# Market Dynamics among the ABX Index, Credit Default Swaps, and Mortgage-Backed Bonds

Michael B. Imerman*
Joseph R. Mason† ‡
Rajesh P. Narayanan§
Meredith E. Rhodes§

July 16, 2018

ABSTRACT

While some authors have attributed the financial crisis to irrational pricing among traders, we establish that information models rationally explain market differences. We do so by exploring arbitrage relationships among the ABX Indices, associated Single-name CDS, and reference Cash RMBS markets. Unlike prior papers, we use dynamic time-varying collateral performance data to reflect underlying collateral fundamentals. Then we identify informed trading using indicators derived from the institutional characteristics of the Cash RMBS. We find that the Cash RMBS market is dominated by informed traders while the ABX Index market is dominated by noise traders. Our paper is the first to show that information relationships for Single-name CDS are the opposite of those found in Corporate CDS, which occurs because Single-name CDS are written on a different contractual basis. Ours is also the first paper to estimate arbitrage relationships with three assets, rather than two. In the three-asset application, the Single-name CDS in the middle of the other two markets responds to each of the others in a classic "three-body" problem. Thus, relationships that may appear random when each pair of contracts, i.e., Cash RMBS and Single-name CDS or portfolios of Single-name CDS and the ABX Indices, are examined in isolation make sense when all three are analyzed together. Thus, the "overshooting" believed to have occurred in the recent financial crisis can be explained with a more complete understanding of contractual features and accounting properly for the three – not two – contracts forming the arbitrage relationship. (244 words)

Special thanks for comments from the 2018 Federal Reserve Bank of Atlanta Real Estate Conference, the 2018 Financial Engineering and Banking Society Conference, Claremont Graduate University, and Louisiana State University as well as Brent Ambrose, Scott Frame, Kristopher Gerardi, George Pennacchi, Vincent Yao, Junbo Wang, and Feng Zhao. Any remaining errors are solely the responsibility of the authors.

* Peter F. Drucker and Masatoshi Ito Graduate School of Management, Claremont Graduate University.
† E.J. Ourso College of Business, Louisiana State University and the Wharton School, University of Pennsylvania.
‡ Corresponding author. 2913 Business Education Complex, Department of Finance, E.J. Ourso College of Business, Louisiana State University, Baton Rouge, LA 70803, *masonj@lsu.edu*.
§ E.J. Ourso College of Business, Louisiana State University.

# Market Dynamics among the ABX Index, Credit Default Swaps, and Mortgage-Backed Bonds

July 16, 2018

ABSTRACT

While some authors have attributed the financial crisis to irrational pricing among traders, we establish that information models rationally explain market differences. We do so by exploring arbitrage relationships among the ABX Indices, associated Single-name CDS, and reference Cash RMBS markets. Unlike prior papers, we use dynamic time-varying collateral performance data to reflect underlying collateral fundamentals. Then we identify informed trading using indicators derived from the institutional characteristics of the Cash RMBS. We find that the Cash RMBS market is dominated by informed traders while the ABX Index market is dominated by noise traders. Our paper is the first to show that information relationships for Single-name CDS are the opposite of those found in Corporate CDS, which occurs because Single-name CDS are written on a different contractual basis. Ours is also the first paper to estimate arbitrage relationships with three assets, rather than two. In the three-asset application, the Single-name CDS in the middle of the other two markets responds to each of the others in a classic "three-body" problem. Thus, relationships that may appear random when each pair of contracts, i.e., Cash RMBS and Single-name CDS or portfolios of Single-name CDS and the ABX Indices, are examined in isolation make sense when all three are analyzed together. Thus, the "overshooting" believed to have occurred in the recent financial crisis can be explained with a more complete understanding of contractual features and accounting properly for the three – not two – contracts forming the arbitrage relationship. (244 words)

## I. Introduction

Understanding credit spreads remains of keen interest to understanding macroeconomic growth, business cycles, and financial crises. One particularly nagging aspect of the empirical literature on spreads is that credit spreads seem persistently "excessive" when compared to theoretically-derived estimates. Such comparisons seem particularly stark in periods of financial crisis, where credit spreads rise to levels that generally prohibit market trading, in a manifestation typically considered a "bank run."

But such spikes are only a problem if the increase is irrational. Much literature on financial crisis – particularly that based on Akerlof (1973) included in the survey by Mishkin (1992) – posits that credit spread spikes in financial crises can be considered rational responses to investors posed with newly-revealed asymmetric information. In fact, there exists evidence that such rationality underlies some of the more important bank runs in history (Calomiris and Mason 1997; 2003) and that, ultimately, market pressure induced by such runs helps sort financial firms in ways that reduce information asymmetry and alleviate the runs (Calomiris and Kahn 1991).

Yet while theoretical models and narratives of the stylized facts of credit spread dynamics abound, empirical evidence of credit spread dynamics is still sparse.

The present paper looks for evidence of asymmetric information relating to high credit spreads witnessed during the recent mortgage crisis. In particular, we examine sources of asymmetric information that affect different types of investors in three arbitrable securities underlying the ABX Index – the underlying Cash Residential Mortgage-backed Securities ("Cash RMBS"), the Single-name Credit Default Swaps ("Single-name CDS") on those Cash RMBS, and the ABX Index positions derived from those Single-name CDS and show that the three markets track each other up the limits of arbitrage implied by measureable and reasonable aspects of information asymmetry.

Ours is the first paper to include in such analysis dynamic collateral performance measures that can account for spread dynamics as underlying cash bond performance evolves over the course of the crisis.

Ours is also the first paper to formally analyze information and noise trading in the context of these securities. We derive three unique measures of information quality from the difference between first-party (trustee) and third-party (vendor) reported performance, the non-linear features of RMBS cash flows, and the discrete RMBS reporting periodicity to identify noise trading from information relating to price discovery.

Ours is also the first paper we have been able to locate that examines arbitrage relationships among *three* securities, rather than two. Our results, therefore, differ slightly from prior research on arbitrage relationships. In accordance with prior literature, we find noise trading in the most liquid market with the lowest trading costs, which in this case is the ABX Index market. Unlike prior literature, however, price discovery information enters through the Cash RMBS market and the ABX Index market, rather than the Single-name CDS market. With information entering via the Cash RMBS market and noise via the ABX Index market, the Single-name CDS are affected seemingly randomly between the two. When properly accounting for characteristics of the three securities and the three – rather than two – securities that interrelate to form the relationships, all three markets track each other predictably allowing arbitrage among the fundamentally-related securities up to the bounds of the related contractual features.

## I. Literature Review

Shiller (1984) sets up a market with two classes of investors, informed investors and uninformed investors. In a world of costly information – both in terms of dollar cost and effort – Shiller's model is considered by many to have elements of a behavioral model. For our purposes, such behavioral differences distinguish investors who desired investment exposure to residential real estate markets before, during, and after the mortgage crisis. Informed investors understood the non-GAAP financial reporting underlying such investments and the (sometimes unsuccessful) attempts by third-party vendors to standardize such reporting, the highly complex non-linearities of RMBS waterfalls, and responded to periodic reporting in predictable ways (see, for instance, Diamond and Verrecchia 1991).

We set up a hybrid model with both structural and reduced-form elements in a manner similar to Duffie and Lando (2001), wherein those authors separate the price effects arising from accounting information from those associated with noise in an environment of asymmetric information. Callen, Livnat, and Segal (2009) adopt a similar approach and establish that accounting information, rather than noise, dominates *Corporate* Single-name Credit Default Swap market pricing. Collin-Dufresne, Goldstein, and Martin (2001) and Collin-Dufresne, Goldstein, and Yang (2012) more recently refine and extend such techniques to single-name Corporate Single-name Credit Default Swaps and Collateralized Debt Obligations, respectively.

To be clear, the noise we measure is not irrational or superfluous. Rather, noise in our context reflects the costs of resolving information asymmetries, i.e., the cost of acquiring information on the detailed workings of the three related contracts (see, for instance, Grossman and Stiglitz 1980). It is well-acknowledged that in environments of high asymmetric information or macroeconomic uncertainty it can be desirable for some investors to mimic the behavior of other, more well-informed, investors rather than expending the cost and effort of becoming informed, themselves (see, for instance, Bikhcandani, Hirschleifer, and Welch 1992, 1993 and Calomiris and Kahn 1993).[5] Indeed, uninformed investing incentivizes informed trading (Black 1986).

Typically, the number of informed investors is limited by information costs. With higher information costs (and fewer informed investors), information is included in prices more slowly than otherwise. If prices take longer to absorb information, uninformed investors may unwind positions more quickly and informed investors reinvest more slowly than otherwise, generally limiting arbitrage and slowing the eventual convergence to equilibrium (Schleifer and Vishny 1997).

When differentially informed investors trade in separate markets, such markets may remain imperfectly integrated for substantial periods of time. Fremault (1991) links index arbitrageurs – who trade in both informed and uninformed markets – are associated with increased informational efficiencies and reduced price differences across such markets. Similarly, Kumar and Seppi (1994) establish that markets with more fragmented information demonstrate persistent price differences. Both Fremault (1991) and Kumar and Seppi (1994) conclude that composite securities like those offered in ABX Markets can help reduce price differences and increase liquidity in cash markets since composite securities draw in different classes of investors than cash bonds (see Subrahmanyam 1991 and Gorton and Pennacchi 1993).

---

[5] Other accepted frictions that increase the costs of arbitrage include funding costs (Brunnermeier and Pedersen 2009), search costs and short-selling costs (Tuckman and Vila 1992; Dow and Gorton 1994; Duffie 1996).

Literature like Easley and O'Hara (2004) show how information quality affects prices and suggest that both the quantity and quality of information matters. Markets for ABX Indices, reference Single-name CDS, and reference Cash RMBS have varying degrees of quantity and quality asymmetries that are used here to identify the markets and their limits to arbitrage. Monthly Cash RMBS reporting does not follow standardized guidelines, either from GAAP or regulatory agencies. Most fundamentally, therefore, investors can follow the reports issued directly from the trusts – first-party information – or can received "standardized" information from third-party vendors that attempt to manipulate the reported data for comparability across trusts.

In the process of standardization, however, those third-parties sometimes make adjustments that – for whatever reason – may deviate substantially from reported first-party data. Based upon discussion with traders, we have reason to believe that the difference between first-party (trustee) and third-party (vendor) reported performance are known generally to informed traders, but not known to uninformed market participants. Thus, while both informed and uninformed traders have the same quantity of information, informed traders use the highest quality accounting information while uninformed traders use the lowest quality accounting information. Similarly, the non-linear cash flow features of Cash RMBS are also known generally to informed traders, but not known generally to uninformed market participants. So while informed traders use the highest quality reports and the most complete structural information, uninformed traders use the lowest quality reports and less complete structural information (or none at all). The discrete Cash RMBS reporting periodicity helps identify different information quality among investors because uninformed traders are measurably "surprised" by the information, while informed traders are not.

## II. Structural Characteristics of the Three Securities

Before analyzing relationships between the related Cash RMBS, Single-name Reference CDS, and the ABX Index, we introduce a brief description of the features of the contracts relevant to our analysis.

### A. Cash RMBS

Unlike prior literature like Demiroglu and James (2012) and Stanton and Wallace (2011), we integrate the dynamic performance of our Cash RMBS as a key measure of informed and uninformed trading.

As noted in much of the prior literature, Cash RMBS are based upon pools of mortgages. Cash flows from the loans in individual pools are combined and then allocated to security interests (the "certificates," sometimes referred to as "tranches") based upon rules articulated in a variety of contracts such as the Pooling and Servicing Agreement, the Prospectus Supplement, Swap Agreements, and potentially others.[6]

While such rules are generally referred to as comprising a "waterfall," the waterfall notion really only refers to the "senior-subordinate" relationship among the certificates. In fact, many other rules, sometimes called "triggers," dictate instances in which cash flows from the original waterfall may be redirected toward and away from various certificates as circumstances regarding loan performance change the relative relationships among the certificates.

Because certificates of varying credit grade are paid down at different rates, even the simple waterfall relationships change over time. For instance, if there are no loan losses and senior certificates are paid down while junior certificates are not, the relative amount of dollar support for the remaining senior certificate balance grows. If there are losses during that paydown period, triggers may redirect cash flows from junior certificates to senior certificates to increase the credit quality of the seniors.[7]

As a result of those dynamics, conditional expectations of cash flows can change in discrete shifts across the lives of the certificates. Based upon our conversations with RMBS traders and experience in the industry, uninformed investors ignored the more sophisticated triggers and were surprised by sudden cash flow changes both before and during the crisis. As a result, we include some of the key terms common to our eighty Cash RMBS deals underlying the ABX Index in order to identify whether traders in various markets are informed. We describe those features in more detail in the data section that follows.

B. Single-name CDS Reference Contracts on Cash RMBS

Single-name CDS contracts are most commonly associated with the corporate bond market,

---

[6] It is important to note that not all such contracts may be publicly available.

