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The agency costs of tranching: Evidence from RMBS☆

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ABSTRACT

This paper documents the agency costs resulting from the deeper tranching of subprime residential mortgage pools. Mortgage servicers are less likely to renegotiate delinquent loans collateralizing a greater number and variety of tranches. We find that an interquartile increase in tranching reduces mortgage servicers' probability of loan renegotiation by 14% relative to the mean. This effect is concentrated in mortgages with greater ambiguity surrounding the loan value maximizing action. Overall, our results support the notion that tranching worsens agency frictions by increasing coordination costs among investors and impeding their monitoring of the agent.

1. Introduction

The benefits of tranching—a feature of asset-backed security (ABS) design—have been extensively studied in the corporate finance literature. Creating multiple tranches allows ABS issuers to raise capital from a wide range of sources and to offer investors more attractive pricing. Tranching improves the liquidity of resulting securities (DeMarzo and Duffie, 1999; DeMarzo, 2005); allows ABS issuers to tailor the risk-return profile of offered securities to investor preferences (Oldfield, 2000); and improves the efficiency of securities markets (Duffie and Rahi, 1995).

However, the corporate finance literature also suggests that increasing the dispersion and diversity of investors (Rauh and Sufi, 2010; Colla et al., 2013) can lead to, or exacerbate, principle–agent problems (Bris and Welch, 2005; Ivashina et al., 2016). Dispersed ownership of the asset pool by heterogeneous investors increases coordination costs and decreases investors' ability and incentives to monitor their agent (Diamond, 1984; Hertzberg et al., 2011) as they hold securities with different priorities and control provisions.

Residential mortgage-backed security (RMBS) markets are not free from principal–agent problems as servicing agents manage loans on behalf of RMBS investors. Mortgage servicers collect payments from borrowers and determine whether to renegotiate delinquent loans. Agency frictions in this market cause suboptimal rates of delinquent loan renegotiation by servicers (Piskorski et al., 2010; Agarwal et al., 2011; Kruger, 2018) and increase loan losses (Maturana, 2017). Investors across the RMBS tranching structure must coordinate to monitor and discipline servicers since Pooling and Servicing Agreements (PSAs) require a majority agreement to act against the agent (Gelpern and Levitin, 2009; Dana, 2010).

This paper argues that coordination frictions between investors in deeply tranched RMBS loan pools—i.e., those with a greater number and variety of bondholders — impede their monitoring of servicing agents and allow agents to shirk on costly effort. In the presence of coordination frictions associated with deeper tranching, servicers are likely to allocate less effort to renegotiations of delinquent loans and, by extension, contribute to larger loan losses. Examining RMBS servicer decisions on 1.5 million delinquent loans, we find that an interquartile increase in tranching reduces servicers' probability of renegotiation by 14 percent relative to the mean. These lower rates of renegotiation are not offset by modification leniency or post-modification re-defaults. Finally, we show that the effects of tranching are driven by both diversity in tranche seniorities and the number of tranches. Overall, the tranching of cash flows appears to worsen agency frictions between investors and their servicer.

Identifying the agency costs of tranching is beset with several empirical challenges. First, we need to observe and measure tranching structures that vary across asset pools. Second, a pool's tranching structure, its credit quality, and the agents' actions are all endogenously

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determined. Third, it may be challenging to observe specific actions taken by the agent which have clear counterfactuals. Finally, agent skill and capacity are often unobserved and could lead to omitted variable bias.

We overcome these challenges by studying debt heterogeneity in the context of private-label RMBS. First, we use data on 3900 non-agency subprime RMBS loan pools that are originated between 2002 and 2007 and financed by a wide range of tranching schemes. For each pool, we construct two tranching measures (i) the number of tranches collateralized by a loan pool, and (ii) a tranche Herfindahl–Hirschman Index (HHI) constructed at the loan-pool level, using the dollar size of each tranche associated with a given pool. On average, each loan pool is financed using 13 tranches, and the number of tranches varies from 1 to 23. The average Tranche HHI is 0.34, with a range between 0.08 and 1. We then validate these measures using data on the RMBS holdings of the universe of life-insurance companies (LICs), and show that these investors do not systematically hold more than one tranche backed by a given loan pool.

Second, we explicitly account for the endogenous relationship between tranching and credit quality by focusing on servicers' actions that are plausibly independent of the composition and quality of the tranched loan pools. We study renegotiation and foreclosure decisions pertaining to 1.5 million already delinquent first-lien mortgages of which 24.7 percent were ultimately renegotiated. Focusing on delinquent loans allows us to isolate and observe loss mitigation decisions over which a mortgage servicer has discretion, and which have a clear counterfactual. Furthermore, we control for a rich set of loan- and borrower-level characteristics that are available to RMBS investors.

Finally, while we do not directly observe servicers' skill or capacity constraints, our empirical setting allows us to control for these factors non-parametrically. Specifically, we exploit the fact that servicers manage multiple loan pools for different RMBS deals and employ a servicer-by-time fixed-effect. Effectively, we compare renegotiation decisions made by the same servicer, on observationally equivalent delinquent mortgages, which reside in loan pools with different degrees of tranching. Overall, our novel empirical setting allows us to isolate the effect of tranching on the agent's mortgage renegotiation decisions.

Using this unique empirical laboratory, we first examine the effect of tranching on the renegotiation of delinquent loans by the servicing agent. We find that an interquartile increase in the number of tranches (decrease in the tranche HHI) reduces the probability of loan modification by 3.5 percentage points (p.p.) (1.9 p.p.). This represents a decrease in loan modification by 14 percent (8 percent) relative to the mean. Servicers adjust their renegotiation only along the extensive margin, as the efficacy of the completed renegotiation is not affected by tranching. There is no relationship between tranching and modification leniency, or the re-default rates of modified loans. This is consistent with tranching influencing the decision to renegotiate, but not the quality of renegotiation, or the effort per loan modification.

These results are robust to various other model specifications. One may be concerned that our tranching measures understate the concentration of investors by giving full credit to cross-collateralized tranches. We find consistent results using alternative measures of tranching which disregard cross-collateralized bonds. RMBS issuers may structure tranches using their superior information (relative to investors) about loan pool credit quality. We confirm the result's robustness to controlling for Begley and Purnanandam (2016) abnormal delinquency measure which proxies for private information held by RMBS issuers.

In the second part of our analysis, we recognize that tranching brings two types of coordination frictions in an environment where a supermajority is required to influence agents' actions (Dana, 2010). First, coordination is challenging when investors hold different cash flow rights (junior vs. mezzanine vs. senior) that are differentially exposed to losses and benefit unequally from monitoring (Gelpern and Levitin, 2009). Second, coordination frictions may arise even if investors hold identical claims. These frictions take the form of free-rider problems in monitoring the agent (e.g., Holmstrom, 1982; Diamond, 1984). Both frictions are arguably amplified by the degree of tranching. To address these economic mechanisms, we decompose our measure into two components: one which captures the variety of cash flow rights (number of subordination levels), and another which captures the number of possible investors (tranches per subordination level). We find that both mechanisms are economically and statistically significant. An increase in each component from the 25th to the 75th percentile predicts, respectively, a 4 percent and 7 percent decrease in renegotiation relative to the mean, controlling for all observable characteristics.

In a third set of tests, we show that tranching leads servicers to shirk on loan renegotiation effort particularly when it is not obvious ex-ante which course of action will benefit investors—renegotiation or foreclosure. For example, high-LTV loans may have higher modification re-default risk (i.e., relatively lower modification NPV), but foreclosure might be associated with higher loss given default (i.e., relatively higher modification NPV) making the "right" decision ambiguous. In our tests we exploit this ambiguity while controlling for the baseline effect of loan characteristics such as LTV on servicers' renegotiation decisions. We find that the effects of tranching are stronger for higher LTV loans. Similarly, we find that renegotiation is more sensitive to tranching for loans experiencing large declines in collateral value, low documentation loans, loans that are accompanied by a second lien, and loans on non-owner-occupied properties. These additional results support our findings on coordination problems and the worsening of agency frictions.

Taken together, our results support the notion that tranching worsens agency frictions by increasing the coordination costs among dispersed investors with varying cash flow rights. Tranching thus impedes investors' ability to monitor their agents and contributes to sub-optimal servicer decisions.

Our findings add to multiple streams of the literature. First, we extend the literature on securitization and loan modification. Piskorski et al. (2010), Agarwal et al. (2011), and Kruger (2018) document that securitized delinquent loans are renegotiated at lower rates and we offer an explanation for their findings. We have built on this literature by recognizing that securitized loans are financed by a variety of tranches held by heterogeneous investors. With deeper tranching it is increasingly costly for dispersed investors to coordinate monitoring and discipline the agent, giving rise to agency problems evidenced by lower loan modification rates.

Second, we add to the security design literature, which has largely focused on the benefits of tranching. Optimal security design often involves tranching to overcome adverse selection and moral hazard problems, and to improve the liquidity of issued securities (Winton, 1995; DeMarzo and Duffie, 1999; DeMarzo, 2005; Begley and Purnanandam, 2016). Tranching creates value by allowing issuers to tailor securities' cash flows, maturities, and seniority to better match investor demand (Oldfield, 2000; An et al., 2009). By creating this variety of securities, tranching also improves the efficiency of capital markets (Duffie and Rahi, 1995). In contrast, our paper highlights the costs of tranching that arise when increased coordination frictions among tranche investors worsen principal–agent problems.

Finally, our findings extend well beyond the RMBS setting. Firms employ multi-tiered capital structures (Rauh and Sufi, 2010 and Colla et al., 2013) which influence financing (Hertzberg et al., 2011; Bennardo et al., 2015) and bankruptcy outcomes (Bris and Welch, 2005; Demiroglu and James, 2015; Ivashina et al., 2016). In the syndicated lending market, the agent bank services the loan package on behalf of other syndicate members and is subject to agency frictions (Dennis and Mullineaux, 2000). In a Collateralized Loan Obligation (CLO), agents akin to mortgage servicers can act in their own best interest to the detriment of CLO investors (Chernenko, 2017; Peristiani and Santos, 2019). In each of these settings, complex financing structures with numerous investors have the potential to exacerbate agency frictions.

Table 1
An example of a RMBS deal.

(1) Tranche	(2) Pools	(3) Class balance
1-A-1	1	145,078,000
1-A-2	1	16,000,000
1-A-3	1	105,000,000
1-A-4	1	26,000,000
2-A-1	2	318,985,000
2-A-2	2	30,000,000
M-1	Both	40,357,000
M-2	Both	15,714,000
B-1	Both	7,143,000
B-2	Both	5,714,000

The table 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 of tranches with claims to loan pool 2 is $418 million.

