche multiplicity on loan modification for various subsamples of the data. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan is modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full Doc	Full Doc	Below CLL	Below CLL	30 Yr FRM	30 Yr FRM	Non-Complex	Non-Complex
VARIABLES	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)
Tranche Count	-0.0231***		-0.0122***		-0.0110***		-0.0233***	
	(0.0042)		(0.0035)		(0.0031)		(0.0033)	
Multiplicity (HHI)		0.0433***		0.0386***		0.0273***		0.0434***
		(0.0066)		(0.0061)		(0.0086)		(0.0064)
House Price Change	-0.0934***	-0.0937***	-0.0260	-0.0260	-0.1369**	-0.1370**	-0.0212	-0.0215
	(0.0255)	(0.0255)	(0.0204)	(0.0204)	(0.0534)	(0.0534)	(0.0227)	(0.0227)
Observations	1,249,234	1,249,234	1,843,142	1,843,142	306,298	306,298	1,579,449	1,579,449
R-squared	0.2080	0.2080	0.2017	0.2017	0.1778	0.1778	0.2087	0.2087
Borrower & Loan Chars	X	X	X	X	X	X	X	X
CBSA x Quarter FE	X	X	X	X	X	X	X	X
Deal FE	X	X	X	X	X	X	X	X
Servicer FE	X	X	X	X	X	X	X	X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.238	0.238	0.219	0.219	0.252	0.252	0.232	0.232

Table 7: Multiplicity of Tranches and Hazard Rate of Loan Modification

The table below shows the effect of tranche multiplicity on the hazard rate of loan modification. The estimation sample is a random 15% sample of mortgages that were originated between and including 2002 and 2007, which went delinquent before January 2009. Failure is defined as a loan receiving a modification. A loan is considered to be censored either if it "self-cures" without any action by the servicer, or if it enters into a foreclosure and is subsequently terminated. Once a loan receives a modification it leaves the sample. Multiplicity (HHI) is the inverse measure of multiplicity. The house price index change represents the change in the zip-code level house prices over the previous three months. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the CBSA level. *** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
VARIABLES				
Cohort of Delinquency 2003	0.288	0.259	0.049	-0.312
	(0.177)	(0.176)	(0.214)	(0.235)
Cohort of Delinquency 2004	0.713***	0.677***	0.542**	-0.026
	(0.170)	(0.170)	(0.237)	(0.259)
Cohort of Delinquency 2005	1.441***	1.376***	1.016***	0.261
	(0.165)	(0.165)	(0.239)	(0.262)
Cohort of Delinquency 2006	2.168***	2.069***	1.586***	0.611**
	(0.175)	(0.175)	(0.245)	(0.271)
Cohort of Delinquency 2007	2.795***	2.706***	2.298***	1.039***
	(0.181)	(0.182)	(0.248)	(0.275)
Cohort of Delinquency 2008	3.197***	3.151***	2.785***	1.313***
	(0.183)	(0.183)	(0.248)	(0.272)
House Price Index Change	-3.893***	-8.059***	-4.123***	-4.351***
	(0.347)	(0.382)	(0.340)	(0.327)
Multiplicity (HHI)	-0.196***	-0.275***	0.293***	0.146**
	(0.041)	(0.034)	(0.079)	(0.060)
Observations	7,074,157	7,074,157	7,015,350	6,893,323
CBSA FE		X		
Deal FE			X	X
Borrower & Loan Chars				X
Cluster	CBSA	CBSA	CBSA	CBSA
Log likelihood	-205565	-204028	-199466	-192995

Table 8: Tranche Count and Hazard Rate of Loan Modification

The table below shows the effect of tranche multiplicity on the hazard rate of loan modification. The estimation sample is a random 15% sample of mortgages that were originated between and including 2002 and 2007, which went delinquent before January 2009. Failure is defined as a loan receiving a modification. A loan is considered to be censored either if it "self-cures" without any action by the servicer, or if it enters into a foreclosure and is subsequently terminated. Once a loan receives a modification it leaves the sample. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. The house price index change represents the change in the zip-code level house prices over the previous three months. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the CBSA level. *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1)	(2)	(3)	(4)
Cohort of Delinquency 2003	0.277	0.246	0.048	-0.312
	(0.178)	(0.177)	(0.214)	(0.235)
Cohort of Delinquency 2004	0.702***	0.663***	0.541**	-0.026
	(0.171)	(0.171)	(0.237)	(0.258)
Cohort of Delinquency 2005	1.442***	1.377***	1.014***	0.260
	(0.165)	(0.165)	(0.239)	(0.261)
Cohort of Delinquency 2006	2.152***	2.048***	1.586***	0.612**
	(0.176)	(0.176)	(0.244)	(0.271)
Cohort of Delinquency 2007	2.779***	2.684***	2.298***	1.039***
	(0.182)	(0.183)	(0.247)	(0.274)
Cohort of Delinquency 2008	3.179***	3.127***	2.785***	1.313***
	(0.184)	(0.185)	(0.248)	(0.272)
House Price Index Change	-3.887***	-8.061***	-4.127***	-4.351***
	(0.347)	(0.382)	(0.340)	(0.327)
Tranche Count	0.065***	0.093***	-0.204***	-0.106***
	(0.010)	(0.010)	(0.039)	(0.029)
Observations	7,074,157	7,074,157	7,015,350	6,893,323
CBSA FE		X		
Deal FE			X	X
Borrower & Loan Chars				X
Cluster	CBSA	CBSA	CBSA	CBSA
Log likelihood	-205556	-204011	-199456	-192992