[7] See, for instance, Baig and Choudhry 2013; See also the Prospectus Supplements for the eighty Cash RMBS deals referenced by the ABX Index (CTSLink 2016; US Bank 2016; Deutsche Bank 2016; J.P. Morgan 2016; BNY Mellon 2016; Citigroup 2016).

where such contracts are written on specific issuers or firms. Protection buyers pay a periodic premium to the seller, and in return the buyer of protection receives payment if credit events occur, which are clearly defined in the relevant ISDA Master Agreement as bankruptcy, failure to pay, or debt restructuring.

In the mid-2000s, the Corporate Single-name Credit Default Swap market was extended to contracts written on asset-backed securities ("ABS"), inclusive of RMBS. But Single-name CDS written on Cash RMBS are very different from their corporate cousins. The main reason for such difference is their basis on the ISDA pay-as-you-go template ("PAUG"), introduced in June 2005. The new template eliminated most of the uncertainty surrounding the definition of a credit event for Cash RMBS certificates. All of the Single-name CDS in the ABX Indices are PAUG.[8]

While a complete description of the differences between PAUG and the standard ISDA CDS template are beyond the scope of this paper, four characteristics – the named reference entity, the definition of a credit event, the payment legs, and the fixed payment cap – are important here.

Corporate CDS refer to all the bonds of the company, not one *particular* bond. For instance, when an investor purchases CDS protection on Ford Motor Company, he is buying protection against Ford's credit risk, not any one specific bond issued by Ford. When an investor purchases CDS on the AAA-rated MSAC 2006-WMC2 certificate, she receives credit protection against an adverse event on that specific certificate, not on Morgan Stanley or WMC Mortgage Corp. It should not, therefore, be surprising that the relationships we find between Cash RMBS and their related Single-name CDS differ from those established in prior literature between a corporate bond portfolio and the related Corporate CDS.

ISDA defines credit events for corporate CDS as relating to bankruptcy, failure to pay, restructuring, and obligation default (ISDA 2003).[9] But the PAUG definition entails a host of other circumstances including, most importantly, writedowns, interest shortfalls, and distressed rating downgrades.[10] The main difference between corporate and PAUG credit events, therefore, is that the

---

[8] For background on PAUG, see e.g. Whetten, Michiko. "Synthetic ABS 101: PAUG and ABX.HE." Nomura, March 7, 2005.

[9] The three other events, repudiation; moratorium, and obligation acceleration, relate primarily to sovereigns.

[10] See Whetten 2005. Writedown means whether the cash bond has been written down due to losses or prepayments. Interest shortfalls occur when there is a difference between the expected coupon (i.e. Libor + spread) and the coupon

PAUG credit events can be reversible. Such possibility introduces a third payment leg to the CDS, wherein the PAUG CDS buyer must make a payment to the seller.

Thus, there are one fixed and two floating payment legs under the PAUG structure. Under the fixed leg, the Single-name CDS buyer makes fixed premium payments based on their notional amount to the seller in exchange for credit risk protection. The fixed leg continues as long as the CDS buyer maintains the contract, so whether a credit event occurs or not, the buyer must make his premium payment. The first floating leg represents any payments made as a result of a credit event. In this case, the protection seller makes a payment to the protection buyer for an amount designated by the credit event. For example, if the credit risk is an interest shortfall, then the seller will make a payment to the buyer for an amount equal to the shortfall. The second floating leg payment will only occur when there is a *reverse* credit event, so that the buyer of protection makes payments to the seller (Goodman et al. 2008; Lehman 2005).

As discussed in more detail later, a key variable included in our analysis is the fixed payment cap included in the PAUG CDS. Most PAUG CDS contracts have fixed cap arrangements, which limit the amount the buyer is required to pay in the event of an interest shortfall to the amount of the premium, which offsets the inflow to the seller (the premium payment) with the outflow (the shortfall interest payment) to the buyer. Such a feature is advantageous to the PAUG CDS seller as he would have no "out-of-pocket" expenses, despite there being a credit event.[11]

---

received. Distressed rating downgrade occurs if any rating agency downgrades the bond to CCC/Caa2 or below or withdraws its rating entirely. Also note that sponsor bankruptcy is not a credit event because the trust is a bankruptcy remote SPE.

[11] While not central to our analysis, PAUG CDS also offer flexibility on closing out positions. There are four options for unwinding an RMBS CDS contract: exercising a clean-up call, termination, novation, and an offsetting position.

- RMBS CDS typically trade with clean-up call provisions, which gives the buyer the option to break his contract if a coupon step up is triggered. Coupon step up occurs when the reference obligation is not called for redemption before a set date, which is outlined in the RMBS documents, before the legal final maturity. A clean-up call provision is valuable to the CDS buyer because it allows them to avoid paying an increased premium if coupon step up occurs.
- Termination occurs when one party pays his counterparty the market value of the CDS.
- Novation requires finding a third-party that will buy the CDS and take over the current owner's premium payments.
- Fourth, an investor can enter into an offsetting position in a similar CDS. This last option exposes the investor to counterparty risk and basis risk (the risk that the new contract is not a perfect hedge). For the first two options, gains or losses on closed out positions are realized upfront, whereas the fourth option, an offsetting position, they are realized only over time (Lehman 2005).

C. ABX Index Referenced to Single-name CDS

Yet further differences exist in the construction and pricing of the ABX Indices. By way of background, the index sponsor, Markit Group, launched the first semi-annual set of ABX Indices in January 2006 (the 2006-1 vintage) with a plan to issue a new index, or "roll," every six-months.[12] After each new roll, all prior indexes were to continue trading until maturity. In the interest of avoiding confusion, we refer to each individual ABX roll as a "vintage," referring to specific index by their specific name, i.e., the 2006-1 AAA. Any mention of the general term "ABX Index" hereafter will be referring generally to all four vintages and each of their five indices.

A consortium of sixteen investment banks, who were also the licensed dealers of the ABX Indices, weighed in on the selection of the 20 deals to be included in each successive roll.[13] To determine which RMBS deals would be included in a vintage, Markit Group gave a list of the largest subprime RMBS deals from the previous six months to each of the investment banks to rank. Markit used these rankings to choose which deals to include based on specific criteria meant to provide diversification. Their criteria required that no more than four deals could come from the same issuer, only six deals could have the same servicer, the principal amount had to be larger than $500 million, and a minimum requirement of 90% first lien loans from borrowers with a FICO credit score of at least 660 (Markit Group 2016).[14] Of the deals that met this criteria, the investment banks would rank deals that were thought to represent the most liquid deals in the RMBS market, which helps mitigate the impact of illiquidity in our analysis.

The five indices within each vintage are based on the initial ratings of certificates in the 20 selected deals. Since there are multiple classes of rated certificates in each category (AAA, AA, A, BBB, -BBB), the ABX uses the first-loss certificate in each category.[15]

---

[12] Markit's plan of successive 6-month rolls was halted after the fourth vintage launched in July 2007, the 2007-2 due to low issuance and few qualifying deals. There have been no subsequent vintages since that date.

[13] These banks were Bank of America, Barclays, Bear Stearns, BNP Paribas, Citigroup, Credit Suisse, Deutsche Bank, Goldman Sachs, Greenwich Capital, JP Morgan, Merrill Lynch, Morgan Stanley, Lehman Brothers, RBS, UBS, and Wachovia.

[14] Note that those criteria placed no restrictions on the *originators* of the underlying loans, leading to a high concentration on a small number of originators like WMC, New Century, and Long Beach Mortgage Company, that provided loans to larger financial institutions through origination conduits.

[15] That is, assuming such first-loss certificate can be distinguished from others. That caveat generally relates to AAA certificates among which the trust does not allocate losses.

The ABX operates according to the same ISDA PAUG template as the reference Single-name CDS. But the ABX Index relates to cash flows of an underlying *portfolio* of bonds, not a *single* bond. Thus, among the relevant credit events included by the Single-name CDS, the ABX omitted the distressed rating downgrade but retained writedowns and interest and shortfalls.

Like the Single-name CDS, if there is a credit event, the protection buyer receives payments from the seller.[16] The ABX PAUG structure is based on only *two* payment legs. The first (fixed) leg is determined by the sponsor before the index is traded, based on the approximate present value of the monthly inflow of fixed, no-default coupon payments of the mortgages in the underlying MBS tranches, adjusting for prepayments (Fender and Scheicher 2009). The Markit Group capped the fixed coupon rate at 5.00%, so that if investors expected that the present value of losses on the underlying RMBS deals would be greater than 5.00% the relevant index would trade below par to account for the additional loss expectations. The second leg of the cash flows was a floating leg that was determined by expectations of principal writedowns or interest shortfalls and reverse credit events.[17]

The pricing on the ABX Index is not exactly the mathematical equivalent of the Cash RMBS or Single-name CDS price. The Markit Group indexed the price of each index to $100 at the issue date of the relevant vintage, which could be as much as six months *after* a deal included in that vintage was issued.[18] Like any swap, on the first trading day, the cash flows from the fixed and the floating legs canceled each other out resulting in the Equation (1), which is the ABX Index price calculation at issue.

$$ABX\ Index\,Price = \$100 + PV\ of\ Coupon\,Payments - PV\ of\ Writedowns\,\&\,Shortfalls \qquad (1)$$

[16] For example, on November 27, 2006, Markit Group determined there was an interest shortfall on one RMBS deal that affected the BBB and BBB- bonds in the ABX 2006-1 vintage. The interest shortfall per million at the index level was $105.35 and $142.02 for the BBB and BBB- indices. If for some reason these events were reversed, the protection buyer had to repay the seller.

[17] Unwinding an ABX index position is similar to a Single-name CDS. If the buyer wants to close out his trade, he has three options: termination, novation, or an offsetting position. If an investor wants to terminate his position, he must pay the opposite party the market value of the ABX index. Novation requires the investor to find a third-party to take over payments. Lastly, the investor can take an offsetting position on the ABX index. Like with the CDS contract, the offsetting position option exposes the investor to additional counterparty risk, but unlike the CDS, the new contract will. be written on the specific index in question, so there are no additional risks associated with different contract features or collateral.

[18] The index could launch below $100 if the fixed coupon rate was capped at 5%.

After each index launched at \$100, price changes resulted from expectations of future writedowns and shortfalls. If the price fell (rose) below (above) \$100, writedowns and shortfalls have increased (decreased) relative to the coupon rate (i.e. spreads have widened (narrowed) relative to the fixed rate). A lower (higher) price means the cost of credit protection increased (decreased) because of credit deterioration (improvement).

Equation (2) shows the calculation of the upfront payment on an on-the-run index.

$$Upfront\ Payment = \frac{(\$100 - ABX\ price)}{\$100} \times Factor \times Notional \tag{2}$$

The initial payment is based on the dollar amount of protection the buyer wants, which is called the notional amount. The percent difference between the indexed price of \$100 and the current price is multiplied by the bond factor (that adjusts for the amount of principal that remains outstanding on the underlying certificate).

For counterparty protection, incremental changes to value are paid to the appropriate party on a monthly basis. Prices may also vary slightly from the fundamentals described above due to counterparty risk, both within the payment period and as the financial crisis progressed.

## III. Theoretical Framework

It should be clear from the above that the three securities – the Cash RMBS, the Single-name CDS, and the ABX Indices – should track one another to a large degree.

From a theoretical perspective, we explain our results using a simple Shiller (1984) framework, distinguishing performance among the Cash RMBS, Single-name CDS, and the composite ABX Index in terms of differences attributable to informed and uninformed investors.[19] Without loss of generality, therefore, we define informed investors as those who respond to information contained directly in the first-party remittance report and uninformed investors as those who rely on third-party data vendors. Informed investors also respond to performance reported to non-linear and linear developments with less noise than uninformed investors.

---

[19] While we use the informed/uninformed investor framework for simplicity and convenience, our results generalize to assuming divergence of opinions about the effects of such effects among equally-informed investors in the face of complex interrelationships among the institutional features of Cash RMBS, Single-name CDS, and the composite ABX Index.

Assume all investors are rational utility-maximizers to the limits of their information. Following Shiller (1984), Equation (3) represents the demand for an asset by the informed traders. Equation (3) is dependent on three factors: (a) $E_t R_t$, which is the return expected by informed traders, (b) $\rho$, a constant, is the return expected by *uninformed* investors, and (c) $\varphi$, another constant, is the abnormal return that would induce the informed investors to hold the entire quantity of the investment. If the return expected by uninformed investors (a) is the same as that of informed investors (b), then informed traders will not demand any of the asset ($Q_t$ =0).

$$Q_t = \frac{\left(E_t R_t - \rho\right)}{\varphi} \tag{3}$$

In equilibrium, the total value demand by uninformed traders per share is $Y_t = P_t\left(1 - Q_t\right)$, providing the rational expectations solution of:

$$P_t = \sum_{k=0}^{\infty} \frac{E_t CF_{t+k} + \varphi E_t\left(Y_{t+k}\right)}{\left(1+\rho+\varphi\right)^{k+1}} \tag{4}$$

In Equation (4), the price of the asset equals the present value of expected future cash flows[20] plus a proportion of expected future uninformed trader demand discounted a the new discount rate of $\rho + \varphi$. Note that in Equation (4) both the relevant amount of future uninformed trader demand and the discount rate depend on $\varphi$, which is the risk premium demanded by informed investors. As $\varphi$ declines to zero (as informed investors become more influential), Equation (4) approaches the functional form of the ordinary efficient markets equation. As $\varphi$ rises, the model collapses to $Y_t = P_t$ so that uninformed investors solely determine price.