2. Data and institutional setting

The RMBS market is a useful empirical laboratory to study the effects of tranching on agency frictions. Here, we describe the economically and empirically important elements of this setting, motivate our hypotheses, and describe the data used to test them.

2.1. Agency problems in RMBS

An RMBS *deal* will typically consist of one or more loan *pools* which are made up of residential *mortgages*. The mortgages generate cash flows as borrowers make interest and principal payments. Loan pools are funded by issuing mortgage-backed securities to investors who receive these cash flows.

The interaction of investors and RMBS issuers determines the deal structure. Investors with a wide range of risk-return preferences participate in the RMBS market. For example, pension funds hold AAA rated securities, insurance companies reach for yield (Merrill et al., 2019) and hedge funds take speculative positions in junior tranches (Mählmann, 2013). RMBS issuers structure securitizations to cater to this demand and achieve the desired credit ratings, default probabilities and yields. Issuers choose the composition of the loan pools and determine the size and priority of RMBS tranches.

While investors receive cash flows from the loan pool, the mortgages are managed by the servicer. This servicing agent collects interest and principal from mortgage borrowers and allocates them to securities based on a waterfall. When borrowers are current on their loans, a servicer exercises little of their own discretion. However, when a borrower becomes delinquent and misses a sequence of payments it is the mortgage servicer who determines whether to foreclose upon the borrower, renegotiate the mortgage, or simply do nothing.

The servicer is arguably better informed than investors about whether modification or foreclosure results in higher expected cash flows from a delinquent mortgage. After all, the servicers, not the investors, are the agents who interact with the borrowers on a day-to-day basis. This creates an opportunity for the servicer to act in their own best interest to the detriment of investors and potentially foreclose upon delinquent loans even when renegotiating is the loan value maximizing action. Piskorski et al. (2010), Agarwal et al. (2011) and Kruger (2018) highlight this agency problem and show that securitized loans are renegotiated at sub-optimally lower rates. These frictions are costly to investors as failure to renegotiate results in loan losses (Maturana, 2017).

Investors can mitigate agency frictions using clauses in the PSA that allow them to terminate the servicer or amend the PSA. However, invoking these clauses requires coordination across dispersed bondholders of varying priorities (Dana, 2010; Thompson, 2011). While servicer termination and PSA amendment are not observable to researchers, we do see examples of likely expensive legal action taken by individual investors when such coordination fails.

For example, in 2009 a hedge fund manager sued American Home Mortgage Servicing Inc. for improperly and rapidly liquidating properties to repay their lines of credit. In 2018, pension funds took legal action against Ocwen for sabotaging loan modifications because the servicer profited from completing foreclosures.[1] These examples illustrate that coordination frictions can be costly, and they make acting on information gathered through monitoring more challenging.

We argue that the more deeply tranched a pool, the greater the number and variety of bondholders with claims to the pool, the harder it is for them to coordinate, and the weaker the monitoring of the agents' actions. Agents in turn should allocate more effort to pools that are more carefully monitored. Taken together, in the presence of coordination frictions, pools that are more deeply tranched should amplify agency frictions and exhibit a lower probability of loan modification conditional on delinquency.

2.2. Data and sample selection

The primary data used to test our hypotheses come from ABSNet Loan. ABSNet aggregates data from RMBS trustee reports, and covers the majority of private-label RMBS issuances. The most important feature of this data is that it provides, for each securitization deal, a mapping from individual mortgages to loan pools, and from loan pools to tranches. The dataset also gives us detailed information on borrower and loan characteristics, loan performance (until December 2013), loan modifications, and the identity of the mortgage servicer, all of which are available at the loan-level.

We use data on 1273 subprime RMBS deals originated between 2002 and 2007. To implement the empirical strategy described in Section 3 we restrict analysis to deals which had more than one loan pool. This leaves us with a sample of 5.8 million residential mortgages residing in about 3900 loan pools. Data from Zillow is used to construct controls for changes in local house prices prior to delinquency.

2.3. Measuring tranching

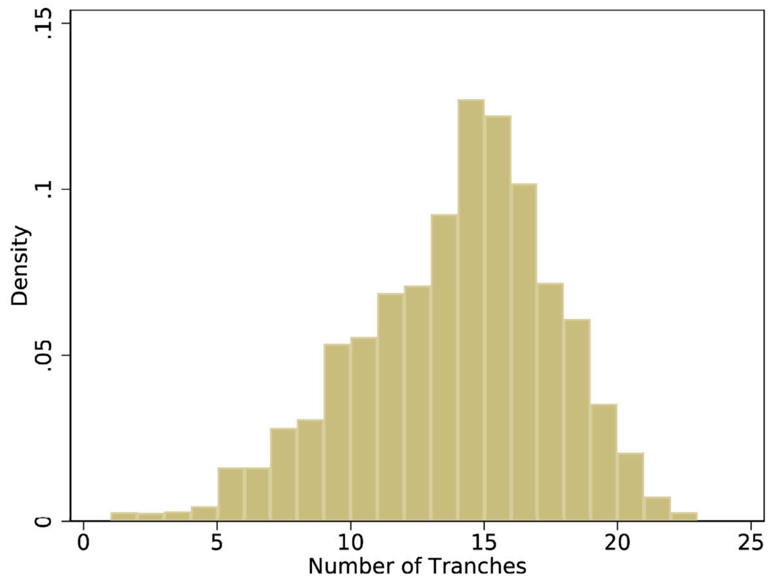
We develop two measures of the tranche structure to test for the effect of RMBS tranching. The first measure is simply a count of tranches collateralized by a given loan pool. The second is a measure of tranche concentration.

Table 1 presents an example of a tranching structure used in RMBS markets. The transaction is the MASTR Adjustable Rate Mortgages (ARM) Trust 2004–11, a $709 million RMBS deal. This deal consists of two loan pools which collateralize a total of 10 tranches. Column 1 lists the tranches, while Column 2 indicates whether the tranches draw cash flows from the first, second, or both the loan pools. Column 3 reports the class balance at issuance for each tranche.

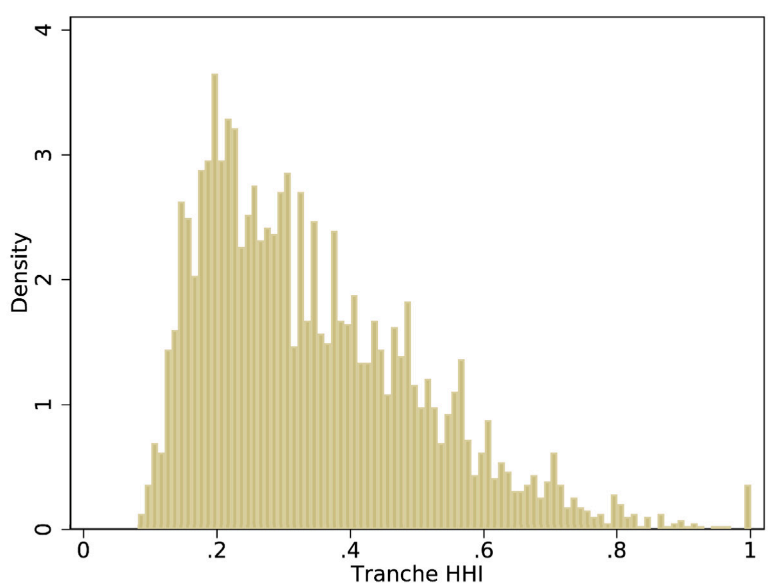
To establish notation, assume that a deal has J tranches given by the set $T = \{T_1, \ldots, T_J\}$ collateralized by K loan pools given by the set $P = \{P_1, \ldots, P_K\}$. Let M be a mapping from the set of loan pools to the set of tranches. $M(P_k)$ is the set of tranches which receive cash flows from loan pool P_k.

The first measure of tranching takes the simplest approach and counts the tranches that have claims to each individual loan pool in a

[1] WSJ article on American Home Mortgage Servicing Inc. lawsuit: https://www.wsj.com/articles/SB123431311043370779 Reuters article on Ocwen lawsuit: https://www.reuters.com/article/us-otc-mbs/new-front-in-mbs-litigation-pension-funds-claim-ocwen-breached-erisa-duty-idUSKCN1GI2VJ.



(a) Distribution of the Number of Tranches



(b) Distribution of Tranche HHI

Fig. 1. Distribution of loan-pool level tranching measures. The diagrams above show the distribution of the Number of Tranches (figure (a)) and of Tranche HHI (figure (b)).

particular RMBS deal. For the example in Table 1, the count for loan pool 1 would be 8 and the count for loan pool 2 would be 6. We plot the distribution of the resulting measure of the number of tranches in Fig. 1a. Table 2a summarizes the moments of the distribution. The number of tranches varies between 1 and 23. This variable has a mean of 13, a median of 14, an interquartile range of 5 and a standard deviation of 4.

The second measure of tranching captures the concentration of the tranches receiving cash flows from a given loan pool. In addition to just the number of tranches, it accounts for the relative size (face value at origination) of each tranche with claims to a loan pool. To construct this measure we follow the Herfindahl–Hirschman Index (HHI) approach used by Sufi (2007) to measure concentration of syndicate members in the syndicated loan market. In terms of the pools, tranches and mapping $M(P_k)$ described above, Tranche HHI is calculated as:

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

where V_{T_j} is the principal balance at origination of the tranche T_j. Essentially Tranche HHI is a weighed average of 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. In the example of the MASTR ARM Trust, pool 1 (tranche HHI of 0.27) is less concentrated and more deeply tranched compared to pool 2 (tranche HHI of 0.6). The distribution of this measure across pools is plotted in Fig. 1(b). Tranche HHI has a mean of 0.34, a median of 0.31, an interquartile range of 0.23 and a standard deviation of 0.17 (see Table 2a).

Table 2
Summary statistics.