Table 9: Does Multiplicity Harm Investors? Effect of Multiplicity by House Price Rebound

The table below shows the effect of tranche multiplicity on loan modification for various subsamples of the data. The data are divided into three groups. Group 1 did not see a rebound in house prices between 2009 and 2012. Group 2 saw a low rebound in house prices while Group 3 saw a large rebound in house prices between 2009 and 2012. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan is modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)
	Baseline	Group 1	Group 2	Group 3
VARIABLES	P(Modify)	P(Modify)	P(Modify)	P(Modify)
Multiplicity (HHI)	0.0465***	0.0528***	0.0434***	0.0234**
	(0.0067)	(0.0074)	(0.0104)	(0.0093)
Observations	1,031,570	615,249	173,062	242,599
R-squared	0.2049	0.2127	0.2135	0.2062
Borrower & Loan Chars	X	X	X	X
HPI Change	X	X	X	X
CBSA x Quarter FE	X	X	X	X
Deal FE	X	X	X	X
Servicer FE	X	X	X	X
Cluster	Deal	Deal	Deal	Deal
Mean of Dep Var	0.275	0.301	0.253	0.226

Table 10: Multiplicity of Tranches and the Type of Modification

The table below shows the effects of tranche multiplicity on the type of loan modification used. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. I further restrict the sample to those loans that were modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Panel A Columns 1 and 2 have as the dependent variable in indicator for whether the modification involved a change in the monthly payment. Panel A Columns 3 and 4 has as the dependent variable $ln(\text{Post Mod PMT}) - ln(\text{Pre Mod PMT})$. Panel A Columns 5 and 6 have as dependent variable an indicator for whether the modification involved a change in the mortgage balance. Panel A Columns 7 and 8 have as the dependent variable $ln(\text{Post Mod Balance}) - ln(\text{Pre Mod Balance})$. Panel B Columns 1 and 2 have as a dependent variable an indicator for whether the modification involved a decrease in the payment without a concurrent increase in the mortgage balance. Panel B Columns 3 and 4 have as the dependent variable an indicator for whether the modification involved an increase in the mortgage balance without an accompanying decrease in the monthly payment. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Panel A: Change in monthly payment and outstanding balance

VARIABLES	(1) P(Pay Change)	(2) P(Pay Change)	(3) Δln(PMT)	(4) Δln(PMT)	(5) P(Bal Increase)	(6) P(Bal Increase)	(7) Δln(Balance)	(8) Δln(Balance)
Multiplicity (HHI)	0.0178***		-0.0202***		0.0035		-0.0019	
	(0.0051)		(0.0060)		(0.0070)		(0.0024)	
Tranche Count		-0.0114***		0.0074**		-0.0041		0.0005
		(0.0033)		(0.0034)		(0.0036)		(0.0013)
Observations	484,295	484,295	474,086	474,086	488,901	488,901	468,479	468,479
R-squared	0.3900	0.3900	0.2381	0.2381	0.1338	0.1338	0.1428	0.1428
Borrower & Loan Chars	X	X	X	X	X	X	X	X
HPI Change	X	X	X	X	X	X	X	X
CBSA x Quarter FE	X	X	X	X	X	X	X	X
Deal FE	X	X	X	X	X	X	X	X
Servicer FE	X	X	X	X	X	X	X	X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.848	0.848	-0.355	-0.355	0.684	0.684	0.00982	0.00982

Panel B: Analysis of commonly used loan modification types

VARIABLES	(1) P(PMT Decrease, No Balance Increase)	(2) P(PMT Decrease, No Balance Increase)	(3) P(Balance Increase, No PMT Decrease)	(4) P(Balance Increase, No PMT Decrease)
Multiplicity (HHI)	0.0012		-0.0262***	
	(0.0069)		(0.0062)	
Tranche Count		0.0026		0.0128***
		(0.0043)		(0.0046)
Observations	488,901	488,901	488,901	488,901
R-squared	0.1420	0.1420	0.2265	0.2265
Borrower & Loan Chars	X	X	X	X
HPI Change	X	X	X	X
CBSA x Quarter FE	X	X	X	X
Deal FE	X	X	X	X
Servicer FE	X	X	X	X
Cluster	Deal	Deal	Deal	Deal
Mean of Dep Var	0.252	0.252	0.206	0.206