While there exist contractual differences among the three, composite securities like the ABX Indices and – to a lesser extent the Single-name CDS – should, therefore, attract more uninformed investors than the Cash RMBS because they require only partial upfront funding. The ABX, in addition, diversifies some degree of idiosyncratic risk, thus lowering adverse selection costs and

[20] For RMBS bonds, the cash flows are the coupon payments. For Single-name CDS and ABX, cash flows are payments in the case of a credit event.

attracting liquidity traders (Subrahmanyam 1991; Gorton and Pennachi 1993). Short-sellers are attracted to the more liquid asset – the ABX Indices – because it is the easiest to locate and fund (Vayanos and Weill 2008).

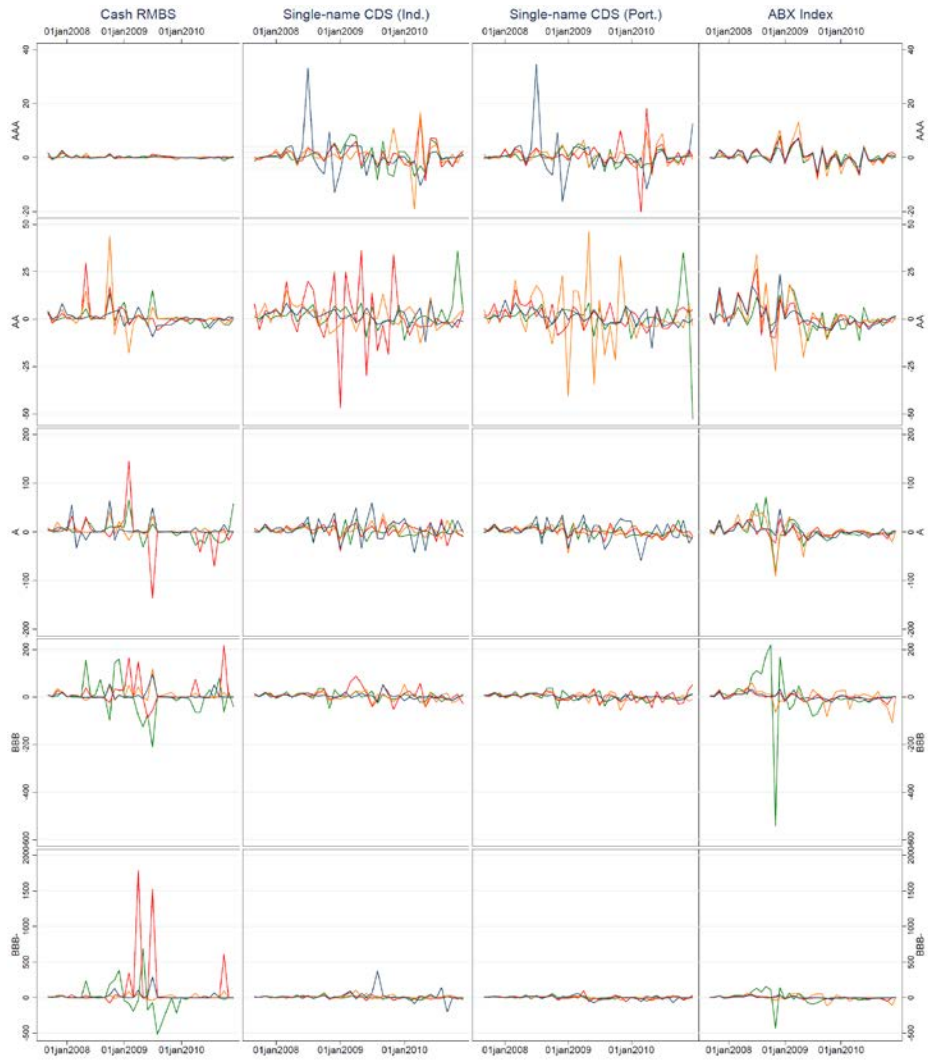
## IV. Data

We are interested in how asymmetric or costly information affects prices, so we generally interpret $\varphi$ as a function of the accuracy of third-party reporting and the degree to which uninformed investors understand non-linear and linear securitization features, whereby informed investors demand higher returns in exchange for expending the resources to properly understand and track these sophisticated investments.

Even in the event that uninformed and informed investors are equally informed, however, our three securities – Cash RMBS, Single-name CDS, and the ABX Indices – will trade at a differential varying with regard to institutional features of each market. For instance, in the Cash RMBS bond market, investors are limited to long-only positions and must fully fund their investments upfront. In contrast, Single-name CDS contracts and the ABX Indices require only partial upfront funding – depending upon whether the security is trading at a premium or a discount – and ongoing premiums.

In this section we discuss the data used in our analysis, including the data on credit spreads for each of the three securities and that quantifying information quality, as well as controls for relative market and macroeconomic performance.

**Figure 1: Changes in Credit Spreads**




A. Dependent Variables: Changes in Bond Spreads

Daily ABX Index spreads are from Bloomberg and the Markit Group for the sample period of July 2007 through December 2010. Daily Single-name CDS quotes from major market participants for the same period also come from the Markit Group.[21] Cash RMBS yields for the 400 certificates (five certificates from each of the twenty deals in each of the four vintages) referenced in the ABX

[21] Markit filters these quotes to remove extreme outliers and stale observations. If there are at least 3 quotes left after the filter process, Markit averages the remaining quotes and reports the composite spread.

Index are from Thomson Reuters.[22]

In our empirical work, we analyze changes in Credit Spreads for each security, as well as differences in the changes in Credit Spreads across pairs of securities. Changes in Credit Spreads for each security are also the basis for our analysis of noise trading and the manner in which information enters the three markets.

Figure 1 presents the changes in Credit Spreads for each security, including across the top four panels both individual Single-name CDS as well as the portfolio of Single-name CDS relevant for the analysis of the ABX Index pricing. The panels are organized vertically by credit grade, from AAA on the top to BBB- on the bottom.

The changes in Credit Spread in Figure 1 move a little for AAA, AA, and A Cash RMBS and ABX Index markets, but more so for Single-name CDS both in individual and portfolio formats. The relationship is reversed for BBB and BBB- credit grades. Most of the volatility takes place in the 2009 time frame.

B. Dependent Variables: Basis and Tracking Error

The Single-name CDS - Cash RMBS basis ("Basis") is the difference between the Single-name CDS spread and the associated Cash RMBS certificate spread. Basis is plotted in the left-hand panels of Figure 2. Basis is measured at the individual tranche level, so there are twenty basis series for each ABX vintage and credit grade (rating) combination.

Figure 2 illustrates that there is a great deal of variation in basis around the mean (the dark line). Arbitrage opportunities among the two securities are conditional on relative pricing differences illustrated by the Basis. Holding security specific differences constant, positive (negative) basis (meaning the Single-name CDS spread is higher (lower) than the bond's credit spread) indicates that the Single-name CDS is undervalued (overvalued) relative to the bond.[23]

---

[22] All of the constituent bonds of the ABX Index are floating rate and therefore, by convention, their spread is defined over LIBOR. We calculate the Cash RMBS credit spread as the certificate yield over 1 month LIBOR. For fixed rate Cash RMBS the spread would be over the Treasury yield with a closely matched maturity.

[23] The arbitrage trade for a positive basis would be to sell the basis. That is, sell the cash bond and sell the Single-name CDS, which is the equivalent of establishing a short credit position and a long credit position, respectively. For a negative basis trade, an investor would go long the basis by buying the Single-name CDS and buying the Cash RMBS, which is the same as gaining a short credit exposure and a long credit exposure, respectively.

**Figure 2: Basis and Tracking Error**

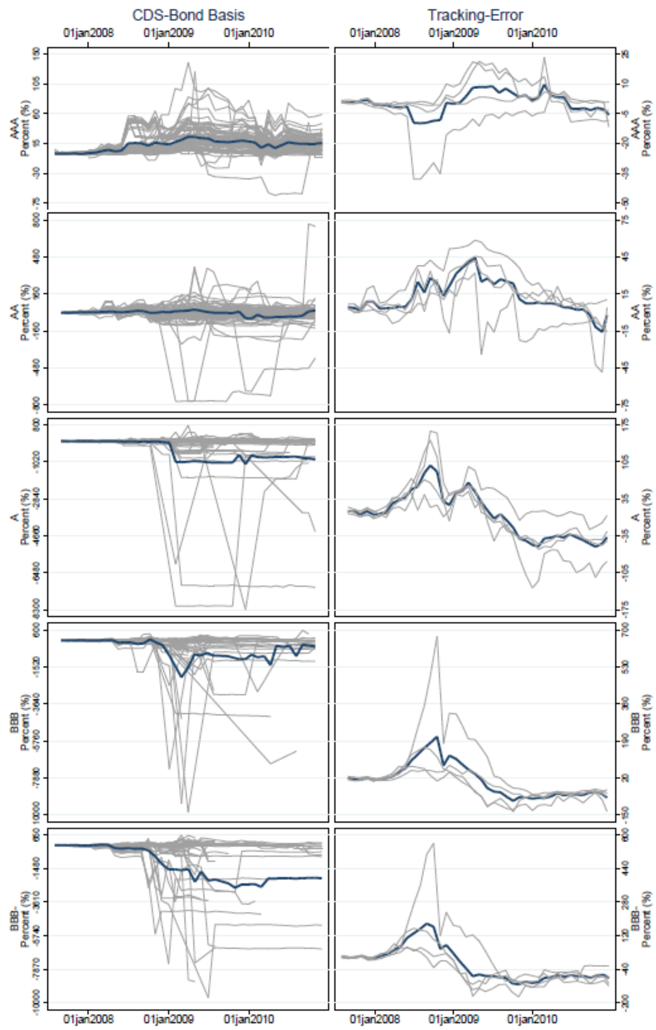



Figure 2 shows that some Basis relationships vary widely across time while others are more stable. While changes in basis are not visually apparent in Figure 2 (because of the inability to distinguish among the 20 tranches in each panel) HEAT 2007-2 is responsible for both the largest increase in basis (+119) as well as the largest decrease (-118), in the AAA panel. At the AA credit grade, the maximum change in Basis is obtained for SAIL 2005-HE3 (+775) while the smallest is MSAC 2006-WMC2 (-221). For the A level, the largest increase is SASC 2006-WF2 (+687) and the largest decrease is MSAC 2005-HE5 (-922), with even larger differences for BBB (MLMI 205-AR1 at

+1,455 and MLMI 2005-AR1 at -1,528) and BBB- (MLMI 2005-AR1 at +5,378 and JPMAC 2006-FRE1 at -7,984).

There is little discernible trend in the high-low Basis width across vintage, holding credit grade constant. The magnitudes or our Basis concur with those discussed in literature like Gorton (2009), seeming to constitute the basis of the ABX "overshooting" puzzle.

We define "Tracking Error" as the difference between the ABX Index spread minus that from that of the associated Single-name CDS portfolio.[24] A positive (negative) tracking error would indicate the ABX subindex is overvalued (undervalue) relative to the Single-name CDS portfolio.

The right-hand panels of Figure 2 depict our Tracking Error variable. Because the ABX has only one series per vintage and credit grade, there are only four lines per panel (as well as the dark line depicting the mean of all four vintages for each credit grade). The average Tracking Error for the AAA credit grade is within +-10 bps, with individual series at times jumping as high at +25 bps and as low as -35 bps. For the AA credit grade, the average ranges between +45 and -15 bps, with individual series in the +-50 bps range. The average A Tracking Error varies between +100 and -50 bps, with individual series ranging between +-150 bps. For BBB and BBB-, we see the average varying between +200 and -100 bps, with individual series varying between +700 and -200 in total.

So while our Basis illustrates the type of magnitudes that have led prior authors to be concerned with relationships between RMBS and the ABX, our Tracking Errors do not show such dramatic magnitudes. Thus, we proceed to measure the reason for such differences based upon relevant deal and tranche performance as well as other relevant deal and tranche characteristics, especially those that may lead to different expectations among what can be considered "informed" and "uninformed" traders.

---

[24] Because basis is the general term to describe the relationship between a cash (in this case, a cash bond) and a derivative security, we differentiate the spread difference between the ABX Index minus that from its associated Single-name CDS portfolio from the relationship between the Cash RMBS and the Single-name CDS basis by referring to this as "Tracking Error." We borrow this terminology from the index fund literature describing how the price of a portfolio of securities that make up an index may perform differently from the index itself. An investor that desires the same exposure as an ABX Index would need to establish 20 separate Single-name CDS contracts. Therefore, we define tracking error as the difference between an ABX Index and the relevant properly-weighted portfolio of factor-adjusted Single-name CDS contracts, using factor adjustments to reflect amortization and writedown of principal related to each certificate. See the ABX Index definition in Market Group Index Annex Archives (Markit 2016).