(a) Pool-level tranching statistics

	N	Mean	St Dev	Min	p10	p25	p50	p75	p90	Max
Number of Tranches	3889	13	4	1	8	11	14	16	18	23
Ln(Number of Tranches)	3889	2.54	0.36	0.00	2.08	2.40	2.64	2.77	2.89	3.14
Tranche HHI	3889	0.34	0.17	0.08	0.16	0.21	0.31	0.44	0.57	1.00

(b) Deal and pool statistics by Tranche HHI

	Panel A Deal-level summary stats by Tranche HHI		Panel B Pool-level summary stats by Tranche HHI	
	Low HHI	High HHI	Low HHI	High HHI
N	637	636	1945	1944
No. of Tranches	18.3	14.0	14.8	12.1
Tranche HHI	0.18	0.36	0.21	0.47
Avg. No. of loans in pool or deal	4899.7	4176.3	1291.0	1680.1
Avg. size ($'s millions) of Pool or Deal	953.4	768.0	269.4	294.1
No. of servicers per pool or deal	1.6	1.5	1.6	1.5
Average credit score	628.1	625.5	633.0	626.1
Average CLTV	83.1	91.8	83.0	89.8
Average interest rate	7.8	7.7	7.6	7.7
% ever 60+ days delinquent in pool or deal	50.3	41.0	47.3	42.3

(c) Loan-level statistics by Tranche HHI

	Panel C All originated loans by Tranche HHI		Panel D 60+ days before Jan 2009 by Tranche HHI	
	Low HHI	High HHI	Low HHI	High HHI
N	2,511,078	3,266,166	733,970	776,263
Modified (%)			26.1	23.5
Foreclosed (%)			69.9	61.7
Credit score (Origination)	623.8	616.8	617.2	604.6
CLTV at origination (%)	84.1	95.1	85.2	91.6
Appraised value at origination ($'000s)	269.9	226.8	307.6	240.1
Not owner occupied (%)	12.2	18.1	11.4	20.3
Has second lien (%)	14.7	11.1	20.3	13.9
Interest rate	8.0	7.9	8.3	8.3
Purchase loans (%)	40.6	32.0	47.7	32.6
Has prepayment penalty (%)	39.7	31.5	48.7	37.6
IO loan (%)	13.5	11.5	18.1	13.8
Balloon payment (%)	12.4	6.8	20.1	12.3
Negative amortization (%)	0.0	0.1	0.0	0.0
Low or no documentation (%)	29.5	29.1	36.1	31.5
Adjustable rate (%)	68.2	76.6	79.9	84.0
Has PMI (%)	5.1	6.8	4.4	8.3
Change in house prices (Orig. to Del.) (%)			−3.18	1.22

The tables presents summary statistics on the sample of loan pools and mortgages used in the analysis. The sample includes mortgages from private-label RMBS deals which closed between and including 2002 and 2007 which consisted of two or more mortgage pools. Table (a) presents summary statistics on our loan-pool level measures of tranching. Table (b) presents deal- and pool-level summary statistics after splitting the sample by below and above median Tranche HHI measured at the deal- and pool-level respectively. Pools with lower tranching have a higher Tranche HHI, and vice-versa. Panel A presents deal-level summary statistics and Panel B presents pool-level summary statistics. Table (c) presents loan-level summary statistics from the sample of mortgages that reside in below-median HHI pools or above-median HHI pools. Panel C presents summary statistics from all originated mortgages. Panel D restricts the analysis to mortgages that became 60+ days delinquent before January 2009, which enter the main analysis.

2.4. Analysis sample and outcome variables

We summarize the data by dividing our sample of RMBS deals and pools into two groups: below median Tranche HHI (i.e. lower concentration and a higher degree of tranching) and above median Tranche HHI (i.e. higher concentration). Being a normalized measure, tranche HHI better facilitates comparisons across RMBS deals or loan pools. In Table 2b we split deals and pools, respectively, into the two groups and report deal-level (Panel A) and pool-level (Panel B) statistics that are constructed using all originated loans. We observe, naturally, that there is a correlation between the composition of the deals or pools, the tranching structure and loan delinquency. Low HHI deals or pools have a larger fraction of mortgages that become at least 60+ days delinquent, despite having loans with lower CLTVs and marginally higher credit scores.

This correlation must be confronted if we are to take the tranching structure as given in our subsequent tests. To address this, we first conduct our analysis at the loan-level and control for all mortgage and borrower characteristics observed by RMBS investors. These loan-level characteristics are listed in Panel C of Table 2c, which documents how they vary for originated mortgages in high and low HHI pools. Individual loans in low HHI pools once again exhibit lower average CLTVs and higher average credit scores than those in high HHI pools. High HHI loans finance homes with lower appraised values, are more likely to be adjustable rate mortgages and finance more non-owner occupied properties.

As a second step, and most importantly, our analysis focuses on servicers' actions over already delinquent loans and so is free from the bias induced by heterogeneity in loan pool quality. Loans whose delinquencies have been realized are more comparable across pools. Additionally, the servicer only has meaningful discretion over managed loans once borrowers are seriously delinquent. We condition our analysis on mortgages becoming 60+ days delinquent and only consider loans becoming delinquent before January 2009, when government intervention in mortgage markets begins in earnest. Table 2c Panel D compares delinquent loans in high HHI pools to those in low HHI pools. The similarities and differences between loans in low vs. high HHI pools is preserved in this narrower sample.

Our measures of tranching are combined with the data on delinquent mortgages to examine the servicer's decision to either renegotiate the loan or foreclose upon the borrower. The servicer may also refrain from any action, but we abstract from this outcome since more than 75% of delinquent loans that were not renegotiated ended up in foreclosure by the end of 2013. Table 2c Panel D shows, counterintuitively, that high HHI loans are modified at unconditionally slightly lower rates than low HHI loans. However, this does not account for important observable differences across loan pools. The regression framework subsequently implemented will perform a more robust comparison across loan pools. Table 2c Panel D also shows that mortgages in low HHI pools have a foreclosure rate that is 8.2 p.p. higher than those in high HHI pools.

3. Estimating the effect of tranching

In this section, we develop our empirical strategy to compare outcomes for delinquent loans across pools with varying tranche structures. In designing the empirical specification, we will use the unique features of our empirical laboratory to account for alternative explanations of results.

The regressions used will take the form of a linear probability model:

$$100 \times Modify_{ikdsct_0t} = \alpha + Tranching_k \beta_1 + \epsilon_{ikdsct_0t} \tag{1}$$

where $Modify_{ikdsct_0t}$ is an indicator variable equal to 1 if a 60+ days delinquent loan was subsequently renegotiated. i denotes the individual loan, k the loan pool, d the RMBS deal, s the servicer, t_0 the quarter of origination, t the quarter of delinquency and c the CBSA in which the residential property is located. $Tranching_k$ is equal to either the Number of Tranches, the natural log of Number of Tranches or Tranche HHI. If tranching reduces the servicer's propensity to renegotiate loans, one should anticipate $\widehat{\beta}_1 < 0$ if $Tranching_k$ = Number of Tranches or $\ln$(Number of Tranches), and $\widehat{\beta}_1 > 0$ if $Tranching_k$ = Tranche HHI.

It is worth noting that interpreting the effect of tranching as the worsening of agency frictions requires loan modification to be the value-maximizing action only for some, but not necessarily all, of the delinquent loans in the analyses. While it is natural that foreclosure be the value-maximizing action for a subset of delinquent loans, the incentives of investors and servicers should be aligned for these mortgages, minimizing agency frictions. Although our analysis primarily looks at the renegotiation outcome, in the Appendix we also present results which consider the foreclosure rate.

We extend this specification to rule out potential alternative explanations for the rate of loan modification. The tranching structure will be endogenously determined with the ex-ante credit quality of the assets. We have already started to address this by restricting analysis to only delinquent mortgages. Additionally, we directly control for loan and borrower characteristics observed by investors that are correlated with loan modification and the tranching structure. We condition on whether the property was owner occupied or not, the presence of private mortgage insurance, whether there was a second lien present on the property, combined loan-to-value (CLTV) at origination, CLTV at origination squared, log of the original appraised value, the interest rate, the borrower's FICO score, the age of the loan (in months) at delinquency, a set of indicators for loan contract features (ARM, IO, Negative Amortization, Balloon, Prepayment Penalties) and the change in house prices at the county level between origination and delinquency. Let X_{ic} denote a vector containing the above control variables. Unobserved heterogeneity in lending standards across space and local economic cycles is absorbed by including CBSA-by-time-of-delinquency fixed-effects, denoted by η_{ct_0}.

The agent's skill and operating capacity are important determinants of their ability to renegotiate mortgages in the face of large and increasing numbers of delinquencies. Such unobservable servicing ability may also be correlated with the tranching structure. For example, loan pools with more complex capital structures may be serviced by agents with higher skill. Some servicers may have less capacity to respond to sharp increases in delinquencies relative to others (Agarwal et al., 2017; Aiello, 2022). We rule out these explanations by taking advantage of the fact that a single servicer can manage loan pools across a number of different RMBS deals. Specifically, we will control for servicer-by-time-of-delinquency fixed-effects, denoted by (ψ_{st}).

Finally, it is not only capital structure that is determined ex-ante, but also any contracting between the investors and the servicer. One may expect the investors and the mortgage servicer to engage in ex-ante contracting to specify, however incompletely, the agents rights, duties, responsibilities, compensation and any restrictions on their actions (highlighted by Kruger, 2018). The contract between the investors and the servicer is known as the Pooling and Servicing Agreement, or PSA. To the extent that such contracting is correlated with borrower and loan-characteristics and servicer skill, its effects will be absorbed by our control variables and fixed-effects. However, to rule out such contracting as an alternative explanation, we also include a set of deal-by-servicer fixed-effects (γ_{ds}). These fixed-effects control non-parametrically for the contents of this contract.

Taking into account these control variables and fixed-effects, the preferred regression specification will be:

$$100 \times Modify_{ikdsct_0t} = \eta_{ct_0} + \gamma_{ds} + \psi_{st} + Tranching_k \beta_1 + X'_{ic}\beta_2 + \epsilon_{ikdsct_0t} \tag{2}$$

This implies that β_1 is estimated from the comparison of delinquent loans within the same deal, managed by the same servicer, covered by the same PSA but which reside in separate loan pools with different degrees of tranching. As a result, we restrict our analysis to RMBS deals which involved at least two loan pools.

A remaining worry is that private information held by RMBS issuers about the loan pool may explain both tranching and post-delinquency outcomes. In additional analyses, we follow Begley and Purnanandam (2016) and use the sample of all originated mortgages to construct a measure of abnormal delinquency; i.e., delinquency that is not explained by observables at origination. Begley and Purnanandam (2016) use this measure to test for the relationship between issuers' private information and RMBS security design. Our results remain robust to directly controlling for this measure in Eq. (2).

4. Results

We implement the empirical strategy described in Section 3 to first estimate the effect of tranching on the servicer's probability of loan modification. We explore two mechanisms behind this effect, and characterize the types of loans that servicers pull back from renegotiating. Additional results will explore the intensive margin and efficacy of loan modifications.

4.1. RMBS tranching and loan modification

Our main result estimates the relation between RMBS tranching and the probability of renegotiation to test for the presence of agency frictions, while ruling out the most important alternative explanations. The results of this test appear in Table 3 and show that servicers are less likely to renegotiate delinquent loans in highly tranched loan pools. We perform these tests using three measures of $Tranching_k$–the number of tranches, log of the number of tranches, and Tranche HHI. The results using each independent variable appear in Panels A, B and C respectively.