Table 11: Multiplicity of Tranches and the GSEs

The table below shows the effect of tranche multiplicity and GSE pool ownership on the probability of loan modification. The sample of mortgages used are those that were originated between and including 2002 and 2007, went delinquent before January 2009, and belonged to deals classified as "Subprime" by ABSNet. Columns 3 and 7 further restrict the sample to those deals which did not have any loan pools specifically created for tranches to be owned by the GSEs. The dependent variable is an indicator equal to one if the delinquent loan is modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. GSE Pool is an indicator equal to one if the loan pool is identified has being one that was subsequently held by the GSEs through the ownership of the corresponding tranches. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)
Tranche Count	-0.0401***	-0.0240***	-0.0216***	-0.0196***				
	(0.0047)	(0.0050)	(0.0081)	(0.0051)				
Multiplicity (HHI)					0.0540***	0.0280***	0.0437***	0.0381***
					(0.0067)	(0.0071)	(0.0100)	(0.0080)
GSE Pool		0.0175***		0.0188***		0.0191***		0.0366***
		(0.0020)		(0.0020)		(0.0021)		(0.0039)
Tranche Count x GSE Pool				0.0127***				
				(0.0024)				
Multiplicity (HHI) x GSE Pool								-0.0453***
								(0.0083)
F-test p-value				0.2363				0.4002
Observations	1,723,834	1,723,834	598,643	2,133,503	1,723,834	1,723,834	598,643	2,133,503
R-squared	0.2144	0.2146	0.2424	0.2109	0.2144	0.2145	0.2424	0.2109
Borrower & Loan Chars	X	X	X	X	X	X	X	X
HPI Change	X	X	X	X	X	X	X	X
CBSA x Quarter FE	X	X	X	X	X	X	X	X
Deal FE	X	X	X	X	X	X	X	X
Servicer FE	X	X	X	X	X	X	X	X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.235	0.235	0.249	0.239	0.235	0.235	0.249	0.239

Internet Appendix - For Online Distribution Only

A Framework Solutions

A.1 Characterizing modification under information asymmetry

Let ϕ^*_ω denote the solution to the constrained first best case; i.e. the case solved under Assumption 2 made above. Let U_H and U_L denote utility to the servicer in the low and high states under truth-telling. Thus, I rewrite the constraints in terms of U_L, U_H and the cost functions and substitute $t_i = U_i + g_i C(\phi_i)$ for $i = \{H, L\}$ into the principal's objective function. This simplifies the problem to:

$$\max_{\{U_H,\phi_H\},\{U_L,\phi_L\}} p\left(Z(\phi_H(g_H)) + (1-p)\left(Z(\phi_L(g_L))\right)\right)$$
$$-pU_H - (1-p)U_L - pgC(\phi_H) - (1-p)g_L C(\phi_L)$$

subject to:

$$U_H \geq U_L - (g_H - g_L)C(\phi_L)\ (ICH)$$
$$U_L \geq U_H + (g_H - g_L)C(\phi_H)\ (ICL)$$
$$U_H \geq 0\ (PCH)$$
$$U_L \geq 0\ (PCL)$$

Lemma 1 is used to solve the optimal contracting problem.

Lemma 1. ***(a)*** *ICL and PCH imply PCL* ***(b)*** $\phi^*_L \geq \phi^*_H$ ***(c)*** *ICL binds* ***(d)*** *ICL binding and (b) implies ICH holds* ***(e)*** *PCH binds.*

Proof:

(a) is self-explanatory (b) is obtained by adding together the ICH and ICL constraints (c) by contradiction. Suppose ICL does not bind, then can reduce U_L without violating any constraints and improve the objective function, hence it cannot be optimal (d) is self-explanatory (e) by contradiction and using the fact that I can ignore ICH by part (d).

The lemma allows us to ignore ICH and PCL and shows that ICL and PCH will indeed bind in equilibrium. Thus I can substitute ICL and PCH into the objective function and take first order conditions with respect to ϕ_H and ϕ_L.

A.2 Solution to contracting with multiple tranches

The contracting problem to be solved now becomes:

$$\begin{aligned}\max_{\{U_H,\phi_H,\gamma_H,P_H\},\{U_L,\phi_L\gamma_L,P_L\}} & p\left(Z(\phi_H,V_H)+(1-p)\left(Z(\phi_L,V_L)\right)\right. \\ & -pU_H-(1-p)U_L-pV_HC(\phi_H)-(1-p)V_LC(\phi_L) \\ & -p\chi(\gamma_H,N)-(1-p)\chi(\gamma_L,N)\end{aligned}$$

subject to:

$$\begin{aligned}U_H \geq U_L-(V_H-V_L)C(\phi_L)-\gamma_L P_H\ (ICH) \\ U_L \geq U_H+(V_H-V_L)C(\phi_H)-\gamma_H P_L\ (ICL) \\ U_H \geq 0\ (PCH) \\ U_L \geq 0\ (PCL) \\ P_L \leq l \text{ and } P_H \leq l\end{aligned}$$

Note the differences in the objective function and the incentive compatibility constraints. The audit costs enter in the objective function in both the high and low states. In (ICL), for example, the expression on the right hand side of the inequality includes the expected cost that will be borne if the agent reports that the low state has occurred and gets audited. He will face penalty P_L. The solution to this contracting problem has the same rates of loan modifications (ϕ_H^*, ϕ_L^*) as in 3.2.2.[26]

[26] First note that it is not necessary to conduct an audit if $\hat{\omega}_L$ is reported, since ICH is slack in the no audit case, and so $\gamma_L = 0$. This in turn makes the choice of P_H irrelevant. Also see that in order to relax ICL as much as possible one can set $P_L = l$. I obtain the solution under the conjecture that PCH and ICL are the only remaining relevant constraints and confirm later the conditions under which this will hold.