C. Identifying Asymmetric Information Variables

1. Gap between First- and Third-party Reporting

Trustees, securities administrators, and servicers routinely use different accounting conventions, cutoff dates, and other techniques in preparing and presenting remittance reports for each securitization. As a result, a third-party industry grew up well before the crisis wherein vendors attempted to standardize and publish comprehensive pool-, deal-, and loan-level data that could be used by investors to more easily evaluate deals. Interviews with investors suggest that informed investors rarely relied upon such third-party data, the reason being that it could (temporarily or permanently) contain unexplained differences from the native deal performance data published on Trustee portals.

In order to establish the fact and magnitude of such differences we reconciled two vendor products with the native Remittance Reports made available on deal trustee web sites. Our third-party data came from Lewtan's ABSNet and BlackBox Logic's BBx databases. Trustee web sites included all trustees servicing Cash RMBS referenced in the ABX Indices, including web sites like Wells Fargo's CTSLink, Deutsche Bank's TSS Investor Reporting Website, and USBank's Trust Gateway Portal. All remittance report data was hand-collected and checked for accuracy. We collected remittance report data from January 2006 to December 2010.[25]

Uninformed investors typically relied upon third-party vendor data to avoid the costs of reconciling deal reported according to different accounting conventions, but in doing so lost the granular view of default risk within any single one of those deals. For purposes of the present analysis, we reconcile completely one simple and crucial pool performance measure among the 80 deals in the four ABS vintages: aggregate loss.[26] We checked each of the eighty Cash RMBS deals' documentation to establish the specific definition of aggregate loss included therein. For all of the Cash RMBS deals, aggregate loss was defined as the cumulative realized loss amount reduced by subsequent recoveries. ABSNet and BBx also follow this definition. The third-party sources, however, show significant and

[25] We started collecting in January 2006, even though our analysis doesn't start until July 2007, in order to gain a better understanding of the data vendor aggregation problems. Further, we also collected delinquency data.

[26] We reconciled several additional variables, but those are of secondary importance to aggregate loss both in terms of the general deal performance structure as well as in the regressions presented below.

persistent patterns of differences between them and the native Remittance Reports.

We hypothesize that uninformed investors are less knowledgeable about such differences than informed investors. We calculated the **"Reporting Gap"** between the three sources for each pool, *i*, and each month, *t*, expressing that as a coefficient of variation in Equation (5) where

$$\text{Reporting Gap}_{i,t} = \frac{\sigma\left(AggregateLoss\right)}{\mu\left(AggregateLoss\right)} \tag{5}$$

and $\sigma\left(AggregateLoss\right)$ is the standard deviation of the net aggregate losses across the three sources and $\mu\left(AggregateLoss\right)$ is the mean of the net aggregate losses across the three sources.

**Figure 3: Reporting Gap Asymmetric Information Variable**

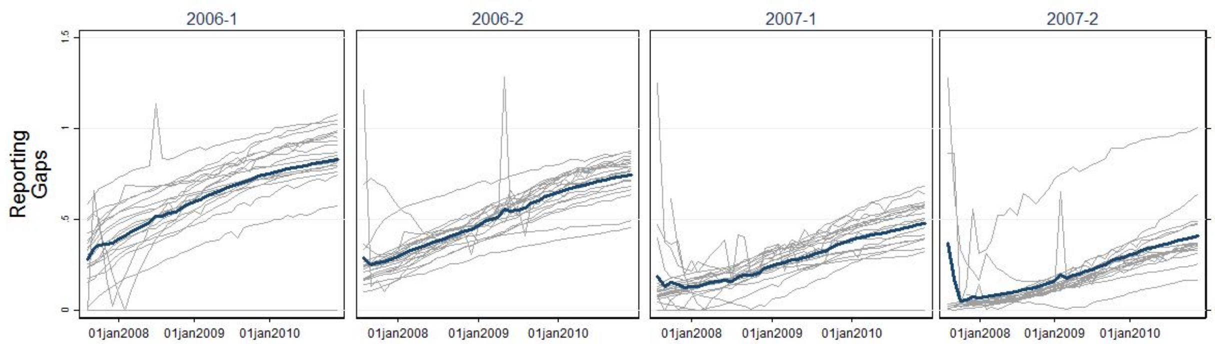



Figure 3 plots our Reporting Gap variable. A large Gap means there are big differences across data sources, while a small Reporting Gap means the three sources are similar. Aggregate Loss, which is the basis of our Reporting Gap, is reported at the overall deal level, so Figure 3 shows twenty lines (plus the dark line representing the mean) in each ABX vintage panel. When deals are relatively new few losses have accumulated, so that the average Gap tends to be small simply as a function of the total possible attained magnitude.

Individual deal-level Reporting Gap, however, can vary significantly around the mean. While Reporting Gap generally rises over time, it can move up and down with occasional corrections to vendor reporting. Clearly, however, such corrections do not typically make up for the entire effect.

If investors in the aggregate demand more required return due to information risk, we expect that Reporting Gap will be positively correlated with individual Cash RMBS spreads. But if uninformed investors take into account third-party reports and informed investors take into account native Remittance Reports, we would expect a positive correlation with Basis or Tracking Error, depending upon whether Single-name CDS markets can be considered to be dominated by informed or uninformed traders. Put another way, if composite securities like the ABX Indices and – to a lesser extent the Single-name CDS – attract more uninformed investors than the Cash RMBS, the effect of Reporting Gap upon Tracking Error should be small and the effect of Reporting Gap upon Basis should be large and the sign determined by the predominate arbitrage relationship, which is what we observe above.

2. Non-linear Features of RMBS Waterfalls

As noted previously, we hypothesize that informed investors are knowledgeable about the more esoteric features of RMBS, following much more detail that just the base waterfall and initial amount of subordination at the time of issue. We include controls for the key non-linear RMBS features commonly found in securitizations: the "Stepdown" (or "Aggregate Loss") trigger and the "Acceleration" trigger. Both those triggers serve to divert cash flows from lower seniority tranches to higher seniority tranches[27] if certain performance measures are breached, allowing certain certificates to "jump" ahead of others in a discrete fashion if pool performance breaches certain thresholds.

*a) Stepdown Triggers*

Stepdown provisions convert principal payments from a *sequential* pay basis – where senior tranches are paid before junior tranches – to a *pro rata* basis – where all tranches are paid proportionally – after a pre-specified "Stepdown Date." Most RMBS deals contain stepdown provisions (see, for instance, Baig et al. 2013; Goodman et al. 2010).

Stepdown is rational for well-performing deals, because it helps pay off high-cost subordinate debt once it becomes apparent that the additional protection provided by that debt is not necessary. But because Stepdown increases credit risk for senior tranches (because junior tranches are paid off

[27] It is important to note that although a tranche may be rated AAA, it is not necessarily the first entitled to principal payments. For some deals, there is sequential payment structures within the AAA rated tranches. In other words, the most-senior AAA tranche will receive payments first. When it is paid off, then payments will start for the second AAA tranche, and so on. For this reason, when discussing cash flow payments in the sections that follow, we will make reference to higher priority tranches and subordinate or lower tranches instead of senior and junior tranches. This is an important distinction when describing the AAA tranches included in the ABX index because the ABX refers to the lowest of such tranches.—the first loss tranche (Markit Group 2016). As a result, AAA tranches may still be sensitive to changes in prioritization of cash flows as lower rated tranches would be, even if the impact will be less.

sooner), Stepdown triggers also *prevent* Stepdown from occurring if the deal is not performing as anticipated.

Stepdown is, therefore, a function of certain credit performance tests. The typical credit performance tests applied to Stepdown are Delinquency Tests and Cumulative Loss tests. The tests are applied each month, and if both tests are passed (delinquencies and losses are low), then the deal will step down. If at least one test fails, no step down will occur. While a deal could – in theory – recover from both such tests, the likelihood of recovering from a Cumulative Loss trigger is more remote than recovering from a Delinquency trigger because while delinquencies fluctuate, losses for the most part remain the same or grow over time. Thus, we focus here on the Cumulative Loss test, leaving aside the Delinquency test.[28]

Cumulative Loss tests compare a deal's aggregate realized loss amount as a percent of the initial pool balance to a loss schedule, which is provided in the deal documents. The loss threshold percent is unique to each deal. It may remain constant over the life of the deal or may dynamically change based on the deal's loss schedule. We examined each deal's documentation and collected the definition of loss and the upward-sloping loss percent schedules, which is used to calculate the threshold, for each deal.

Our Cumulative Loss test variable is calculated as the difference between the relevant threshold value and the current percent of net cumulative losses, as shown in Equation (6).

$$Distance\text{-}to\text{-}LossTrigger_{i,t} = \left(Threshold_{i,t} - Agg.RealizedLossPercent_{i,t}\right) \tag{6}$$

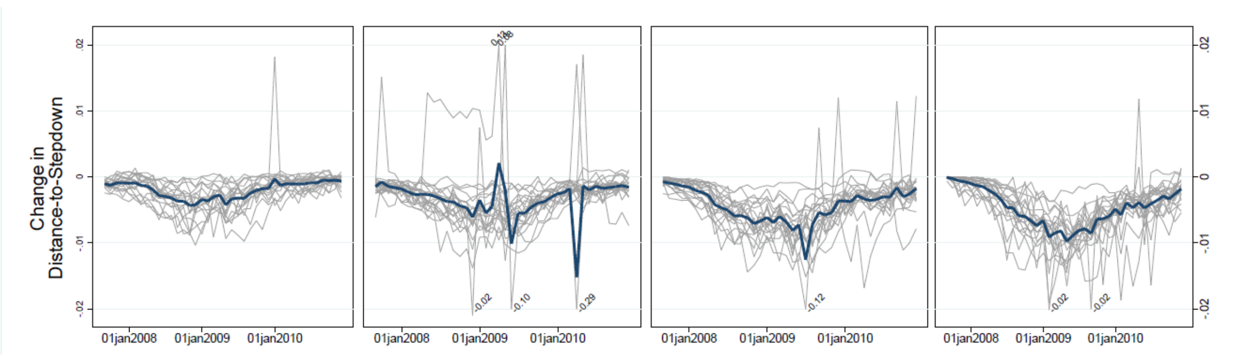
Cumulative Loss is defined consistently across deals (by us as well as the deal documentation) as the cumulative realized loss amount reduced by any subsequent recoveries, and the percent of realized

[28] We constructed a distance-to-delinquency variable based each deal's definition of 60-day delinquent; however, when added to our credit risk models, it was not a significant determinant of credit spreads. We dropped the variable to have a more parsimonious model and excluded its description and variable construction from the paper in the interest of brevity, but both can be found in the internet appendix. Delinquency triggers are typically based on the amount of Office of Thrift Supervision (OTS) 60+ day delinquencies, which are commonly called seriously delinquent loans (SDQ). The exact definition of what constitutes a 60+ day delinquent can vary across deals. There are two types of threshold percentages. One is a constant or static percent for each bond class that is set forth in the deal documents. The other is a dynamic threshold that is calculated based on the product of the current subordination percent and a constant percent. As the collateral of the deal performs and credit support changes due to prepayments and losses, the dynamic threshold will change month to month (Goodman et al. 2008).

loss to be compared to the trigger is calculated as the ratio of aggregate net losses over the initial pool balance, $Agg.RealizedLossPercent_{i,t}$. The trigger is breached when the measure becomes negative. We incorporate into our model the monthly change in Distance to Loss – **"Δ Distance-to-Stepdown"** – as well as its squared term.

Figure 4 depicts our Δ Distance-to-Stepdown variable. Like Reporting Gap, Δ Distance-to-Stepdown is reported at the overall deal level, so Figure 4 shows twenty lines (plus the dark line representing the mean) in each ABX vintage panel.

**Figure 4: Change in Distance to Stepdown (Δ Distance-to-Stepdown) Variable**




The Δ Distance-to-Stepdown variable is, on average, running negative and then back to zero as the deals exceed their Cumulative Loss triggers and then recover, somewhat. Some deals run positive for a while, and others – including the 2006-2 vintage average – exhibit sizable upward spikes in some periods, reflecting cumulative net recoveries or other influences. While all of the Cash RMBS deals eventually breach their cumulative loss triggers, there is wide variation in timing among the deals.

*b) Acceleration Triggers*

Acceleration is the opposite of Stepdown. Moreover, while a Stepdown that is prevented by the triggers reflects no change in cash flows, an Acceleration that is triggered actively diverts principal flows *away from* the lower tranches to pay down the senior tranches more quickly. While Acceleration is the opposite of Stepdown, it need not be the exact mirror opposite.[29] One reason is that not all deals in the RMBS universe contain Acceleration triggers. All of the reference Cash RMBS in the ABX

[29] Still, the two are highly correlated so that we only represent one as a continuous variable in our models below.

Indices, however, do contain such triggers.

Acceleration is triggered by an Overcollateralization ("OC") shortfall. The OC is an account built up with additional collateral contributed to the deal, bolstered by excess interest earned on the pool of loans over the amount due certificate holders in the trust. Sometimes swap agreements are also used to provide additional cash flows to OC.

Each pool has a "target" OC specified in the deal documentation. Target OC levels can change during the life of a deal.[30] If an OC deficiency occurs (generally, when Cumulative Losses have eaten up all or almost all of the OC), all periodic *excess* interest and principal flows will be diverted to the bond classes specified as entitled to principal payments in order to accelerate bond amortization within those classes.[31]

Our Acceleration variable, **"Acceleration Breach,"** is derived from the acceleration status reported in the remittance reports. The variable takes the value of one if the current OC value drops below the target amount and zero otherwise.