Moving across the table from Column 1 to Column 5, the specifications used become increasingly stringent, with Column 3 implementing the preferred specification from Eq. (2). Column 1 presents results from a specification with CBSA-by-origination-quarter-year fixed-effects, servicer fixed-effects, delinquency-year-quarter fixed-effects and deal fixed-effects. Column 2 replaces the deal and servicer fixed-effects with

Table 3
Tranching and loan modification.

	(1) P(Modify)	(2) P(Modify)	(3) P(Modify)	(4) P(Modify)	(5) P(Modify)
Mean of dependent variable	24.28	24.28	24.28	24.29	24.29
Panel A:					
Number of Tranches	−0.678***	−0.676***	−0.691***	−0.715***	−0.716***
	(0.074)	(0.074)	(0.075)	(0.074)	(0.074)
Observations	1,469,556	1,469,540	1,469,512	1,468,499	1,468,499
R-squared	0.208	0.210	0.216	0.232	0.235
Panel B:					
Ln(Number of Tranches)	−4.911***	−4.878***	−5.056***	−5.421***	−5.421***
	(1.037)	(1.036)	(1.048)	(1.070)	(1.066)
Observations	1,469,556	1,469,540	1,469,512	1,468,499	1,468,499
R-squared	0.208	0.210	0.216	0.231	0.235
Panel C:					
Tranche HHI	8.043***	8.012***	8.124***	8.375***	8.405***
	(0.953)	(0.953)	(0.939)	(0.917)	(0.920)
Observations	1,469,556	1,469,540	1,469,512	1,468,499	1,468,499
R-squared	0.208	0.210	0.216	0.231	0.235
Borr. and loan controls	X	X	X	X	X
CBSA by Orig Qtr FE	X	X	X	X	X
Del. Qtr FE	X	X	–	–	–
Servicer FE	X	–	–	–	–
Deal FE	X	–	–	–	–
Deal × Servicer FE	–	X	X	–	–
Servicer × Del. Qtr FE	–	–	X	–	–
Deal × Servicer × Del. Qtr FE	–	–	–	X	X
Originator FE	–	–	–	–	X
Cluster	Deal	Deal	Deal	Deal	Deal

The table shows the effect of tranching on the probability that a delinquent loan is renegotiated. The sample includes mortgages in deals which closed between 2002 and 2007, and which went delinquent before January 2009. The dependent variable is equal to 100 if the delinquent loan is renegotiated and is 0 otherwise. Panel A uses the Number of Tranches as the independent variable, Panel B uses Ln(Number of Tranches), and Panel C uses Tranche HHI. Number of Tranches is the number of tranches collateralized by the loan pool that the mortgage resides in. Tranche HHI is an HHI based measure of tranching (a higher Tranche HHI corresponds to a lower degree of tranching). Loan-level controls include: credit score, 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, and the change in house prices at the county level between origination and delinquency. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

a deal-by-servicer fixed-effect, since the contracting between servicers and investors takes place at the deal level. It shows that the coefficient remains stable. Column 3 implements the specification described in Eq. (2) with servicer-by-time-of-delinquency fixed-effects.

We find in Column 3 that moving between the 25th to the 75th percentile of the Number of Tranches (11 to 16 tranches) corresponds to a 3.5 p.p. decrease in the probability of loan modification, a 14.2 percent decrease relative to the mean. Using the log of the Number of Tranches, we find that a 45 percent increase in the number of tranches (11 to 16 tranches, again) predicts a decrease in the servicer's probability of renegotiation of 1.9 p.p. Similarly, a decrease in Tranche HHI from the 75th to the 25th percentile (0.44 to 0.21) is associated with a 1.9 p.p. decrease in the loan modification probability. Together, these estimates show that RMBS tranching has a significant effect on loan modification which is orthogonal to asset characteristics, servicer skill and capacity, and the contents of the PSA contract.

To further assess the robustness of these estimates, Column 4 and 5 use even more stringent specifications. Column 4 includes a deal-by-servicer-by-delinquency-year-quarter fixed-effect to also control for changes in the deal structure over time as the pool's losses are assigned to the various tranches through the cash-flow waterfall. Column 5 includes an originator fixed-effect to control for unobservable heterogeneity in underwriting standards across lenders. The coefficients on $Tranching_k$ remain stable.

In constructing the number of tranches and tranche HHI, we give full credit to cross-collateralized tranches (such as tranche M-1 in the MASTR Trust example) which may understate the concentration of tranching. To address this concern, we reconstruct our measures after dropping cross-collateralized tranches. The re-constructed measures across the remaining 1443 loan pools portray lower average tranching (higher concentration) and have a wider distribution (Table A.1a) compared to our original measures. The results from using the reconstructed measure in our baseline specification appear in Table A.1b and are consistent with our findings.

Finally, we confirm these results by estimating the specification on a related outcome variable, an indicator for whether a delinquent loan was eventually foreclosed upon by the servicer, whether or not it was renegotiated. The results in Table A.2 show that increasing the number of tranches and reducing the Tranche HHI is associated with an increase in the probability that a delinquent mortgage eventually ends up in foreclosure. This may be because a servicer renegotiates fewer loans in highly tranched pools, or because the renegotiations in highly tranched pools are less effective. In the next sub-section, we show that the latter does not appear to be true, and that the higher foreclosure rate likely reflects a lower renegotiation rate.

Overall, the results show that tranching structure has an effect on the servicing agent's actions, suggesting that it worsens agency frictions.

4.1.1. Leniency and efficacy of loan modifications

Fewer modifications as a result of greater tranching might simply reflect more effort taken by the servicer in selecting mortgages that were most likely to benefit from loan modification. Similarly, the

Table 4
Tranching and modification leniency and type.

	(1) % change in PMT	(2) PMT decrease > 25%?	(3) % change balance	(4) Principal forgiven?	(5) Missed PMT capitalized?	(6) PMT deferred?	(7) Term increase?
Mean of dependent var.	−23.49	36.70	0.511	10.35	76.81	0.859	3.267
Panel A:							
Number of Tranches	0.047	−0.092	0.004	0.129***	0.073	0.009	0.000
	(0.076)	(0.091)	(0.011)	(0.046)	(0.142)	(0.017)	(0.019)
Observations	349,367	352,041	351,989	352,041	352,041	352,041	352,041
R-squared	0.179	0.183	0.059	0.226	0.189	0.168	0.592
Panel B:							
Ln(Number of Tranches)	−0.206	−1.108	0.032	1.708***	−0.096	0.078	−0.008
	(0.959)	(1.198)	(0.144)	(0.604)	(1.847)	(0.197)	(0.261)
Observations	349,367	352,041	351,989	352,041	352,041	352,041	352,041
R-squared	0.179	0.183	0.059	0.226	0.189	0.168	0.592
Panel C:							
Tranche HHI	−0.196	1.387	0.320*	−2.450***	−0.424	−0.066	0.139
	(0.816)	(1.085)	(0.164)	(0.621)	(1.142)	(0.224)	(0.215)
Observations	349,367	352,041	351,989	352,041	352,041	352,041	352,041
R-squared	0.179	0.183	0.059	0.226	0.189	0.168	0.592
Borr. and loan controls	X	X	X	X	X	X	X
CBSA by Orig Qtr FE	X	X	X	X	X	X	X
Deal × Servicer FE	X	X	X	X	X	X	X
Servicer × Del. Qtr FE	X	X	X	X	X	X	X
Cluster	Deal	Deal	Deal	Deal	Deal	Deal	Deal

The table shows the effect of tranching on the type of loan modification, conditional on a loan being renegotiated. The sample includes mortgages in deals which closed between 2002 and 2007, which went delinquent before January 2009 and which were subsequently renegotiated. The dependent variables are: Column (1), the percentage change in monthly payments (×100); Column (2), equal to 100 if payment decrease is greater than 25 percent; Column (3) percentage change in balance (×100); Column (4) equal to 100 if principal has been forgiven; Column (5) equal to 100 if missed payments were capitalized; Column (6) equal to 100 if payment was deferred; and Column (7) equal to 100 if term to maturity was increased. Panel A uses Number of Tranches as the independent variable, Panel B uses Ln(Number of Tranches) and Panel C uses Tranche HHI. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

servicer may modify fewer loans but give borrowers larger concessions thereby resulting in more successful renegotiations. To examine whether tranching changes the servicer's effort *per* loan modification, we examine the intensive margin of renegotiation and the re-default rate of loan modifications.

Table 4 documents the effect of tranching on loan modification type and leniency for the sample of renegotiated loans. We consider several outcome variables; the percentage change in the mortgage payment, an indicator for whether the payment decreased by more than 25 percent, the percentage change in the balance outstanding, whether principal was forgiven, whether missed payments were capitalized, whether payments were deferred and whether the term-to-maturity was increased. We use the same set of fixed-effects as specified in Eq. (2). No clear pattern emerges from Table 4 and there is only one result with statistical significance. An increase in the number of tranches between the 25th and 75th percentile, or a decrease in the Tranche HHI between the interquartile range, is associated with a 0.6 p.p. increase in the probability of having principal forgiven. Not only is this a small effect relative to the sample probability of principal forgiven, but it is also not reflected in a meaningful change to the monthly payment or the loan balance outstanding. We conclude that tranching does not appear to be associated with the leniency of loan modification implemented.

Table 5 shows the effect of tranching on post-modification re-default and foreclosure outcomes. We consider the probability of re-default within six or twelve months, and the probability of entry into foreclosure within twelve or twenty-four months after modification. Each coefficient in Panel A and Panel B is statistically insignificant suggesting that there is no relationship between the number of tranches and the probability of post-modification foreclosure. Panel C, if anything, suggests that a decrease in Tranche HHI is associated with a small increase in the probability of re-default within six months, equivalent to 1 percent of the sample mean. However, this coefficient is significant only at the 10 percent level. We conclude that there is no positive relationship between the degree of tranching and the efficacy of the loan modification.

Taken together, the results of Tables 4 and 5 show that servicers do not change the effort per loan modification in highly tranched pools. Overall, servicers reduce renegotiation effort by modifying delinquent loans at a lower rate.

4.2. Mechanisms

In the RMBS market, many PSAs require a supermajority to influence agents' actions (Dana, 2010; Thompson, 2011) and investors must coordinate to monitor and discipline the agent. We posit two mechanisms by which tranching creates coordination costs between investors and worsens agency problems, that are evidenced by lower loan modification rates.