However it gives rise to the following additional first order constraint:

$$\chi_\gamma(\gamma_H, N) = \frac{1-p}{p} l$$

B Appendix graphs and tables

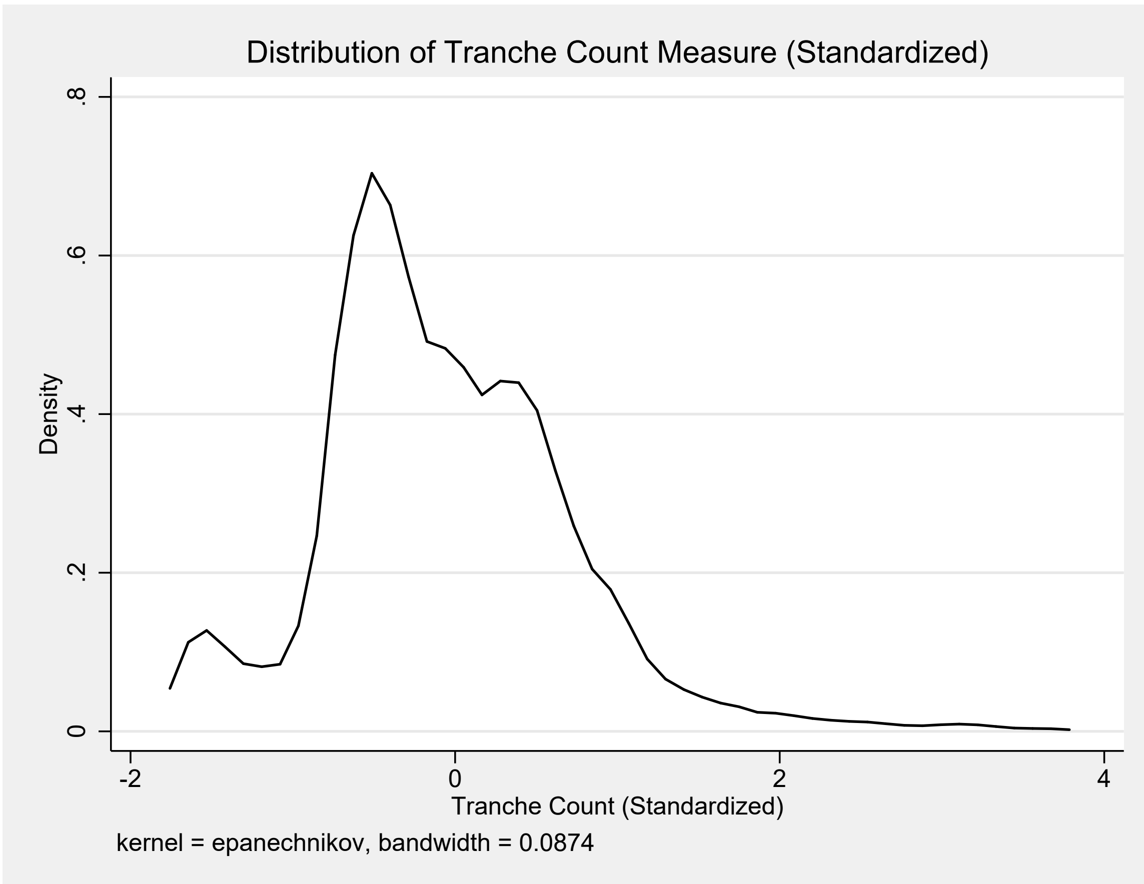


Figure B.1: Distribution of Tranche Count measure

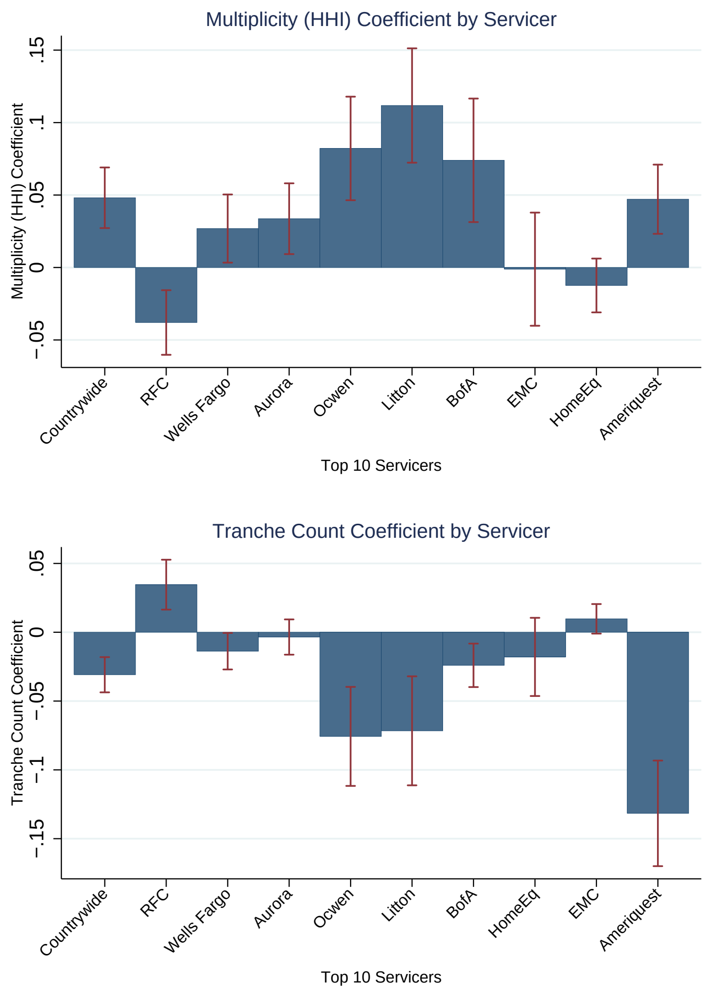


Figure B.2: Multiplicity (HHI) and Tranche Count coefficients by servicer (Top 10 servicers)
The figure above displays the results from estimating the main regression specification separately on each of the 10 largest servicers in my sample. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. Standard errors are clustered at the deal level.