The impact of Acceleration and Stepdown depends on the relative seniority of the certificate. They have negative effects on senior Cash RMBS prices, ceteris paribus, because the certificates are paid off more quickly in Stepdown and Acceleration breach (meaning *failure* to Stepdown) than otherwise (and will, therefore, return less interest over a shorter life than originally expected). Importantly for our study, however, Acceleration and Stepdown have the opposite effect on senior Single-name CDS prices because the certificates are less likely to experience loss under most of the credit event definitions provided in the ISDA Master Agreement (while the certificates may be less likely to experience principal loss, the mere fact of Acceleration and Stepdown may indicate uncertainty about interest shortfalls).

The expected effect of Acceleration and Stepdown is uncertain for junior Cash RMBS certificates because while the faster senior payoff can be valuable, the fact of an OC shortfall indicates adverse performance of the underlying collateral. Either way, the fact of a trigger breach (or impending

[30] If a deal reaches its Stepdown date without having a trigger event (either a Cumulative Loss or Delinquency trigger breach) then the target OC level will adjust downward according to a schedule outlined in the deal documents.
[31] One might think of the combined effect of a Stepdown breach and Acceleration as a "turbo" amortizing of the senior class(es).

breach) is crucial for informed investors because they will anticipate that *something* will be changing soon, even if they cannot yet anticipate the effects of that change. For Single-name CDS, the fact of Acceleration and Stepdown increase the risk of all related credit events. Divergent expectations may induce Basis and Tracking Error, with the separation among informed and uninformed investors relying upon whether the distinction between the two lies between Cash RMBS and Single-name CDS or between Single-name CDS and the composite ABX Index.[32]

3. Dynamic Remittance Information

Information on the credit performance of the underlying RMBS deals comes from monthly aggregate RMBS deal-level remittance reports. The remittance reports show the amounts to be paid to investors as well as collateral and other relevant deal/pool performance on a monthly basis. For all ABX deals, the report is released on the 25th of each month. If the 25th falls on a weekend or a holiday, then it is released on the next business day. In the empirical specifications below, we include an indicator variable for the release date to establish whether investors are responding to new information releases.

Basis and Tracking Error should also correspond dynamically with the month-to-month reported performance of the related Cash RMBS pool(s). In order to account for such dynamics, we include a variable accounting for the remaining amount of subordination providing tranche credit protection each month. We collect subordination percentages directly from the remittance reports. We calculate the change in subordination by taking the difference between the current subordination percent from that reported in the previous month, reporting the increases/decrease in credit protection for each tranche as **"Δ Subordination"** A positive (negative) value means there is an increase (decrease) in subordination, indicating there is a larger (smaller) cushion to absorb any losses the tranche may experience.[33]

---

[32] As noted previously, while we use a simple informed/uninformed investor framework, our results generalize to divergence of opinions about the effects of such effects among equally-informed investors.

[33] Subordination is related to cumulative loss as implemented in computing our Distance-to-Stepdown variable, but may be buffered by OC and other elements, as explained above. Thus, Subordination is sufficiently different from the other variables in that it is not highly correlated with those other variables.

**Figure 5: Tranche Δ Subordination Asymmetric Information Variable**

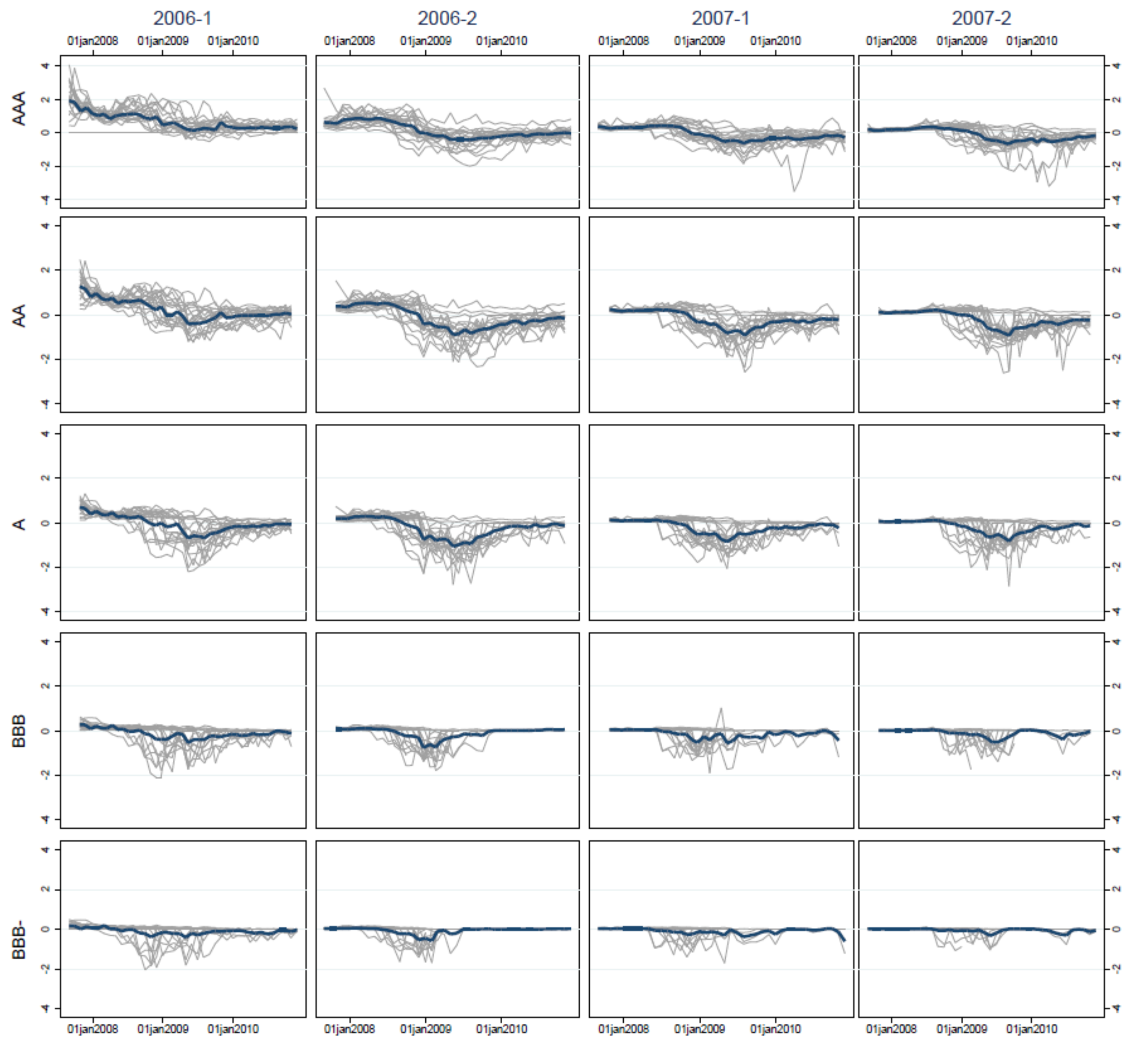



Figure 5 depicts Δ Subordination percentages over time. The Δ Subordination variable is shown for twenty tranches related to each credit grade in each ABX Index vintage, along with the associated mean (the dark line). Again, we see a general trend in the average, with considerable variation around that average across the individual Cash RMBS deals with some performing worse than others and some exhibiting upward and downward spikes in certain periods.

The average pattern is for Δ Subordination to decline, and then revert to zero. Such a pattern is illustrative of subordination being depleted and then, having been fully depleted, demonstrating no further changes. Because of that non-linearity in Δ Subordination, we also include an indicator variable for whether a tranche is currently absorbing losses in the month, **"Loss Tranche."** Loss Tranche also accounts for the possibility that uninformed investors that do not regularly track the performance of Cash RMBS may be surprised by the fact of loss if they are only analyzing standardized information, since they may be unaware of the impending loss measured by the declining subordination specifically related to their deal by the potentially unique accounting provided by the trustee. Thus, we allow the *fact* of loss to contain different information than the *level* of loss measured by the Subordination variable.

D. Counterparty Risk, Market Liquidity, Macroeconomic, and Other Variables

Because the Cash RMBS, Single-name CDS, and ABX Indices provide different contract and payoff characteristics, each may be affected differently by market conditions. Two key market conditions are liquidity and counterparty risk. Macroeconomic variables control for systematic risk, and a lag dependent variable controls the AR1 nature of financial market dynamics, generally.

We control for **"Counterparty Risk"** for the Single-name CDS and the ABX Indices using a variation on Morkoetter, Pleus, and Westerfeld (2012), assuming the primary counterparties are the market makers in the indices. We use the arithmetic mean of the 5-year CDS spreads on the 15 ABX Index market makers[34] reported by Markit, filtering those by the same process as the Single-name CDS spreads. Since we do not have Single-name CDS counterparty data by which to measure risk in that market, we assume those same 15 banks also participate in the Single-name CDS market as protection sellers. We assume there is no counterparty risk in Cash RMBS markets since those reflect investments in brain-dead bankruptcy-remote REMICS.

Market liquidity is incorporated following Bai and Collin-Dufresne (2011), including the variable **"Funding Cost"** that is constructed using the difference between the general collateral repurchase rate and the 3-month LIBOR.[35] Both are collected from the website of the Federal Reserve

[34] There were 16 banks in the consortium that assist in the construction of the ABX index, but RBS Securities and Greenwich Capital were owned by the same parent company, so there is only one CDS written on them.

[35] Bai and Collin-Dufresne (2011) use 3-month T-bill rates; however, they were examining basis using fixed-rate corporate bonds. In our analysis, our bonds are floating rate bonds, which is why we elect to use LIBOR instead of T-bill rates. We also ran the model using 1-month and 6-month LIBOR for robustness and obtained similar results. Those results are available upon request.

Bank of St. Louis (FRED). Our approach assumes investors use the repo market for arbitrage funding, and that funding Single-name CDS and ABX Index investments is valuable at rates above LIBOR is economically viable while funding Cash RMBS bonds at rates above LIBOR is not.[36]

We follow Stanton and Wallace (2011) using the **"Short-interest Ratio"** as a proxy for market demand imbalances. We calculate the ratio slightly differently, however, as the market value of shares sold short over the average daily trading volume for the month using the Bloomberg financial services ETF (Ticker: XLF). The interpretation is the same, reflecting the days needed to cover a short position. The higher the ratio, the longer it takes a short seller to completely close their short positions if asset prices begin to increase. The intuition behind this measure is that if the market is bearish on the financial sector, then there would be an increase in demand for insurance to protect against losses due to mortgages, which would increase the cost of insurance overall and decrease basis between the different products available for creating such coverage.

We include interest rate variables measuring both the change in interest rates and the slope of the yield curve. Both are based on data collected from FRED. The **"Δ Slope"** is computed as the difference between the 10- and 1-year constant maturity Treasury rates. The **"Δ Spot"** is the change in the 10-year constant maturity Treasury rate. Both control for market expectations of future changes in economic growth and inflation, which would influence prepayments and defaults of the underlying mortgage pools.

We include weekly and monthly **"S&P 500"** returns, as appropriate for the model periodicity, to control for the overall state of the economy and broader market risk. Such general market declines affect all financial market participants alike.

We allow for an AR1 structure of all dependent variables by including single-period lags of each as a control variable.

## V. Empirical Tests

We perform three sets of tests related to our analysis. First, we analyze the arbitrage relationships posed in the Spreads of the three contracts as well as the differences in spreads across

[36] Other factors, such as margin requirements and haircuts by counterparty are not available.

pairs of contracts – the Basis and Tracking Error relationships. Then, we establish the source of the noise in the arbitrage relationships. Last, we analyze price discovery to identify the direction of the noise as it moves along the three related securities. We conclude that price discovery enters through the Cash RMBS and noise enters through the ABX Indices, leaving the Single-name CDS to be seemingly inexplicably influenced by both. Thus, while co-movements may seem random in an analysis of any *two* securities, they make sense in the context of the three, together.

A. Credit Spread Models

We begin our empirical analysis by examining the impact of our asymmetric information variables on changes in Credit Spreads of each security.[37] In this section, we consider the first-order impact of our asymmetric information variables – Reporting Gap; Δ Distance-to-Stepdown (and its squared term); Acceleration Breach; Δ Subordination; and Loss Tranche – on credit spreads by credit grade within each market.

We estimate Cash RMBS and associated Single-name CDS regressions on the deal level, and corresponding Single-name CDS and associated ABX Index regressions on a portfolio level. We run fixed-effects panel regressions of weekly changes in spreads while controlling for our Asymmetric Information variables as well as our Counterparty Risk, Market Liquidity, Macroeconomic, and Other variables. We use spread in percentage points, not basis points, so changes in spreads are changes in percent spread. The regressions include a lagged dependent variable and correct the standard errors following the Baltagi and Wu (1999) methodology. Weekly changes are from Wednesday to Wednesday to eliminate noise that may occur due to day of the week effects.[38]

We eliminate bond-week observations from bonds that are on the "cusp" of experiencing losses. Cusping bonds can demonstrate dramatic changes in yields when they are the target of long-short activity. We exclude "cuspy" observations by eliminating the 55 outliers that are more than three times the average Cook's distance, a statistical measure used to detect outlying observations in data.