First, coordination becomes challenging when investors hold different cash flow rights, i.e., tranches. For example, junior bondholders with equity-like claims prefer the servicer to take value-maximizing actions. In contrast, senior bondholders could be indifferent from a cash flow perspective, or as Stulz and Johnson (1985) argue theoretically, may want servicers to foreclose and resolve borrower distress.[2] Gelpern and Levitin (2009) suggest that it is only the "fulcrum" mezzanine tranche that may desire renegotiations. Investors may not agree on whether and how to act against the agent or may not be sufficiently incentivized to monitor them. The greater the variety of cash flow rights

[2] Suppose a pool has two tranches a junior equity tranche and a senior bond. The junior tranche is a call option on the value of the pool. The senior-bond holder effectively holds a default-free discount bond and is short a put option on the underlying assets. Thus, bond-holders want to lower the value of the put option by lowering the volatility of pool value. This can be achieved by servicers foreclosing upon borrowers and forcing a resolution of their distress.

Table 5
Tranching and redefault of modified loans.

	(1) P(Re-default 6m)	(2) P(Re-default 12m)	(3) P(F′close 12m)	(4) P(F′close 24m)
Mean of dependent variable	29.15	44.20	12.49	22.79
Panel A:				
Number of Tranches	0.019	0.022	−0.010	0.041
	(0.069)	(0.078)	(0.048)	(0.062)
Observations	355,798	355,798	355,798	355,798
R-squared	0.100	0.137	0.093	0.100
Panel B:				
Ln(Number of Tranches)	−0.063	0.159	0.241	1.017
	(0.738)	(0.855)	(0.531)	(0.688)
Observations	355,798	355,798	355,798	355,798
R-squared	0.100	0.137	0.093	0.100
Panel C:				
Tranche HHI	−1.580*	−1.404	0.200	−0.515
	(0.870)	(1.002)	(0.690)	(0.874)
Observations	355,798	355,798	355,798	355,798
R-squared	0.100	0.137	0.093	0.100
Borr. and loan controls	X	X	X	X
CBSA by Orig Qtr FE	X	X	X	X
Deal × Servicer FE	X	X	X	X
Servicer × Del. Qtr. FE	X	X	X	X
Cluster	Deal	Deal	Deal	Deal

The table shows the effect of tranching on the post-modification performance of a renegotiated loan. The sample includes mortgages in deals which closed between 2002 and 2007, which went delinquent before January 2009 and which were subsequently renegotiated. The dependent variables are: Column (1), equal to 100 if the modified loan re-defaults within 6 months of modification; Column (2) equal to 100 if the modified loan re-defaults within 12 months; Column (3) equal to 100 if the modified loan enters foreclosure within 12 months; Column (4) equal to 100 if the modified loan enters foreclosure within 24 months. Panel A uses Number of Tranches as the independent variable, Panel B uses Ln(Number of Tranches) and Panel C uses Tranche HHI. Number of Tranches is the number of tranches collateralized by the loan pool that the mortgage resides in. Tranche HHI is an HHI based measure of tranching (a higher Tranche HHI corresponds to a lower degree of tranching). Loan-level controls include: credit score, 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, and the change in house prices at the county level between origination and delinquency. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 6
Mechanisms: Disagreement between investors and free-rider problems.

(a) Additional pool-level statistics

	N	Mean	St Dev	Min	p10	p25	p50	p75	p90	Max
Number of Subordination Levels per pool	3889	10.5	2.9	1.0	7.0	9.0	11.0	12.0	14.0	18.0
Tranches per Subordination Level per pool	3889	1.3	0.3	1.0	1.0	1.1	1.3	1.4	1.6	8.0
Ln(Number of Subordination Levels per pool)	3889	2.30	0.37	0.00	1.95	2.20	2.40	2.48	2.64	2.89
Ln(Tranches per Subordination Level per pool)	3889	0.25	0.20	0.00	0.00	0.12	0.22	0.36	0.49	2.08

(b) Regression result

	(1) P(Modify)	(2) P(Modify)
Mean of dependent variable	24.29	24.29
Ln(Number of Tranches)	−5.056***	
	(1.048)	
Ln(Number of Subordination Levels)		−3.082***
		(0.986)
Ln(Tranches per Subordination Level)		−6.711***
		(1.178)
Observations	1,469,512	1,469,512
R-squared	0.216	0.216
Borr. and loan controls	X	X
CBSA by Orig Qtr FE	X	X
Deal × Servicer FE	X	X
Servicer by Del. Qtr FE	X	X

The tables shows the effect of tranching on the probability that a delinquent loan is renegotiated. The sample includes mortgages in deals which closed between 2002 and 2007, and which went delinquent before January 2009. The dependent variable is equal to 100 if the delinquent loan is renegotiated and is 0 otherwise. Table (a) presents additional summary statistics on the number of subordination levels with claims to a loan pool, and the number of tranches per subordination level with claims to the loan pool. Table (b) decomposes the ln(Number of tranches) into these two components and includes these components as regressors. The ln(No. of Subordination levels) proxies for the potential disagreement between investors, while the ln(Tranches per Subordination Level per pool) proxies for the potential for free-rider problems. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 7
Which modifications do servicers forego?.

	(1) $Tranching_k$: No. Tranches Dep Var: P(Modify)	(2) $Tranching_k$: Ln(Tranches) Dep Var: P(Modify)	(3) $Tranching_k$: Tranche HHI Dep Var: P(Modify)
Mean of dependent variable	24.19	24.19	24.19
Panel A: CLTV			
Medium CLTV (0.8 < CLTV ≤ 0.95)	3.413***	7.814***	−2.568***
	(0.677)	(1.379)	(0.594)
High CLTV (CLTV ≥ 0.95)	1.101	8.929***	−11.332***
	(1.167)	(2.137)	(0.850)
$Tranching_k$	−0.335***	−1.598	4.026***
	(0.085)	(1.013)	(1.356)
$Tranching_k$ × Medium CLTV	−0.359***	−3.635***	2.672**
	(0.050)	(0.547)	(1.265)
$Tranching_k$ × High CLTV	−0.607***	−6.309***	11.247***
	(0.079)	(0.826)	(1.765)
R-squared	0.217	0.217	0.217
Panel B: House price decline			
Medium house price decline indicator	1.455***	3.830***	−1.907***
	(0.515)	(0.962)	(0.304)
Large house price decline indicator	1.282	5.551***	−4.358***
	(0.843)	(1.756)	(0.419)
$Tranching_k$	−0.606***	−4.095***	3.362***
	(0.083)	(1.060)	(1.022)
$Tranching_k$ × Medium HP decline	−0.100***	−1.456***	5.601***
	(0.036)	(0.369)	(0.753)
$Tranching_k$ × Large HP decline	−0.150***	−2.439***	10.611***
	(0.055)	(0.653)	(1.163)
R-squared	0.217	0.217	0.217
Panel C: Low Doc Loan			
Low or No Doc	−0.358	5.490***	−8.011***
	(0.569)	(1.320)	(0.346)
$Tranching_k$	−0.563***	−3.819***	6.264***
	(0.074)	(1.021)	(0.965)
$Tranching_k$ × Low or No Doc Loan	−0.394***	−4.389***	5.690***
	(0.039)	(0.503)	(0.780)
R-squared	0.217	0.217	0.217
Panel D: Second lien present?			
Second lien present indicator	7.931***	12.943***	1.703***
	(0.791)	(1.378)	(0.483)
$Tranching_k$	−0.638***	−4.677***	7.319***
	(0.074)	(0.998)	(0.929)
$Tranching_k$ × Second Lien Present	−0.302***	−3.571***	5.251***
	(0.052)	(0.518)	(1.138)
R-squared	0.217	0.217	0.217
Panel E: Not owner occupied			
Not owner occupied indicator	−5.659***	3.561	−15.175***
	(1.079)	(2.274)	(0.649)
$Tranching_k$	−0.633***	−4.544***	7.412***
	(0.074)	(0.999)	(0.958)
$Tranching_k$ × Not owner occupied	−0.555***	−6.531***	4.875***
	(0.074)	(0.866)	(1.710)
R-squared	0.217	0.217	0.217
Observations	1,491,928	1,491,928	1,491,928
Borr. and loan controls	X	X	X
CBSA by Orig Qtr FE	X	X	X
Deal × Servicer FE	X	X	X

(*continued on next page*)

attached to a loan pool, the higher the potential for disagreement and the worse is the agency friction.

Second, coordination problems can arise even when investors hold identical cash flow rights to a loan pool. If each investor takes costly effort to monitor it gives rise to free-rider problems in the spirit of Holmstrom (1982), Diamond (1984) or Hertzberg et al. (2011). Insufficient monitoring effort weakens the ability of investors to exercise control over their agent, allowing the servicer to take value destroying actions.

To distinguish between these channels we collect and utilize data on each tranche's subordination level—a measure of tranche seniority. Using this data, and the fact that a pool may collateralize multiple tranches of the same seniority, we decompose the log number of

Table 7 (*continued*).

	(1) $Tranching_k$: No. Tranches Dep Var: P(Modify)	(2) $Tranching_k$: Ln(Tranches) Dep Var: P(Modify)	(3) $Tranching_k$: Tranche HHI Dep Var: P(Modify)
Servicer by Del. Qtr FE	X	X	X
Cluster	Deal	Deal	Deal

The tables shows the effect of tranching on the probability that a delinquent loan is renegotiated. It shows how this effect varies for mortgages with different characteristics. Panel A studies heterogeneous effects by loan CLTV ratio. Panel B studies effects by house price decline between origination and delinquency. Panels C, D and E examine low documentation status, the presence of second liens at origination, and owner occupancy respectively. Each column of a panel uses a different measure of tranching depth as the dependent variable. Column (1) uses the number of tranches, Column (2) uses the natural log of the number of tranches, and Column (3) uses the Tranche HHI measure. The sample includes mortgages in deals which closed between 2002 and 2007, and which went delinquent before January 2009. The dependent variable is equal to 100 if the delinquent loan is renegotiated and is 0 otherwise. Table A.4 presents results from regressions combining all interactions into one specification. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

tranches into two components:

$$\ln(\text{No. of Tranches})_k = \underbrace{\ln(\text{No. of Subordination Levels})_k}_{A} + \underbrace{\ln\left(\frac{\text{No. of Tranches}}{\text{No. of Subordination Levels}}\right)_k}_{B}$$

The first component (A) captures disagreement between investors, while the second (B) captures the dispersion of investors and the hypothesized free-rider problems. The number of subordination levels per loan pool varies from 1 to 18 with a median of 11 and an interquartile range of 3 (see Table 6a). The number of tranches per subordination level per pool varies between 1 and 8, with a median of 1.3 and an interquartile range of 0.3. We include both measures in our baseline specification, with the results appearing in Table 6b. Column 1 reports results from using the log number of tranches, in effect restricting the coefficients on components A and B to be identical. Column 2 reports results from including each component as a separate regressor.