Table B.1: Correlation between Tranche Multiplicity Measures and Loan Features

The table below presents results from a regression of the each of the tranche multiplicity measures on mortgage features at origination. The unit of observation for this regression is a loan pool. Each covariate is a loan pool average of the mortgages in the particular loan pool. The regressions are weighted least square regressions with weights equal to the number of loans within each loan pool. Standard errors are clustered at the deal level. *** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)	(5)	(6)
	Tranche Count	Tranche Count	Tranche Count	HHI	HHI	HHI
LTV>0.8	-0.530***	-0.352***	-0.229***	0.088***	0.042*	0.119***
	(0.101)	(0.091)	(0.069)	(0.025)	(0.023)	(0.028)
FICO<660	0.511***	0.258***	-0.393***	-0.249***	-0.184***	0.167***
	(0.094)	(0.086)	(0.150)	(0.019)	(0.018)	(0.045)
Cash Out Refi	-0.580***	-0.464***	-0.612***	0.230***	0.199***	0.334***
	(0.084)	(0.077)	(0.078)	(0.023)	(0.021)	(0.034)
Not Owner Occupied	-0.317***	-0.406***	-0.571***	0.071***	0.083***	0.147***
	(0.076)	(0.071)	(0.079)	(0.021)	(0.017)	(0.027)
ARM	-0.488***	-0.366***	-0.192***	0.151***	0.125***	0.122***
	(0.044)	(0.037)	(0.028)	(0.010)	(0.010)	(0.015)
PMI	-0.066	-0.059	-0.141	0.084***	0.081***	0.062
	(0.143)	(0.129)	(0.207)	(0.024)	(0.021)	(0.134)
CLTV>LTV	-0.161*	-0.247***	-0.333***	0.019	0.041***	0.180***
	(0.089)	(0.077)	(0.059)	(0.014)	(0.013)	(0.027)
CLTV	-0.005*	0.002	0.039***	-0.002	-0.004***	-0.032***
	(0.003)	(0.003)	(0.011)	(0.001)	(0.001)	(0.007)
Prepayment Penalty	0.104*	-0.117**	-0.062	-0.076***	-0.032***	0.020
	(0.060)	(0.053)	(0.081)	(0.014)	(0.012)	(0.039)
HELOC	-1.212***	-1.115***	-0.674***	0.353***	0.324***	0.412***
	(0.114)	(0.102)	(0.136)	(0.057)	(0.061)	(0.073)
IO	0.114	-0.223***	0.102	-0.031*	0.057***	-0.098***
	(0.071)	(0.070)	(0.082)	(0.017)	(0.016)	(0.030)
Negative Amortization	0.591***	0.388***	0.402***	-0.134***	-0.079***	-0.274***
	(0.090)	(0.086)	(0.121)	(0.023)	(0.022)	(0.064)
Low or No Doc	0.222***	0.120*	-0.031	-0.020	0.004	-0.121***
	(0.077)	(0.069)	(0.092)	(0.016)	(0.015)	(0.030)
Observations	11,516	11,516	11,516	11,516	11,516	11,516
R-squared	0.076	0.173	0.889	0.142	0.234	0.732
Vintage FE		X			X	
Deal FE			X			X

Table B.2: Multiplicity of Tranches and Foreclosure

The table below shows the effect of tranche multiplicity on entry into foreclosure. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan enters foreclosure. The indicator would be equal to zero if the loan was renegotiated before it entered foreclosure. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)
Tranche Count	0.0200***	0.0216***	0.0229***	0.0230***				
	(0.0031)	(0.0033)	(0.0035)	(0.0034)				
Multiplicity (HHI)					-0.0608***	-0.0619***	-0.0641***	-0.0652***
					(0.0054)	(0.0054)	(0.0059)	(0.0058)
Observations	2,225,128	2,224,566	2,222,003	2,225,543	2,225,128	2,224,566	2,222,003	2,225,543
R-squared	0.2238	0.2279	0.2374	0.2144	0.2239	0.2280	0.2375	0.2145
Borrower & Loan Chars	X	X	X	X	X	X	X	X
HPI Change	X	X	X	X	X	X	X	X
CBSA FE			X	X			X	X
CBSA x Quarter FE	X	X			X	X		
Deal FE	X			X	X			X
Servicer FE	X		X		X		X	
Deal x Servicer FE		X				X		
Deal x Quarter FE			X				X	
Serv x Quarter FE				X				X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.586	0.586	0.586	0.586	0.586	0.586	0.586	0.586

Table B.3: Effect of Multiplicity on Modification: Controlling for loan pool variation