[37] We subtract 1-month LIBOR from YTM to obtain credit spreads for Cash RMBS. Other securities are quoted in spreads so that no further adjustment is necessary.

[38] Day-of-the-week effect induced noise should be temporary and short-term, which would most likely not impact the expectations of an informed investor enough for us to consider it. We believe this is a conservative approach, which would make any results we find more convincing.

That technique also removed another 15 bond-week observations with negative yields unrelated to cusping. Removing the 70 observations does not drastically change our results.

Table I presents the results for the regressions. Reporting Gap has a negative sign for all but the AA (Cash RMBS) and BBB (Single-name CDS) credit grades. Reporting Gap obtains at least 5% statistical significance for all the Cash RMBS credit grades except AA and BBB, though it is not statistically significant for any of the Single-name CDS models. In Table II, Reporting Gap again has a negative sign for almost all the credit grades in both the Single-name CDS portfolios and ABX Indices (excepting the AAA's) but is statistically significant only for the ABX Index AA, A, and BBB- coefficients.

[TABLE I]

[TABLE II]

The negative coefficient suggests that as Reporting Gaps increase, spreads decrease. Merton (1987) suggests that sectors with fewer informed investors trade at lower prices (higher yield spreads) than those with more informed investors. But since each of the four models is independent of one another, we cannot compare directly the effects of Reporting Gaps across models.

ABX market spreads are positively associated with Δ Distance-to-Stepdown (and Δ Distance-to-Stepdown squared) at the AAA and AA levels, as expected, but the variable is not statistically significant for Cash RMBS or Single-name CDS markets (individually or in portfolio form). The Δ Subordination (appropriately) negative and statistically significant only for the A Cash RMBS model, the Acceleration Breach is (appropriately) negative and statistically significant for the AAA Cash RMBS model, and Loss Tranche is (appropriately) positive and statistically significant for the BBB and BBB- Cash RMBS and (individual) Single-name CDS models. The signs and significance of those variables – while spotty – is promising because ours is the first paper to include dynamic performance in explaining these securities' spreads, others having included only static measures at the date of the initial offering (see, e.g. Fender and Scheicher, 2009; Stanton and Wallace, 2011; and Dungey, Dwyer, and Flavin, 2013).

Note also that $R^2$'s for the Cash RMBS models are highest for all credit grades, while the Single-name CDS (individual and portfolio) model $R^2$'s are lower and noticeably higher for the A and

BBB levels, levels that were the focus on long-sort traders in the crisis. Similarly, ABX $R^2$'s are lower than those of Single-name CDS (individual and portfolio) and noticeably higher that for the AAA and BBB/BBB- levels, a wider long-short distance than targeted by Single-name CDS investors. Thus, it appears that while the spread regressions are picking up credit dynamics and arbitrage trading in particular credit grades known to be active in the crisis there exist nonlinearities among such relationships that can only be clarified with more detailed analysis.[39]

B. Basis and Tracking Error Regressions for Testing Arbitrage

Levels of credit spreads may not reveal important relationships that are only evident in the context of Basis (for the Cash RMBS – Single-name CDS relationships) and Tracking Error (for the Single-name CDS and ABX Index relationships). Basis models are comprised of monthly fixed-effects panel regressions at the certificate level, while Tracking Error models are monthly monthly fixed-effects panel regressions at the portfolio level. Both use month-end performance measures from July 2007 through December 2010. Following Baltagi and Wu (1999), we include a lagged dependent to account for AR(1) serial correlation.

Summary statistics for all variables are reported in Table III and correlations in Table IV. Basis is calculated as the difference in Single-name CDS minus Cash RMBS spreads in percentage points. Tracking Error is the similar difference in ABX Index spreads minus those on the related portfolio of Single-name CDS contracts, constructed based on bond-weighted average of factor adjusted Single-name CDS spreads of the referenced bonds in each ABX subindex. As a result of the portfolio construction procedure, all collateral performance variables in the Tracking Error models are bond-weighted averages of factor adjusted measures of each bond performance measure.

[TABLE III]

[TABLE IV]

[39] We also examined weekly spread changes for the portfolios of Cash RMBS that corresponds to each respective ABX Index. Unlike the individual Cash RMBS results, Reporting Gap is only negative and significant for the AAA credit grade. Compared to portfolios of Single-name CDS, the $R^2$'s for the portfolios of Cash RMBS are larger for all except the A and BBB ratings. Compared to the ABX Index results, $R^2$'s for the portfolios of Cash RMBS are similar for the lower rated portfolios (BBB and BBB-), lower for the AAA and A, and considerably higher for the AA rated portfolios. Nonetheless, while $R^2$'s are sometimes higher in the Cash RMBS portfolio models, variable coefficients show mixed results of signs and significance and are harder to interpret.

Basis is, on average, negative suggesting that Cash RMBS trade at higher spreads than equivalent Single-name CDS while Tracking Error is, on average, positive suggesting that the ABX Index also trades at higher spreads than the reference portfolio of Single-name CDS. Because of the three-asset relationship, certain results can be used to bound one another and infer movements of one leg of the Basis/Tracking Error, while in other cases results are inconclusive.

On the whole, the Basis and Tracking Error results add information to our understanding of relationships between the three securities that simple spread models cannot discern. Results for both regressions are shown in Table V. Since the Cash RMBS and the Single-name CDS differ with respect to contractual features and market design, we expect some differences in co-movements to exist, controlling for other influences in the markets as a whole.

In the Basis model, Reporting Gap is (nearly) increasing in absolute value across credit grades. Reporting Gap is only significant for A rated and BBB- rated securities, but with opposite signs (positive and negative, respectively). Thus, when the Reporting Gap is larger, the A tranche Basis increases, while the BBB- tranche Basis declines. The differential result could arise from the different types of investors at various credit grades, particularly in Single-name CDS markets where the above section illustrated that A and BBB markets are best explained in spread regressions.

[TABLE V]

Reporting Gap is consistently negatively associated with Tracking Error, statistically significant in each credit grade and (nearly consistently) decreasing in credit grade. It must, therefore, be that ABX Index spreads are lower than Single-name CDS spreads for larger Reporting Gaps. Thus, it appears that Single-name CDS investors may have been better informed than ABX Index investors, as the informed/uninformed investor model suggests, with little discernible difference between Single-name CDS and Cash RMBS investor reactions to Reporting Gap.

Since Δ Distance-to-Stepdown is on average negative, deals are moving toward Stepdown breach and paying off senior certificates faster and junior certificates slower than otherwise (a negative performance signal). As Δ Distance-to-Stepdown becomes more negative, we would expect spreads to widen with the higher risk. The coefficient on the AAA Basis relationship is negative and statistically significant, suggesting Cash RMBS investors respond to lower Δ Distance-to-Stepdown with higher spreads relative to Single-name CDS. The coefficients for lower credit-level relationships, however, are not statistically significant nor do they demonstrate any discernible pattern. There is no statistically significant relationship between Δ Distance-to-Stepdown and Tracking Error at any credit grade. Thus, it appears that AAA Cash RMBS investors are most informed about Stepdown, driving spreads higher (and Basis lower).

The sign of Δ Subordination (where it is statistically significant, in the A Basis model and the AAA and AA Tracking Error models) is negative, suggesting that as losses mount – and Δ Subordination decreases – Basis and Tracking Error increase. The only way that the effect on both Basis and Tracking Error could be negative is if Single-name CDS spreads increase and Cash RMBS spreads increase even further, consistent with the hypothesis that ABX Index investors are the least informed and Cash RMBS investors the most informed, with Single-name CDS investors in between.

The Short Interest and Counterparty Risk variables are significant in the Basis models[40], but less so in the Tracking Error models. As expected, Funding Cost is important for Basis – since that is the difference between Cash RMBS and Single-name CDS – but not for Tracking Error. Overall market condition variables matter more for Basis than for Tracking Error, as would be expected if Cash RMBS markets contained less noise than ABX Index markets (with Single-name CDS markets in between).[41]

C. Noise Trading Analysis with Principal Components

One way of identifying whether our three markets are related and arbitragable is to distinguish

[40] We find a negative relationship between the Short Interest Ratio and Basis in the AAA model, significant at the 1% level, suggesting that there were no insurance demand imbalances. The result directly contrasts Stanton and Wallace (2011), possibly because we use a broader measure for interest in the financial services sector. For the lower credit rated tranches, however, Short Interest Ratio has a positive coefficient, suggesting that there is an increase in insurance demand to protect against losses for these securities. Another possible reason for the difference between our results and Stanton and Wallace (2011) could be that we control for additional factors, such as cash flow triggers, whether the bond is currently taking on losses, and contractual features. The reason for the difference is not important for our work, so we leave additional analysis of the result future research.

[41] We also ran a basis model for the Cash RMBS portfolio – ABX Index basis, although we exclude the results for brevity. Similar to the Single-name CDS portfolio – ABX Index model, Reporting Gap is negative in each credit grade and statistically significant for all credit grades except AAA and is (nearly consistently) decreasing in credit grade. The result suggests that RMBS investors are better informed than ABX Index investors. That result is confirmed in later analysis using an informed/uninformed trader models. Compared to the Single-name CDS portfolio – ABX Index models, $R^2$'s are higher but variable coefficients show mixed results of signs and significance and are harder to interpret.

noise trading from trading on fundamentals, under the hypothesis that less informed trading is akin to noise while more informed trading is akin to trading on fundamentals. We analyze principal components from the residuals from the weekly regressions following Collin-Dufresne, Goldstein, and Martin (2001), we perform principal components analysis ("PCA") on the residuals of each model.

Collin-Dufresne et al. (2001) find a dominant, systematic component in the residuals that is not captured by their structural credit risk model. Like Duffie and Singleton (1997), they suggest that their results are driven by local supply and demand shocks that are not based on credit or liquidity factors. Longstaff and Myers (2014) similarly use PCA to confirm the results of Collin-Dufresne et al. (2001) using equity tranches of collateralized debt obligations (CDOs). In our application, after controlling for credit, contractual, and market variables we do not expect there to be a dominant factor in the residuals. If there were, we would interpret that as being consistent with noisy supply and demand shocks from uninformed investors.

[TABLE VI]

Table VI presents the results of principal component analysis on the covariances of the residuals from the weekly Cash RMBS, Single-name CDS (individual and portfolio), and ABX Index models from Tables I and II. We perform separate PCA of the covariance matrix of the combined residuals from our spread models.[42] The first and second columns report how much of the variance in residuals is explained by the first and second principal components, respectively. Adjusted $R^2$'s are from each of the spread models. The unexplained portion in the fourth column is 1 minus $R^2$, approximating how much of the variation in the credit spreads lies outside of the credit risk model. The fifth column, "Potential Impact," is the unexplained portion of variation multiplied by the first principal component. Potential Impact, therefore, is a simplified measurement of how much of the unexplained portion may be explained by the systematic factor (represented by the first principal component). Using the interpretation that the systematic factor is noise trading supply and demand

[42] We use the combined residuals, which is the overall error ($\varepsilon_{i,t}$) and the fixed-error component ($\mu_i$). The fixed-error component represents the impact on the changes in spreads of all unobserved variables that are constant across time. The technique estimates the effect of characteristics about the bond that do not change over time, such as underwriter of the RMBS deal, underwriter of the loans, or shelf registration. It is likely that uninformed demand is affected by these characteristics, which is why we use the combined residuals. For example, some investors may buy only deals of a specific institution, like Goldman Sachs, because of their perceived reputation.

shocks, the Potential Impact is the amount of credit risk pricing that can be attributed to noise traders.

Our Cash RMBS model captures most of the variation in spreads.[43] The average adjusted $R^2$ across credit ratings is 73%, with the highest being the AA-rated bonds at 77%, and the lowest for the A-rated bonds at 68%. Those results are dramatically different than the results for the Single-name CDS and the ABX Indices. The Single-name CDS A and BBB credit grade models obtain adjusted $R^2$'s of 37% and 49%; other credit grades obtain far lower explanatory ability. The ABX Index models obtain their highest $R^2$'s for the AAA, BBB, and BBB- models.

With Cash RMBS, the first component (Column 1) generally becomes more dominant as credit rating declines. The first principal component (PC) explains approximately 28% of the variation in residuals for the AAA rated bonds, and 69% of the BBB- bonds. This would be consistent with uninformed traders, such as speculative traders, concentrating their activity in the most risky assets with the expectation that the risk would be offset by a substantial return. Considering the Cash RMBS spread model already explains approximately 70% of changes in bond spreads and the simple mechanics of calculating the potential uninformed trader impact, it is reasonable to conclude that while uninformed trading exists in the Cash RMBS market, it does not predominate. As noted previously, Potential Impact (Column 5) is the unexplained portion of variation multiplied by the first principal component. Column 5 shows that the Potential Impact of noise trading rises with decreased credit grade, but does not predominate in the Cash RMBS market.[44]

---

[43] It has been suggested in the literature that the VIX is a determinant of corporate credit spreads, and some of the existing ABX studies include it in their analyses. As a result, we run separate models including changes in the VIX as a control variable for market volatility, and our results hold. In our models, VIX has little explanatory power in the Cash RMBS and the Single-name CDS markets, and result in lower adjusted-$R^2$'s for both markets. For the ABX Index results, $R^2$'s are slightly higher with the VIX explaining mostly the lower credit rated subindexes. Results are available from the authors on request.