The coefficients in column 2 suggest that an increase in the Number of Subordination levels (component A) from the 25th to the 75th percentile predicts a 0.9 p.p. lower probability of loan modification. This is suggestive evidence that disagreement between investors with heterogeneous claims makes it difficult to coordinate oversight of the agent. An increase in the Number of Tranches per Subordination Level (component B) from the 25th to 75th percentile predicts another 1.6 p.p. decrease in the rate of loan modification. Increasing the number of claims to a loan pool is correlated with greater impediments to renegotiation. Together these estimates enable a more nuanced interpretation of our main result.

4.2.1. Data validation: Tranching and the number of investors

This section has thus far argued that RMBS tranching amplifies agency costs by creating claims with varied and competing cash flow rights and by generating free-rider problems in monitoring the agent. In this subsection we validate our measures by documenting that a particular subset of investors–life insurance companies–do not systematically hold more than one tranche backed by a given loan pool.

Our primary dataset does not reveal the identity of RMBS tranche-holders and there does not exist a dataset on the universe of RMBS investors. In the absence of such a dataset, we obtain information from the National Association of Insurance Commissioners (NAIC) on the December 2006 holdings of a subset of RMBS investors–life insurance companies (LICs). Merrill et al. (2019) provide a description of the data. We map tranches held by LICs to the tranches in the ABSNet data using bond CUSIPs. Then, using the tranche-to-loan-pool mapping we identify the pools collateralizing tranches held by LICs. Merging the two datasets yielded data on 282 insurers who held 2613 tranches in 935 subprime private-label RMBS deals in our sample. This constitutes data on about 2200 loan pools. Based on statistics from NAIC and SIFMA, LICs held 7 percent of all outstanding non-agency RMBS as at December 31st, 2010.

Examining life insurers' patterns of bond-holding, we find that on average, a LIC held 1.2 tranches in any deal that it invested in (median: 1 tranche). As Fig. A.1(a) documents, 83 percent of investments in subprime RMBS involved the acquisition of a single tranche (95 percent involved the acquisition of 2 or fewer tranches). This shows that LICs were unlikely to hold multiple claims to the same loan pool or deal. The binned-scatter plot in Fig. A.1(b) plots the positive relationship between the log total number of tranches collateralized by the loan pool (conditional on being held by a life-insurer) and the log number of LICs with claims to that pool. The estimated coefficients of this fit appear in Table A.3. The result from Column 2 which controls for loan pool size and deal fixed-effects shows that a 10 percent increase in tranche count corresponds to a 18 percent increase in the number of LICs with claims to that loan pool.

While this data only covers a subset of RMBS investors, who may be subject to a specific set of portfolio constraints, it provides suggestive evidence that investors tend to hold a single tranche from a given deal. It is thus likely that the creation of multiple tranches disperses ownership of the underlying mortgages.

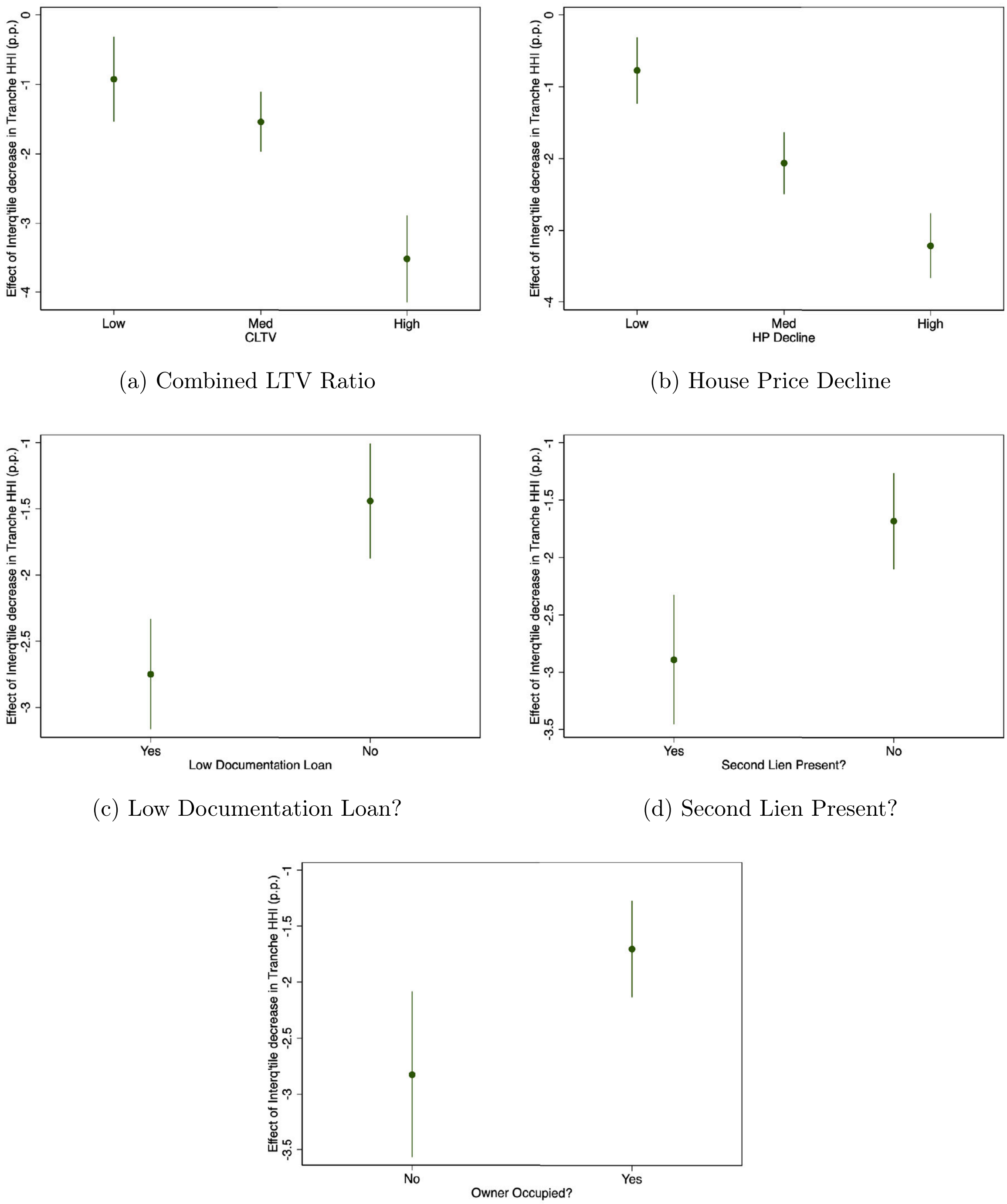
4.3. Which renegotiations do agents forego?

If deeper tranching weakens monitoring of the agent, one should expect servicers to shirk on effort particularly when the value-maximizing action–renegotiate or foreclose–is not obvious ex-ante. For example, consider high CLTV loans. On the one hand, high CLTV loans may be more likely to re-default post modification, lowering the NPV of renegotiation relative to foreclosure. On the other hand, high CLTV loans may have higher loss given default upon foreclosure, increasing the NPV of renegotiation relative to foreclosure.

We take advantage of this ambiguity, and consistent with the above example show that, in deeply tranched pools, servicers pull back from renegotiating delinquent loans of borrowers who are likely to be deeply underwater. Conditional on a rich set of observables including CLTV and collateral values, higher tranching is associated with lower modification by the servicer for borrowers using high CLTV mortgages, or borrowers who have experienced large declines in asset prices between loan origination and their entry into delinquency. Fig. 2 Panel (a) shows that the effect of an interquartile decrease in Tranche HHI on renegotiation probability is 2.8 times higher for loans in the highest CLTV tercile relative to the lowest CLTV tercile. Panel (b) documents that the effect on loans with the deepest decline in house prices is 4 times stronger than for those in the lowest tercile of house price declines. Fig. A.2 repeats this analysis using the number of tranches, and these figures report regression results from Table 7.

Separate from the ambiguity of value-maximizing actions and the tranching structure, such loans may have lower loan baseline modification rates. The direct effect of each loan characteristic will be absorbed by the main effects in each regression (e.g., by indicators for medium CLTV and high CLTV), while our interpretation is based on the interaction terms.

An examination of additional features of borrowers and mortgages support these findings. We find stronger effects of tranching on low documentation loans (Panel (c) of Fig. 2), loans on properties that had second-liens (Panel (d)), and loans for non-owner occupied properties



(a) Combined LTV Ratio

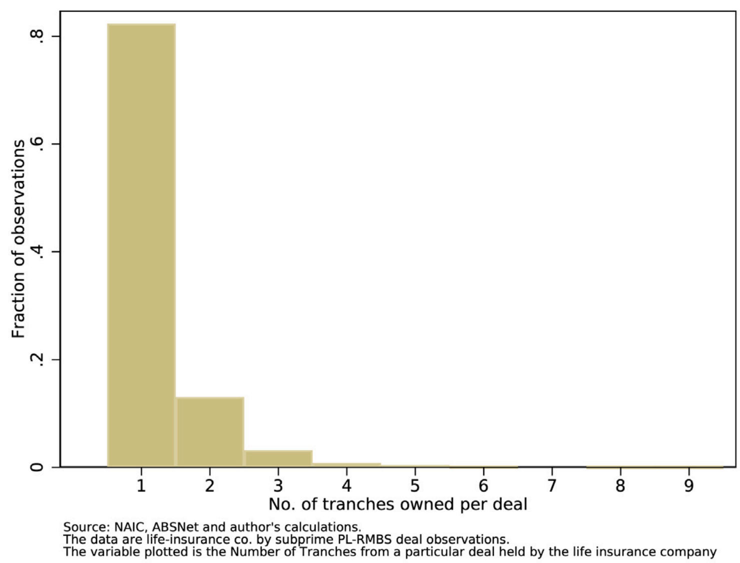
(b) House Price Decline

(c) Low Documentation Loan?

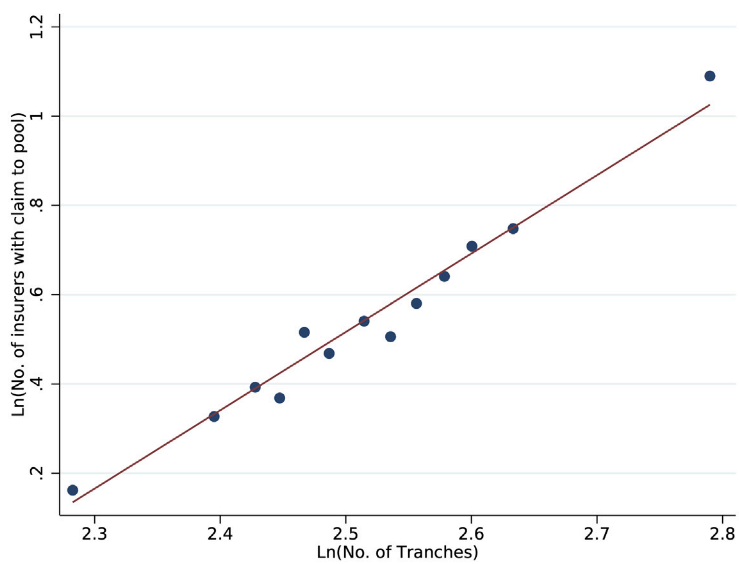
(d) Second Lien Present?