The table below shows effect of tranche multiplicity on loan modification. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan is modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. % of Original Loan Pool Active is measured as the total balance of all active mortgages in a loan pool divided by the total balance of the loan pool at the deal's inception. Δln(Active Balance) is measured as the log change in the loan pool's total active balance over the last quarter. % Active Balance in Delinquency is measured as the total balance of loans in delinquency divided by the total active balance . Δln(Delinquent Balance) is the log change in the delinquent balance of the loan pool over the last quarter. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)	P(Modify)
Multiplicity (HHI)	0.0471***	0.0471***	0.0471***	0.0471***	0.0494***	0.0471***	0.0494***	0.0342***	0.0365***
	(0.0053)	(0.0052)	(0.0053)	(0.0052)	(0.0054)	(0.0053)	(0.0054)	(0.0055)	(0.0056)
% of Original Loan Pool Active		0.0262*		0.0257*					0.0536***
		(0.0151)		(0.0151)					(0.0174)
Δln(Active Balance)			0.0011***	0.0011***					0.0006
			(0.0004)	(0.0004)					(0.0005)
% of Active Balance in Delinquency					0.0608***		0.0605***		0.1061***
					(0.0209)		(0.0211)		(0.0275)
Δln(Delinquent Balance)						0.0008***	0.0008***		0.0007*
						(0.0003)	(0.0003)		(0.0004)
Geographic Diversification (HHI)								-0.0603***	-0.0689***
								(0.0134)	(0.0137)
Observations	1,781,754	1,781,754	1,781,754	1,781,754	1,781,754	1,781,754	1,781,754	1,781,754	1,781,754
R-squared	0.2053	0.2053	0.2053	0.2054	0.2054	0.2053	0.2054	0.2054	0.2055
Borrower & Loan Chars	X	X	X	X	X	X	X	X	X
HPI Change	X	X	X	X	X	X	X	X	X
CBSA x Quarter FE	X	X	X	X	X	X	X	X	Y
Deal FE	X	X	X	X	X	X	X	X	Y
Servicer FE	X	X	X	X	X	X	X	X	Y
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235

Table B.4: Effect of Multiplicity on Foreclosure by Subsamples

The table below shows effect of tranche multiplicity on entry into foreclosure for various subsamples of the data. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan enters foreclosure. The indicator would be equal to zero if the loan was renegotiated before it entered foreclosure. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full Doc	Full Doc	Below CLL	Below CLL	30 Yr FRM	30 Yr FRM	Non-Complex	Non-Complex
VARIABLES	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)	P(F'close)
Tranche Count	0.0379***		0.0188***		0.0109***		0.0368***	
	(0.0045)		(0.0034)		(0.0039)		(0.0034)	
Multiplicity (HHI)		-0.0760***		-0.0499***		-0.0539***		-0.0746***
		(0.0065)		(0.0058)		(0.0098)		(0.0066)
Observations	1,249,234	1,249,234	1,843,142	1,843,142	306,298	306,298	1,579,449	1,579,449
R-squared	0.2130	0.2130	0.2240	0.2240	0.2212	0.2213	0.2100	0.2100
Borrower & Loan Chars	X	X	X	X	X	X	X	X
HPI Change	X	X	X	X	X	X	X	X
CBSA x Quarter FE	X	X	X	X	X	X	X	X
Deal FE	X	X	X	X	X	X	X	X
Servicer FE	X	X	X	X	X	X	X	X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal	Deal
Mean of Dep Var	0.535	0.535	0.571	0.571	0.487	0.487	0.528	0.528

Table B.5: Multiplicity of Tranches and Hazard Rate of Foreclosure

The table below shows the effect of tranche multiplicity on the hazard rate of entry into foreclosure. The estimation sample is a random 15% sample of mortgages that were originated between and including 2002 and 2007, which went delinquent before January 2009. Failure is defined as a loan entering foreclosure . A loan is considered to be censored either if it "self-cures" without any action by the servicer, or if it is modified. Once a loan receives a modification it leaves the sample. Multiplicity (HHI) is the inverse measure of multiplicity. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. The house price index change represents the change in the zip-code level house prices over the previous three months. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the CBSA level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES								
Cohort of Delinquency 2003	-0.016	0.024	-0.406***	-0.305***	-0.013	0.024	-0.405***	-0.304***
	(0.067)	(0.066)	(0.073)	(0.078)	(0.065)	(0.065)	(0.073)	(0.077)
Cohort of Delinquency 2004	-0.211***	-0.164***	-0.549***	-0.365***	-0.232***	-0.187***	-0.547***	-0.364***
	(0.059)	(0.060)	(0.077)	(0.086)	(0.059)	(0.060)	(0.077)	(0.086)
Cohort of Delinquency 2005	-0.118*	-0.051	-0.639***	-0.364***	-0.137**	-0.070	-0.637***	-0.363***
	(0.062)	(0.065)	(0.085)	(0.096)	(0.062)	(0.065)	(0.084)	(0.096)
Cohort of Delinquency 2006	0.134*	0.239***	-0.635***	-0.294***	0.075	0.177**	-0.633***	-0.293***
	(0.074)	(0.073)	(0.095)	(0.109)	(0.076)	(0.075)	(0.095)	(0.109)
Cohort of Delinquency 2007	0.433***	0.577***	-0.352***	-0.075	0.368***	0.509***	-0.351***	-0.073
	(0.097)	(0.090)	(0.097)	(0.117)	(0.101)	(0.094)	(0.096)	(0.116)
Cohort of Delinquency 2008	0.381***	0.556***	-0.400***	-0.245**	0.314***	0.486***	-0.399***	-0.244**
	(0.093)	(0.084)	(0.092)	(0.121)	(0.096)	(0.087)	(0.091)	(0.121)
House Price Index Change	-6.095***	-4.391***	-5.452***	-3.819***	-6.042***	-4.368***	-5.441***	-3.815***
	(0.707)	(0.510)	(0.689)	(0.556)	(0.707)	(0.512)	(0.686)	(0.556)
Multiplicity (HHI)	-0.083	-0.122*	-0.290***	-0.149***				
	(0.071)	(0.065)	(0.073)	(0.047)				
Tranche Count					0.100***	0.112***	0.202***	0.112***
					(0.010)	(0.009)	(0.038)	(0.026)
Observations	7,044,507	7,044,507	7,044,507	6,912,502	7,044,507	7,044,507	7,044,507	6,912,502
CBSA FE		X				X		
Deal FE			X	X			X	X
Borrower and Loan Chars				X				X
Cluster	CBSA	CBSA	CBSA	CBSA	CBSA	CBSA	CBSA	CBSA
Log likelihood	-335831	-333756	-326616	-317657	-335699	-333597	-326594	-317649