[44] We also analyzed the portfolios of Cash RMBS in each ABX vintage, but omitted the results for brevity. The average $R^2$ of the Cash RMBS portfolio model is 16%, with the highest being the AA portfolio at 35% and the lowest for the A-rated portfolio at 5%. The first PC generally becomes more dominant as the credit rating decreases, which is consistent with speculative activity being concentrated in riskier securities. However, the first PC for the BBB- portfolio is less dominant than that for the BBB portfolio (0.74 and 0.97, respectively).

The potential impact of influences outside of our credit variables affecting spreads is highest for the A and BBB portfolios (0.92 and 0.80, respectively). The other three credit ratings, AAA, AA, and BBB-, are substantially lower (0.44, 0.62, and 0.60, respectively). The potential impact for these credit ratings is lower than that measured in both the Single-name CDS portfolio model and ABX Index model, suggesting that the Cash RMBS market is less influenced by noise traders, whether measured on a single-Cash RMBS bond basis or as a portfolio of Cash RMBS.

The Single-name CDS model in Table I does not explain as much of the changes in spreads, particularly for the AAA, AA, and BBB- swaps. For these ratings, the first PC explains an average 36% of the residual variation. Given the low adjusted $R^2$ of the credit risk model and the relatively low percentages of residual variation explained by the first PC, the Potential Impact of noise trading in Single-name CDS is higher than the Cash RMBS market.

Even though the adjusted $R^2$'s of the spread model are approximately the same for the Single-name CDS in both individual and portfolio form, the PCA results suggest that the systematic component in the residuals for the portfolios is somewhat different from that of individual Single-name CDS. The first PC is more dominant for the portfolios than for the single-name contracts across all credit grades, explaining more than 56% of residual variation for all ratings except for the BBB- portfolio (which has a first PC that explains 39%). Thus, the Potential Impact of noise trading in Single-name CDS portfolios is higher than both individual Single-name CDS and the Cash RMBS market.

The first PC is clearly dominant in the ABX Index spread models. The average percentage explained by the first PC is 87%. The first PC of the AA-rated subindexes explains the lowest percentage at 74%, while the first PC of the BBB subindexes explains the most residual variation at 94%. Given the overall average adjusted $R^2$ of 17% for the ABX Index in Table II, that dominant first PC suggests that there is a strong systematic factor in the residuals. The Potential Impact of the systematic component of residual variation is much higher for the ABX Index than for both portfolio and individual Single-name CDS and Cash RMBS. Overall our results suggests that uninformed trading is more prevalent in the ABX Index, followed by the portfolio of Single-name CDS, individual

---

The unexplained portion of spread variation ($1-R^2$) in the Cash RMBS portfolio model is greatest for the AAA portfolio (0.94), and the lowest for the AA-rated portfolio (0.65). Interestingly, despite having the greatest unexplained spread variation (0.94), the AAA-rated portfolio is subjected to the lowest potential impact from uninformed traders (0.44). BBB- and AA have the next lowest potential impact at 0.60 and 0.62, respectively. All three ratings (AAA, AA, and BBB-) have lower potential impacts than the ABCDS portfolios and the ABX index.

Combining the Cash RMBS portfolio results with those for the individual Cash RMBS, it appears that informed investors trade in individual bonds and not in the "ABX Index" portfolios of 20 bonds. The result is consistent with Merton (1987), in that investors become experts on a subset of the universe because of costs. It is costly to become informed on all deals given the non-standardized collateral reporting and deal features prevalent in the securitized product market. Therefore, informed investors become informed on a limited number of securities and choose to only trade in those securities.

Single-name CDS and, lastly, Cash RMBS, as suggested by informed investor theory.

D. Price Discovery Analysis with VECM

While our noise trading analysis is useful, since noise is part of the residual structure it does not help us understand where information enters the system and how it flows to the different investors. Further investigating the price discovery process can, therefore, confirm the ordering of informed and uninformed investor in our system. Contrary to the existing corporate CDS literature, we find that price discovery appears to occur in the Cash RMBS market with the Single-name CDS market following behind.

To explore further pricing dynamics and information flows we use a modified vector error-correction model (VECM) methodology based on that of Blanco, Brennan, and Marsh (2005) ("BBM").[45] Equations (7) and (8) represent the VECM used to examine whether information flows into the Single-name CDS or the RMBS market, while Equations (9) and (10) are the VECM equations used for the ABX and Single-name CDS markets.

$$\Delta ABCDS_{i,t} = \lambda_1\left(ABCDS_{i,t-1} - \alpha_0 - \alpha_1 RMBS_{i,t-1} - \alpha_2 ReportDate\right) + \beta_1 ReportDate + \sum_{j=1}^{p}\gamma_1 \Delta ABCDS_{i,t-j} + \sum_{j=1}^{p}\delta_1 \Delta RMBS_{i,t-j} + \varepsilon_{1t} \tag{7}$$

$$\Delta RMBS_{i,t} = \lambda_2\left(ABCDS_{i,t-1} - \alpha_0 - \alpha_1 RMBS_{i,t-1} - \alpha_2 ReportDate\right) + \beta_2 ReportDate + \sum_{j=1}^{p}\gamma_2 \Delta ABCDS_{i,t-j} + \sum_{j=1}^{p}\delta_2 \Delta RMBS_{i,t-j} + \varepsilon_{2t} \tag{8}$$

$$\Delta ABX_{i,t} = \lambda_1\left(ABX_{i,t-1} - \alpha_0 - \alpha_1 ABCDS_{i,t-1} - \alpha_2 ReportDate\right) + \beta_1 ReportDate + \sum_{j=1}^{p}\gamma_1 \Delta ABX_{i,t-j} + \sum_{j=1}^{p}\delta_1 ABCDS_{i,t-j} + \varepsilon_{1t} \tag{9}$$

$$\Delta ABCDS_{i,t} = \lambda_2\left(ABX_{i,t-1} - \alpha_0 - \alpha_1 ABCDS_{i,t-1} - \alpha_2 ReportDate\right) + \beta_2 ReportDate + \sum_{j=1}^{p}\gamma_2 \Delta ABX_{i,t-j} + \sum_{j=1}^{p}\delta_2 ABCDS_{i,t-j} + \varepsilon_{2t} \tag{10}$$

[45] We also ran the BBM regressions with a structural break in the cointegrating relationship to account for the report release date. The change does not affect our results reported here. Results are available from the authors upon request.

Unique to the deals included in ABX Index is that the ABX sponsor required remittance report to be released on the 25th of every month. If the 25th is a holiday or a weekend, then the report is released on the next business day.[46] To capture information effects of this release, we add an indicator variable, $ReportDate$, equal to 1 on the trading days before, on, and after the report date. We include the trading day before in case any information was leaked prior to release and the trading day after to capture any residual information transmission to Single-name CDS and ABX Index markets.

Our first modification to the VECM methodology of BBM stems from trading patterns in the Cash RMBS market. According to bond traders, it was difficult to find a quote the day before a report date because no one wanted to enter a position until the new information was released. We interpret that lack of trading as a short structural break every month around the report day and, therefore, include that in the conitegrating relationship. Our second modification is that we also include the indicator variable outside of the cointegrating relationship to identify the additional information content of report dates to the respective investors in these markets.

We test for cointegration in the price relationships and structural breaks for each model using the Johansen et al. (2000) testing procedure. We construct asymptotic critical values based on the proportion of the sample that occurs around each break. Then for only those securities with relationships that are cointegrated, we run the modified VECM specifications. The λ's in each equation are interpreted as how the traders in each market respond to the price differences between markets.

For Equations (7) and (8), which model the relationship between the Cash RMBS and Single-name CDS markets, $\lambda_1$ indicates how the Cash RMBS market responds to information and $\lambda_2$ how the Single-name CDS market responds. That is, we test whether information at time *t* affects the Cash RMBS price at *t*, but affects the only Single-name CDS market at *t+1*, rather than t, suggesting that prices move faster in the Cash RMBS market than the Single-name CDS market. If price discovery occurs in the Cash RMBS (Single-name CDS) market, we expect $\lambda_1$ ($\lambda_2$) to be negative (positive) and significant as the Cash RMBS (Single-name CDS) market adjusts to price differences beyond equilibrium and the Single-name CDS (Cash RMBS) market lags behind.

Equations (9) and (10) illustrate how information flows between the ABX Index and the

[46] Some deals in the industry report on other days of the month. The deals analyzed here, however, all report on the 25th.

Single-name CDS portfolio. Again, the point is that if information entering the Single-name CDS market affects Single-name CDS prices at time *t*, but only affects the ABX Index market at time *t+1*, we would say the Single-name CDS market is more informed. The coefficient $\lambda_1$ is interpreted as how the Single-name CDS market responds to information and $\lambda_2$ is the ABX Index market's response. If price discovery occurs in the Single-name CDS (ABX Index) market, we expect $\lambda_1$ ($\lambda_2$) to be negative (positive) and significant as the Single-name CDS (ABX Index) market adjusts to price differences beyond equilibrium and the Single-name CDS (bond) market lags behind.

1. Cash RMBS and Single-name CDS Markets

*a) Cointegration Results*

Table VII presents the relationship between Single-name CDS and Cash RMBS markets (Equations (9) and (10)) and Table VII presents the relationship between the ABX Index and Single-name CDS markets (Equations (11) and (12)). We expect to see information entering the three-asset relationship from the Cash RMBS, flowing to Single-name CDS and then the ABX Index, the mirror opposite of our noise trading results.

[TABLE VII]

The results in Table VII are comprised of tranche-level regressions on each deal-credit grade combination in every ABX Index vintage. The results of the roughly 400 regressions are, therefore, summarized over four panels in order to convey the results in a meaningful and digestible manner.

In Table VII, Panel A, Column 1 reports the number of constituents Available in each vintage-credit grade combination. Column 2 reports number of cointegrated relationships from the total number Available in Column 1. Cointegration depends upon vintage and credit grade, with the Cash RMBS - Single-name CDS relationship becoming less cointegrated as credit grade declines and new vintages are released over time. The constituents in the AAA and AA grades are generally cointegrated at the 95-100% level, while lower rated securities are less cointegrated.

Columns 3 through 6, show the mean and median values of the speed of adjustment coefficients, the λ's, for all cointegrated relationships regardless of statistical significance. If informed investors are concentrated in the Cash RMBS market, we expect information to flow to the Cash RMBS market before the Single-name CDS market – that is, we expect to see $\lambda_1$ negative. The mean and median for $\lambda_1$ is mostly negative, with the exception of bonds contained in the 2006-2 BBB subindex (although the median for 2006-2 BBB is negative, as well, suggesting there are some relationships skewing the mean). While we also expect to see the mean and median $\lambda_2$ positive, Table VII Panel A only obtains positive mean and median $\lambda_2$ for lower credit grade relationships. Higher rated subindexes generally have negative mean and median $\lambda_2$.

Of course, the mean and median may be masking important differences among the models within each vintage-credit grade groups. Table VII Panel B, therefore, reports the count of λ's that are the expected sign and significant at the 10% level. Column 1 reports the number of relationships where only the Cash RMBS market responds to information – that is, $\lambda_1$ is negative and statistically significant and $\lambda_2$ is statistically insignificant. Column 2 reports those for which only the Single-name CDS responds to information – that is, $\lambda_1$ statistically insignificant and $\lambda_2$ is positive and statistically significant. Column 3 reports the number of relationships where both markets respond – that is, $\lambda_1$ is negative and statistically significant and $\lambda_2$ is positive and statistically significant. Column 4 reports the number of relationships where either or both of the speed of adjustment coefficients are significant, but have the wrong sign, therefore rendering the interpretation of information flows ambiguous. Column 5 reports relationships where neither market appears to respond to new information in the market.

Table VII Panel B shows that Cash RMBS markets respond to price information and price discovery, while Single-name CDS markets generally do not. While for high credit grades sometimes neither market responds strongly, results are clearest for credit grades in the middle and lower-middle part of the spectrum (AA, A, and BBB).

Table VII Panel C, examines further the instances in which both the Cash RMBS and Single-name CDS play a significant role in price discovery (Panel B, Column 3) to establish which may be dominant. Panel C applies the Hasbrouck (1995) and Gonzalo and Granger (1995) to the BBM methodology to distinguish dominance, hypothesizing the Single-name CDS market would be considered the dominant market if either λ is over 0.5. The results in Panel C suggest that the Single-name CDS market does not play a dominant role in price discovery, indicating further that informed investors are concentrated in the RMBS market.

### *b) Fundamental Performance Results*

Table VII Panel A also shows the mean and median values of the report date indicator variables, the β's, in columns 7 through 10. $\beta_1$ indicates how information flows to the Single-name CDS market on the release of the remittance report, and $\beta_2$ is for the Cash RMBS market. A positive (negative) response would have a negative (positive) coefficients as spreads decrease (increase).