(e) Owner Occupied?

Fig. 2. Effect of deeper tranching on modification; by loan characteristics. The diagrams above document the effect of an interquartile decrease in the tranche HHI on delinquent loans with varying characteristics. Fig. 2a documents the effect by loans' combined LTV ratios, Fig. 2b by the house price decline experienced by borrowers between origination and delinquency, Fig. 2c by the low documentation status of the loan, Fig. 2d by whether the loan had a second lien present at origination, Fig. 2e by whether the property is owner occupied. A complementary figure showing the effect of an interquartile increase in the number of tranches appears in the Appendix.



(a) Number of tranches held conditional on investing in RMBS deal



(b) Binned-Scatter: Number of tranches vs number of life-insurers with claim to pool

Fig. A.1. Life Insurance Companies' holdings of RMBS deals. The diagrams above use data on the portfolio holdings of life-insurance companies to test the hypothesis that the creation of multiple tranches disperses the ownership of the underlying collateral. Figure (a) considers life-insurance-company-by-deal level data to measure the probability that an insurance company's investment in a deal consists of an investment in only a single tranche. Figure (a) maps life-insurance companies to tranches and tranches to loan pools in ABSNet, and the binned scatter-plot depicts the relationship between the total number of tranches collateralized by a loan pool, and the number of life insurers with a claim to the loan pool.

(Panel (e)). Overall, these additional results support our findings on coordination problems and the worsening of agency frictions.[3]

[3] Table A.4 presents results from including all variables and interactions in a single regression.

4.4. Loan pool credit quality and tranching

One concern about our results may be that the loan pool's credit quality is reflected in both the RMBS capital structure and the probability of loan modification. We have accounted for this endogenous relation in a few ways: restricting analysis to delinquent mortgages, controlling for a rich set of borrower and loan characteristics, and using

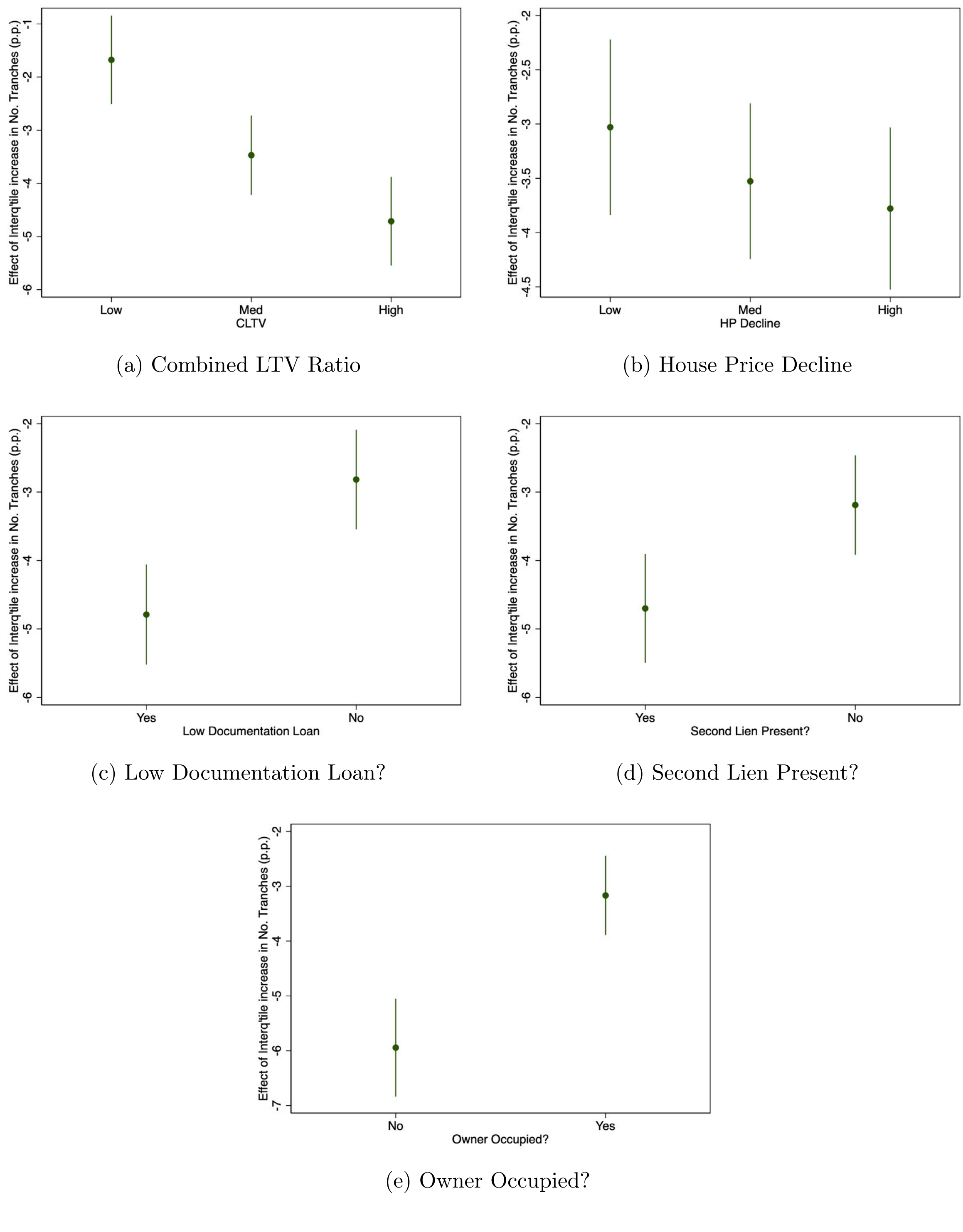


Fig. A.2. Effect of deeper tranching on modification by loan characteristics (No. of Tranches). The diagrams above document the effect of an interquartile increase in the number of tranches collateralized by a loan pool on delinquent loans with varying characteristics. Fig. 2a documents the effect by loans' combined LTV ratios, Fig. 2b by the house price decline experienced by borrowers between origination and delinquency, Fig. 2c by the low documentation status of the loan, Fig. 2d by whether the loan had a second lien present at origination, Fig. 2e by whether the property is owner occupied.

a stringent fixed-effects specification to absorb unobserved heterogeneity across space, time, originators and servicers. In this section, we conduct an additional robustness check to address this concern.

A large set of theoretical studies in finance indicate that ABS issuers may incorporate their private information into their choice of capital structure (e.g. see Leland and Pyle, 1977; DeMarzo and Duffie, 1999

Table A.1
Robustness: Measuring tranching excluding cross-collateralized tranches.

(a) Pool-level statistics excluding cross-collateralized tranches

	N	Mean	St Dev	Min	p10	p25	p50	p75	p90	Max
Number of Tranches (Excl. X-Coll. Tranches)	1443	3	3	1	1	1	2	4	6	19
Ln(Number of Tranches) (Excl. X-Coll. Tranches)	1443	0.78	0.75	0.00	0.00	0.00	0.69	1.39	1.79	2.94
Tranche HHI (Excl. X-Coll. Tranches)	1443	0.69	0.31	0.11	0.30	0.39	0.68	1.00	1.00	1.00

(b) Regression result

	(1) P(Modify)	(2) P(Modify)	(3) P(Modify)
Mean of dependent variable	24.76	24.76	24.76
No. of Tranches (Excl. X-Collateralized)	−0.244***		
	(0.076)		
Ln Tranche Count (Excl. X-Collateralized)		−1.008***	
		(0.200)	
Tranche HHI (Excl. X-Collateralized)			2.476***
			(0.374)
Observations	742,345	742,345	742,345
R-squared	0.170	0.170	0.170
Borr. and loan controls	X	X	X
CBSA by Orig Qtr FE	X	X	X
Deal × Servicer FE	X	X	X
Servicer by Del. Qtr FE	X	X	X
Cluster	Deal	Deal	Deal

The tables shows the effect of tranching on the probability that a delinquent loan is renegotiated. The sample includes mortgages in deals which closed between 2002 and 2007, and which went delinquent before January 2009. The dependent variable is equal to 100 if the delinquent loan is renegotiated and is 0 otherwise. In this table, the Number of Tranches and Tranche HHI have been reconstructed after excluding cross-collateralized tranches. This leaves us with data on 1443 loan pools across 710 deals that include at least two loan pools that provide cash flows to non-cross-collateralized tranches. Table (a) presents additional summary statistics on the reconstructed measures. Table (b) estimates our baseline specification using these reconstructed measures. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

and DeMarzo, 2005). For example, if issuers know that the pool is riskier, they might subordinate the senior bond with a larger number of mezzanine tranches for protection. These theories raise the concern that our results are explained by this ex-ante channel rather than by agency costs between investors and the agent *after* the issuance of RMBS. To rule out this explanation we exploit the fact that we observe all the originated loans in the deals analyzed. This allows us to construct a proxy variable for issuers' private information about pool credit quality, include it in our preferred regression on delinquent loans and assess the robustness of our results.

We follow Begley and Purnanandam (2016) and construct our proxy variable—Ex-post Abnormal Delinquency—at the pool level. We first estimate a logit-model of mortgage delinquency on the sample of all originated mortgages. The predicted probability of delinquency implied by the parameters represents a measure of "normal" or expected default.[4] To compute abnormal delinquency, we compare each loan's predicted probability to the actual delinquency outcome, and aggregate this comparison to the loan-pool level:

$$AbDelinquency_k = \sum_{i=1}^{N_k} w_i \left(delinquent_{i,k} - \widehat{delinquent}_{i,k} \right) \tag{3}$$

where N_k is the number of loans (i) in each loan pool k, w_i is a weight constructed using the loan's origination balance, $delinquent_{i,k}$ is an indicator for whether loan i becomes delinquent and $\widehat{delinquent}_{i,k}$ is the logit-model's predicted probability of delinquency. The distribution of this measure, which is centered around zero, is documented in Table A.5a.

[4] We estimate a logit model of entry into serious delinquency as a function of: credit score, combined loan-to-value ratio, low documentation loan indicator, loan purpose, owner-occupied indicator, ARM indicator, balloon indicator, negative amortization indicator, second lien present indicator and state fixed-effects. We estimate the model and form predicted values separately for each year of origination from 2002 to 2007.

Table A.5b shows the estimated coefficients after including this variable as a regressor. The three columns show the results for each of our measures of tranching respectively. The coefficients of interest continue to suggest that servicers are less likely to renegotiate loans in more deeply tranched pools.