Table B.6: Multiplicity of Tranches and Redefault

The table below shows the effect of tranche multiplicity on the rate of redefault of renegotiated loans. The sample of mortgages used are those that were originated between and including 2002 and 2007, those which went delinquent before January 2009 and were subsequently modified. The dependent variable is an indicator equal to one if the modified loan subsequently enters 90+ days delinquency. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

	(1)	(2)
VARIABLES	P(90+)	P(90+)
Tranche Count	0.0015	
	(0.0036)	
Multiplicity (HHI)		-0.0097
		(0.0067)
Observations	391,712	391,712
R-squared	0.1680	0.1680
Borrower & Loan Chars	X	X
HPI Change	X	X
CBSA x Quarter FE	X	X
Deal FE	X	X
Additional Controls	X	X
Cluster	Deal	Deal
Mean of Dep Var	0.728	0.728

Table B.7: Effect of Multiplicity by House Price Rebound (Foreclosure)

The table below shows the effect of tranche multiplicity on entry into foreclosure for various subsamples of the data. The data are divided into three groups. Group 1 did not see a rebound in house prices between 2009 and 2012. Group 2 saw a low rebound in house prices while Group 3 saw a large rebound in house prices between 2009 and 2012. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan enters foreclosure. The indicator would be equal to zero if the loan was renegotiated before it entered foreclosure. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

VARIABLES	(1) Baseline P(F'close)	(2) Group 1 P(F'close)	(3) Group 2 P(F'close)	(4) Group 3 P(F'close)
Multiplicity (HHI)	-0.0441***	-0.0488***	-0.0463***	-0.0236**
	(0.0062)	(0.0070)	(0.0109)	(0.0093)
Observations	1,031,570	615,249	173,062	242,599
R-squared	0.2107	0.2135	0.2226	0.2105
Borrower & Loan Chars	X	X	X	X
HPI Change	X	X	X	X
CBSA x Quarter FE	X	X	X	X
Deal FE	X	X	X	X
Servicer FE	X	X	X	X
Cluster	Deal	Deal	Deal	Deal
Mean of Dep Var	0.657	0.624	0.684	0.719

Table B.8: Robustness to Tranche Seniority

The table below shows the effect of tranche multiplicity on loan modifications. The sample of mortgages used are those that were originated between and including 2002 and 2007, and those which went delinquent before January 2009. The dependent variable is an indicator equal to one if the delinquent loan is modified. Tranche Count is the standardized measure of the number of tranches collateralized by a particular loan pool. Multiplicity (HHI) is the inverse measure of multiplicity. Average Tranche Seniority measures the weighted average subordination of the RMBS tranches that are collateralized by a particular loan pool. House Price Change is calculated as the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Additional loan-level controls include: indicators for owner-occupied property, private mortgage insurance, presence of second-lien, and whether the loan is interest-only, adjustable rate, negative amortization, has a balloon payment, and has prepayment penalties; CLTV at origination, CLTV at origination squared, log of appraised value at origination, the interest-rate, the age of the loan (in months) at delinquency. Standard errors are clustered at the deal level. *** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
VARIABLES	P(Modify)	P(Modify)	P(Modify)	P(Modify)
Tranche Count	-0.0091***	-0.0097***		
	(0.0033)	(0.0035)		
Multiplicity (HHI)			0.0361***	0.0364***
			(0.0052)	(0.0052)
Average Tranche Seniority	-0.0019	-0.0075	0.0118	0.0053
	(0.0154)	(0.0157)	(0.0152)	(0.0154)
Observations	2,224,854	2,224,292	2,224,854	2,224,292
R-squared	0.1977	0.2019	0.1978	0.2020
Borrower & Loan Chars	X	X	X	X
HPI Change	X	X	X	X
CBSA x Quarter FE	X	X	X	X
Deal FE	X		X	
Servicer FE	X		X	
Deal by Servicer FE		X		X
Cluster	Deal	Deal	Deal	Deal
Mean of Dep Var	0.214	0.214	0.214	0.214

C Pooling and Servicing Agreement Excerpts

This section presents a few excerpts from the Pooling and Servicing Agreements of RMBS deals. They highlight the need for a given level of coordination among MBS bond-holders to effect change in the Pooling and Servicing Agreement and discipline the mortgage servicer. Often, the Pooling and Servicing Agreements allowed changes to be made without the consent of the certificate-holders in order to cure any ambiguity or mistake. Typically, the PSA sections on 'Amendment' or 'Limitations to the Rights of Certificate Holders' discussed the percentage of certificate holders' interests that needed to be represented before any changes could be made. See Thompson (2011) for additional discussion.

WaMu Mortgage Pass-Through Certificates, Series 2004-AR13

Section 10.03: Limitation on Rights of Certificate Holders

No Certificateholder shall have any right by virtue or by availing of any provision of this Agreement to institute any suit, action or proceeding in equity or at law upon or under or with respect to this Agreement, unless such Holder previously shall have given to the Trustee a written notice of default and of the continuance thereof, as hereinbefore provided, and ***unless also the Holders of Certificates evidencing Percentage Interests aggregating not less than 25% of REMIC II shall have made written request upon the Trustee to institute such action, suit or proceeding*** *in its own name as Trustee hereunder and shall have offered to the Trustee such reasonable indemnity as it may require against the costs, expenses and liabilities to be incurred therein or thereby, and the Trustee, for 60 days after its receipt of such notice, request and offer of indemnity, shall have neglected or refused to institute any such action, suit or proceeding.*

Structured Asset Securities Corp 2005-S4

Section 8.01 Limitation on Rights of Holders.

No Certificateholder, solely by virtue of its status as Certificateholder, shall have any right by virtue or by availing of any provision of this Agreement to institute any suit, action or proceeding in equity or at law upon or under or with respect to this Agreement, ***unless such Holder previously shall have given to the Trustee a written notice of an Event of Default and of the continuance thereof, as hereinbefore provided, and unless also the Holders of Certificates evidencing not less than 25% of the Class Principal Amount (or Percent-***

age Interest) of Certificates of each Class affected thereby *shall have made written request upon the Trustee to institute such action, suit or proceeding in its own name as Trustee hereunder and shall have offered to the Trustee such reasonable indemnity as it may require against the cost, expenses and liabilities to be incurred therein or thereby...*

Banc of America Mortgage 2006-A

Section 11.01: Amendment

This Agreement may also be amended from time to time by the Depositor, the Servicer and the Trustee, with the consent of the Holders of Certificates of each Class of Certificates which is affected by such amendment, evidencing, as to each such Class of Certificates, Percentage Interests aggregating not less than 66-2/3%, *for the purpose of adding any provisions to or changing in any manner or eliminating any of the provisions of this Agreement or of modifying in any manner the rights of the Holders of such Certificates; provided, however, that no such amendment shall (A) reduce in any manner the amount of, or delay the timing of, collections of payments on Mortgage Loans or distributions which are required to be made on any Certificate without the consent of the Holder of such Certificate or (B) reduce the aforesaid percentage required to consent to any such amendment, without the consent of the Holders of all Certificates then Outstanding.*

J.P. Morgan Mortgage Trust 2006-A4

Section 8.01: Rights of Certificate Holders

No Certificateholder, solely by virtue of its status as Certificateholder, shall have any right by virtue or by availing of any provision of this Agreement to institute any suit, action or proceeding in equity or at law upon or under or with respect to this Agreement, unless such Holder previously shall have given to the Trustee and the Securities Administrator a written notice of an Event of Default and of the continuance thereof, as hereinbefore provided, and ***unless also the Holders of Certificates evidencing not less than 25% of the Class Principal Amount of Certificates of each Class affected thereby shall have made written request upon the Trustee and the Securities Administrator to institute such action, suit or proceeding in its own name as Trustee hereunder*** *and shall have offered to the Trustee and the Securities Administrator such reasonable indemnity as they may require against the cost, expenses and liabilities to be incurred therein or thereby...*

CHL Mortgage Pass-Through Trust 2006-3

Section 10.01: Amendment

This Agreement may also be amended from time to time by the Depositor, each Seller, the Master Servicer and the Trustee with the consent of the Holders of a Majority in Interest of each Class of Certificates in the applicable Certificate Group affected thereby for the purpose of adding any provisions to or changing in any manner or eliminating any of the provisions of this Agreement or of modifying in any manner the rights of the Holders of Certificates; provided, however, that no such amendment shall (i) reduce in any manner the amount of, or delay the timing of, payments required to be distributed on any Certificate without the consent of the Holder of such Certificate, (ii) adversely affect in any material respect the interests of the Holders of any Class of Certificates in a manner other than as described in (i), ***without the consent of the Holders of Certificates of such Class evidencing, as to such Class, Percentage Interests aggregating 66-2/3%*** *or (iii) reduce the aforesaid percentages of Certificates the Holders of which are required to consent to any such amendment, without the consent of the Holders of all such Certificates in the applicable Certificate Group then outstanding.*

Section 10.08: Limitations of the rights of Certificateholders

No Certificateholder shall have any right by virtue or by availing itself of any provisions of this Agreement to institute any suit, action or proceeding in equity or at law upon or under or with respect to this Agreement, unless such Holder previously shall have given to the Trustee a written notice of an Event of Default and of the continuance thereof, as provided in this Agreement, ***and unless the Holders of Certificates evidencing not less than 25% of the Voting Rights evidenced by the Certificates shall also have made written request to the Trustee to institute such action, suit or proceeding in its own name as Trustee hereunder*** *and shall have offered to the Trustee such reasonable indemnity as it may require against the costs, expenses, and liabilities to be incurred therein or thereby....*