5. Conclusion

Taken together, our results support the notion that tranching worsens agency frictions by increasing the coordination costs among dispersed investors with varying cash flow rights. Tranching thus impedes investors' ability to monitor the servicing agents and contributes to potentially sub-optimal servicer decisions. We document that servicers renegotiate fewer mortgages in more deeply tranched pools, adjusting their behavior along the extensive margin. Coordination costs arise from two mechanisms: increased disagreement between senior versus subordinated investors and free-rider problems in monitoring among numerous dispersed investors.

Our findings extend well beyond the RMBS setting. Firms employ multi-tiered capital structures (Rauh and Sufi, 2010 and Colla et al., 2013) which influence financing (Hertzberg et al., 2011; Benardo et al., 2015) and bankruptcy outcomes (Bris and Welch, 2005; Demiroglu and James, 2015; Ivashina et al., 2016). In the syndicated lending market, the agent bank services the loan package on behalf of other syndicate members and is subject to agency frictions (Dennis and Mullineaux, 2000). In a CLO, agents akin to mortgage servicers can act in their own best interest to the detriment of CLO investors (Chernenko, 2017; Peristiani and Santos, 2019). In each of these settings, complex financing structures with numerous investors have the potential to exacerbate agency frictions.

Our results suggest potential avenues to reduce agency frictions and empower investors to better monitor agents. For example, PSAs might put more weight on the agreement and coordination of junior investors in determining when the agent could be terminated, rather than require a majority agreement. This argument echoes Winton, 1995 who advocates that junior investors are best positioned to verify the actions of a firm.

Table A.2
Tranching and foreclosure.

	(1) P(F′close)	(2) P(F′close)	(3) P(F′close)	(4) P(F′close)	(5) P(F′close)
Mean of dependent variable	66.03	66.03	66.03	66.04	66.04
Panel A:					
Number of Tranches	0.521***	0.521***	0.515***	0.507***	0.507***
	(0.056)	(0.056)	(0.055)	(0.055)	(0.055)
Observations	1,469,556	1,469,540	1,469,512	1,468,499	1,468,499
R-squared	0.206	0.208	0.213	0.233	0.233
Panel B:					
Ln(Number of Tranches)	5.710***	5.694***	5.628***	5.602***	5.588***
	(0.752)	(0.749)	(0.747)	(0.733)	(0.731)
Observations	1,469,556	1,469,540	1,469,512	1,468,499	1,468,499
R-squared	0.206	0.208	0.213	0.233	0.233
Panel C:					
Tranche HHI	−7.464***	−7.497***	−7.509***	−7.584***	−7.596***
	(0.720)	(0.719)	(0.717)	(0.731)	(0.731)
Observations	1,469,556	1,469,540	1,469,512	1,468,499	1,468,499
R-squared	0.206	0.208	0.213	0.233	0.233
Borr. and loan controls	X	X	X	X	X
CBSA by Orig Qtr FE	X	X	X	X	X
Del. Qtr FE	X	X	–	–	–
Servicer FE	X	–	–	–	–
Deal FE	X	–	–	–	–
Deal × Servicer FE	–	X	X	–	–
Servicer × Del. Qtr FE	–	–	X	–	–
Deal × Servicer × Del. Qtr FE	–	–	–	X	X
Originator FE	–	–	–	–	X
Cluster	Deal	Deal	Deal	Deal	Deal

The table shows the effect of tranching on the probability that a delinquent loan is foreclosed. The sample includes mortgages in deals which closed between 2002 and 2007, and which went delinquent before January 2009. The dependent variable is equal to 100 if the delinquent loan is subsequently foreclosed upon and is 0 otherwise. Panel A uses the Number of Tranches as the independent variable, Panel B uses Ln(Number of Tranches), and Panel C uses Tranche HHI. Number of Tranches is the number of tranches collateralized by the loan pool that the mortgage resides in. Tranche HHI is an HHI based measure of tranching (a higher Tranche HHI corresponds to a lower degree of tranching). Loan-level controls include: credit score, 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, and the three month change in house prices at the county level (using Zillow data) prior to the incidence of early delinquency. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

CRediT authorship contribution statement

Sanket Korgaonkar: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing, Visualization, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data

Appendix. Appendix graphs and tables

See Figs. A.1 and A.2 and Tables A.1–A.5.

Table A.3
Data validation: Tranching and the number of investors.

	(1) Ln(#Insurers)	(2) Ln(#Insurers)	(3) Ln(#Insurers)
No. of Tranches	0.178***		
	(0.0179)		
Ln(No. of Tranches)		1.865***	
		(0.182)	
Tranche HHI			−1.366***
			(0.173)
Observations	2207	2207	2207
R-squared	0.838	0.837	0.794
Pool size control	X	X	X
Deal FE	X	X	X
Cluster	Deal	Deal	Deal

The table documents the relationship between the number of tranches collateralized by a loan pool and held by life-insurance companies, and the number of unique life-insurance companies which have claims to a particular loan pool. The analysis combines the sample of life insurance companies and the CUSIPs of the tranches they held as at December 2006 with the tranche-to-loan-pool mapping in the ABSNet data. The analysis is thus carried out at the loan-pool level. Column (1) presents a regression of the log number of insurers with claims to a pool on the Number of Tranches. Column (2) uses as the independent variable the log of the Number of Tranches. Column (3) uses Tranche HHI as the independent variable. Each regression controls for the size of the loan pool and deal fixed-effects. Standard errors are clustered at the deal level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table A.4
Which modifications do servicers forego?.

	(1) $Tranching_k$: No. Tranches Dep Var: P(Modify)	(2) $Tranching_k$: Ln(Tranches) Dep Var: P(Modify)	(3) $Tranching_k$: Tranche HHI Dep Var: P(Modify)
Mean of dependent variable	24.19	24.19	24.19
$Tranching_k$	−0.050	1.868*	−2.878*
	(0.103)	(1.132)	(1.596)
Medium CLTV (0.8 < CLTV ≤ 0.95)	3.535***	8.171***	−2.461***
	(0.685)	(1.423)	(0.593)
High CLTV (CLTV ≥ 0.95)	1.811	10.885***	−11.579***
	(1.342)	(2.540)	(0.909)
$Tranching_k$ × Medium CLTV	−0.364***	−3.752***	2.454*
	(0.050)	(0.562)	(1.271)
$Tranching_k$ × High CLTV	−0.651***	−7.018***	12.149***
	(0.092)	(0.979)	(1.946)
Medium house price decline indicator	1.083**	3.255***	−1.739***
	(0.517)	(0.987)	(0.309)
Large house price decline indicator	0.649	4.422**	−4.151***
	(0.846)	(1.751)	(0.426)
$Tranching_k$ × Medium HP decline	−0.072**	−1.229***	5.128***
	(0.036)	(0.378)	(0.774)
$Tranching_k$ × Large HP decline	−0.105*	−2.008***	10.005***
	(0.055)	(0.651)	(1.196)
Low or No Doc	−0.291	6.019***	−7.927***
	(0.558)	(1.198)	(0.341)
$Tranching_k$ × Low or No Doc loan	−0.397***	−4.577***	5.514***
	(0.038)	(0.457)	(0.772)
Second lien present indicator	4.442***	5.702***	4.012***
	(0.976)	(1.897)	(0.583)
$Tranching_k$ × Second lien present	−0.067	−0.860	−1.792
	(0.064)	(0.714)	(1.418)
Not owner occupied indicator	−4.961***	5.621***	−15.576***
	(1.106)	(2.094)	(0.626)
$Tranching_k$ × Not owner occupied	−0.603***	−7.310***	5.986***
	(0.075)	(0.800)	(1.642)
Observations	1,491,928	1,491,928	1,491,928
R-squared	0.218	0.217	0.217
Borr. and loan controls	X	X	X
CBSA by Orig Qtr FE	X	X	X
Deal × Servicer FE	X	X	X
Servicer by Del. Qtr FE	X	X	X
Cluster	Deal	Deal	Deal

The tables shows the effect of tranching on the probability that a delinquent loan is renegotiated. It shows how this effect varies for mortgages with different characteristics. Each column of the table uses a different measure of tranching depth as the dependent variable. Column (1) uses the number of tranches, Column (2) uses the natural log of the number of tranches, and Column (3) uses the Tranche HHI measure. The sample includes mortgages in deals which closed between 2002 and 2007, and which went delinquent before January 2009. The dependent variable is equal to 100 if the delinquent loan is renegotiated and is 0 otherwise. Standard errors are clustered at the deal level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table A.5
Robustness to abnormal delinquency (pool credit quality).

(a) Additional pool-level statistics

	N	Mean	St Dev	Min	p10	p25	p50	p75	p90	Max
Ex post Abnormal Delinquency (pool)	3889	0.01	0.12	−0.81	−0.08	−0.04	0.00	0.06	0.12	0.94

(b) Regression result

	(1) P(Modify)	(2) P(Modify)	(3) P(Modify)
Mean of dependent variable	24.28	24.28	24.28
Number of Tranches	−0.883***		
	(0.100)		
Ln(Number of Tranches)		−6.303***	
		(1.314)	
Tranche HHI			10.010***
			(1.181)
Ex post Abnormal Delinquency (pool)	0.186***	0.140**	0.161***
	(0.054)	(0.057)	(0.055)
Observations	1,469,512	1,469,512	1,469,512
R-squared	0.216	0.216	0.216
Borr. and loan controls	X	X	X
CBSA by Orig Qtr FE	X	X	X

(*continued on next page*)

Table A.5 (*continued*).

(b) Regression result

	(1) P(Modify)	(2) P(Modify)	(3) P(Modify)
Deal × Servicer FE	X	X	X
Servicer by Del. Qtr FE	X	X	X
Cluster	Deal	Deal	Deal

The tables shows the effect of tranching on the probability that a delinquent mortgage is renegotiated. The sample includes mortgages in deals which closed between 2002 and 2007, and which went delinquent before January 2009. Ex post Abnormal Delinquency is a measure constructed by first estimating a logit model of mortgage delinquency on the sample of all originated loans, and then taking a weighted average at the pool level of the difference between loan-level actual delinquency and predicted probability of delinquency. Ex post Abnormal Delinquency reflects delinquency that is unexplained by the logit model. Table (a) summarizes the Ex Post Abnormal Delinquency variable. Table (b) presents the regression results. The dependent variable is equal to 100 if the delinquent loan is renegotiated and is 0 otherwise. Number of Tranches is the number of tranches collateralized by the loan pool that the mortgage resides in. Tranche HHI is an HHI based measure of tranching (a higher Tranche HHI corresponds to a lower degree of tranching). Loan-level controls include: credit score, 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, and the change in house prices at the county level between origination and delinquency. Standard errors are clustered at the deal level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

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