There do not appear to be any distinct patterns in the β's reported in Table VII Panel A. For $\beta_1$, the mean and median for the higher grade securities are mostly negative while the lower grade securities are mostly positive. For $\beta_2$, the mean and median are generally positive.

Table VII Panel D summarizes the impact of remittance report information release on each market by reporting the count of relationships in which combinations of the two markets respond to the information in the reports and then comparing the direction of the response.

Column 1 shows a positive response ($\beta_1<0$) and Column 2 shows a negative response ($\beta_1>0$) for models where the Single-name CDS market is the only one to respond to the remittance report date. Columns 3 and 4 report results for the Cash RMBS market, with Column 3 counting positive responses ($\beta_2<0$) and Column 4 negative responses ($\beta_2>0$). For those relationships where both markets respond (Column 5), we distinguish those that respond the same way positively (Column 6) and those that respond the same way negatively (Column 7), as well as those where the response is positive for Single-name CDS and negative for Cash RMBS (Column 8) and vice versa (Column 9).

The most notable result from this panel is that the Cash RMBS market responds to remittance releases more often than the Single-name CDS market. The reaction is generally a negative one, although since performance is generally detonating that is not at all surprising. Single-name CDS market high credit grade tranches from the 2006-1 vintage seem to respond positively to remittance reports. With each successive vintage, however, fewer of the relationships show a "Single-name CDS only" response in Columns 1and 2.

When looking at times when both markets respond, the both markets generally respond negatively (5 out of the 10 instances when both respond), especially for the 2006-2 and 2007-2 vintages and for lower credit ratings.

The results derived from analyzing Cash RMBS – Single-name CDS relationships suggest that information is integrated into Cash RMBS markets before Single-name CDS markets. Combined with the noise trading results, we can conclude that is because more informed investors trade in Cash RMBS than Single-name CDS. While our result is different from findings with regard to corporate CDS, there are important differences between the two markets. The monthly remittance report formats for Cash RMBS differ by trustee and can change over time, whereas the SEC filings relied upon by corporate investors follow a more standardized format, but are issued less frequently.

### 2. Single-name CDS and ABX Index Markets

#### *a) Cointegration Results*

To consider pricing dynamics and information flows in the ABX Index and Single-name CDS markets, we repeat the prior analysis using ABX Index spreads and those derived from the equivalent portfolio Single-name CDS. With the ABX Index and Single-name CDS markets, all of the model pairs are cointegrated.

[TABLE VIII]

The VECM results are reported in Table VIII. If price discovery occurs in the Single-name CDS markets, $\lambda_1$ will be negative and statistically significant. If price discovery occurs in the ABX Index market, then $\lambda_2$ will be positive and statistically significant. The results in Table VIII indicate that price discovery occurs mostly in the ABX Index market, especially in the later vintages and lower credit ratings. Only in the first vintage does the Single-name CDS market seem to contribute significantly at the lower rated subindexes. Both the Hasbrouck (1995) and Gonzalo-Granger (1995) measures confirm that the ABX Index market is dominant in price discovery.

#### *b) Fundamental Performance Results*

Perhaps, what is most noticeable is how consistently the ABX Index market responds on remittance report dates, as indicated by $\beta_1$. For most of the ABX Index credit grades, the response is significantly positive.[47]

Thus, it appears that remittance report information flows into the ABX Index market rather than the Single-name CDS market. But the positive response suggests that ABX Index is undervalued between report releases, responding strongly to releases when they occur. The combination of this result with the origination of noise trading in ABX Index markets established above suggests that the

[47] A positive (negative) response would have a negative (positive) coefficient because the dependent is the change in spreads of each respective market.

ABX Index experiences more uninformed trading *between* reports but responds to the fundamental information when it is released, re-anchoring the ABX Index back to a fundamental price.

## V. Conclusions

While we find that fundamentals drive the Cash RMBS market a combination of noise *and* fundamentals drive the ABX Index market, with Single-name CDS markets torn between the two. Informed investors seem to dominate the ABX Index market around remittance report dates in contrast to uninformed noise trading at other times, and new information released at remittance dates reveals the ABX Index is undervalued relative to the underlying pool performance of constituent deals. Variables accounting for informed investing – specifically Reporting Gaps, Δ Distance to Stepdown, Acceleration Breach, and Δ Subordination – add power to the spread model that drive our noise trading analysis and help separate our markets.

In response to narratives from the financial crisis, therefore, we find that the ABX Index market may have "overshot" fundamental values at times (particularly between remittance dates), but is that a problem if informed investors can arbitrage the uninformed on and around report dates? Our results suggest that while informed and uninformed investors may have held varying priors, the fundamental price discovery in Cash RMBS markets and ABX Index markets still dominated irrationality, proxies by noise.

Moreover, the noise is in response to a classic asymmetric information problem induced among investors by vendor performance reporting differences, sophisticated non-linear securitization triggers, and important differences in the Cash RMBS payment terms and the pay-as-you-go CDS terms. If policy makers desire less asymmetric information – and, therefore, noise – harmonization among those institutional details would be desired.

Overall, however, our paper contributes important findings about information quality, noise trading, and price discovery in an interesting and important financial sector showing that the three-asset arbitrage pricing problem can yield very different results from the two-asset problem. The three-asset problem should not, therefore, be allowed to sow confusion with regard to the role of the ABX Index markets in the crisis.

## REFERENCES


Akerlof, George A., 1973, The demand for money: A general equilibrium inventory-theoretic approach. *The Review of Economic Studies*, 40(1), 115-130.

Bai, Jennie and Pierre Collin-Dufresne, 2013, The CDS-Bond Basis. AFA 2013 San Diego Meetings Paper. Available at SSRN: https://ssrn.com/abstract=2024531

Baig, Suleman, and Moorad Choudhry, 2013, *The Mechanics of Securitization: A Practical Guide to Structuring and Closing Asset-Backed Security Transactions*. John Wiley & Sons.

Baltagi, Badi H., and Ping X. Wu, 1999, Unequally spaced panel data regressions with AR (1) disturbances. *Econometric Theory*, 15.06, 814-823.

Bikhchandani, Sushil, David Hirshleifer, and Ivo Welch, 1992. A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy*, 100(5), 992-1026.

Bikhchandani, Sushil, David Hirshleifer, and Ivo Welch, 1998. Learning from the behavior of others: Conformity, fads, and informational cascades. *The Journal of Economic Perspectives*, 12(3), 151-170.

Black, Fischer, 1986, Noise. *The Journal of Finance*, 41(3), 528-543.

Blanco, Roberto, Simon Brennan, and Ian W. Marsh, 2005, An empirical analysis of the dynamic relation between investment-grade bonds and credit default swaps. *The Journal of Finance*, 60(5), 2255-2281.

BNY Mellon, not dated, Corporate Trust Investor Reporting. Retrieved 2016 from https://gctinvestorreporting.bnymellon.com/

Brunnermeier, Markus K., and Lasse H. Pedersen, 2009, Funding liquidity and market liquidity. *Review of Financial Studies*, 22(6), 2201-2238.

Callen, Jeffrey L., Joshua Livnat, and Dan Segal, 2009. The impact of earnings on the pricing of credit default swaps. *The Accounting Review*, 84(5), 1363-1394.

Calomiris, Charles W., and Charles M. Kahn, 1991, The role of demandable debt in structuring optimal banking arrangements. *American Economic Review*, 81(3), 497-513.

Calomiris, Charles W., and Joseph R. Mason, 1997, Contagion and bank failures during the Great Depression: The June 1932 Chicago banking panic. *American Economic Review*, 87(5), 863-883.

Citigroup, not dated, Investor Reporting for Structured Finance. Retrieved 2016 from https://sf.citidirect.com

Collin-Dufresne, Pierre, Robert S. Goldstein, and J. Spencer Martin, 2001, The determinants of credit spread changes. *The Journal of Finance*, 56(6), 2177-2207.

Collin-Dufresne, Pierre, Robert S. Goldstein, and Fan Yang, 2012. On the Relative Pricing of Long-Maturity Index Options and Collateralized Debt Obligations. *The Journal of Finance*, 67(6), 1983-2014.

CTSLink, not dated, Securities reports. Retrieved 2016 from https://www.ctslink.com

Demiroglu, Cem, and Christopher James, 2012, How important is having skin in the game? Originator-sponsor affiliation and losses on mortgage-backed securities. *Review of Financial Studies*, 25, 11, 3217-3258.

Deutsche Bank, not dated, Trust and Securities Services. Retrieved 2016 from https://tss.gtb.db.com/portal/investor-services/default.aspx

Diamond, Douglas W., and Robert E. Verrecchia, 1991, Disclosure, liquidity, and the cost of capital. *The Journal of Finance*, 46(4), 1325-1359.

Dow, James and Gary B. Gorton, 1994, Arbitrage chains. *The Journal of Finance*, 49(3), 819-849.

Duffie, Darrell, 1996. Special repo rates. *The Journal of Finance*, 51(2), 493-526.

Duffie, Darrell, and David Lando, 2001. Term structures of credit spreads with incomplete accounting information. *Econometrica*, 69(3), 633-664.

Duffie, Darrell, and Kenneth J. Singleton, 1997, An econometric model of the term structure of interest-rate swap yields. *The Journal of Finance*, 52(4), 1287-1321.

Dungey, Mardi, Gerald P. Dwyer, and Thomas Flavin, 2013, Systematic and liquidity risk in subprime-mortgage backed securities. *Open Economies Review*, 24, 5–32.

Easley, David, and Maureen O'Hara, 2004, Information and the cost of capital. *The Journal of Finance*, 59(4), 1553-1583.

Fender, Ingo, and Martin Scheicher, 2009, The pricing of subprime mortgage risk in good times and bad: evidence from the ABX.HE indices. *Applied Financial Economics*, 19, 1925–1945.

Fremault, Anne, 1991, Stock index futures and index arbitrage in a rational expectations model. *Journal* *of Business*, 64(4), 523-547.

Gonzalo, Jesus, and Clive Granger, 1995, Estimation of common long-memory components incointegrated systems. *Journal of Business & Economic Statistics*, 13(1), 27-35.

Goodman, Laurie S., Shumin Li, Douglas J. Lucas, Thomas A. Zimmerman, and Frank J. Fabozzi, 2008, *Subprime Mortgage Credit Derivatives*, volume 159, John Wiley & Sons.

Gorton, Gary B. and George G. Pennacchi, 1993. Security baskets and index-linked securities. *Journal of Business*, 66(1), 1-27.

Gorton, Gary, 2009, Information, liquidity, and the (ongoing) panic of 2007. *American Economic Review*, 99, 567–72.

Grossman, Sanford J., and Joseph E. Stiglitz, 1980, On the impossibility of informationally efficient markets, American Economic Review, 70(3), 393–408.

Hasbrouck, Joel, 1995, One security, many markets: Determining the contributions to price discovery. *The Journal of Finance*, 50 (4), 1175-1199.

ISDA, 2003, ISDA Credit Derivatives Definitions, Retrieved at http://cbs.db.com/new/docs/2003_ISDA_Credit_Derivatives_Definitions.pdf

Johansen, Søren, Rocco Mosconi, and Bent Nielsen, 2000, Cointegration analysis in the presence of structural breaks in the deterministic trend. *The Econometrics Journal*, 3.2: 216-249.

J.P. Morgan, not dated, Structured Finance Reporting. Retrieved 2016 from https://www.jpmorgan.com/tss/General/Structured_Finance_Reporting/1155558012118

Kumar, Praveen, and Duane J. Seppi, 1994, Information and index arbitrage. *Journal of Business*, 67(4), 481-509.

Lehman Brothers Fixed Income Research, 2005, ABS Credit Default Swaps – A Primer.

Longstaff, Francis A., and Brett W. Myers, 2014, How does the market value toxic assets? *Journal of Financial and Quantitative Analysis*, 49(2), 297-319.

Markit Group, not dated, ABX.HE Index Rules. Retrieved 2016 from http://www.markit.com/Documentation/Product/ABX

Merton, Robert C., 1987, A simple model of capital market equilibrium with incomplete information, *The Journal of Finance*, 42, 483–510.

Mishkin, Frederic S., 1992, Anatomy of a financial crisis. *Journal of Evolutionary Economics*, 2(2), 115-130.

Morkoetter, Stefan, Johanna Pleus, and Simone Westerfeld, 2012, The impact of counterparty risk on credit default swap pricing dynamics. *The Journal of Credit Risk*, 8, 63.

Shiller, Robert, 1984. Stock prices and social dynamics. *Brookings Papers on Economic Activity*, 2, 457-510.

Shleifer, Andrei, and Robert W. Vishny, 1997, The limits of arbitrage. *The Journal of Finance*, 52(1), 35-55.

Stanton, Richard, and Nancy Wallace, 2011, The bear's lair: Index credit default swaps and the subprime mortgage crisis. *The Review of Financial Studies*, 24, 3250–3280.

Subrahmanyam, Avanidhar, 1991, A theory of trading in stock index futures. *The Review of Financial Studies*, 4(1), 17-51.

Tuckman, Bruce, and Jean-Luc Vila, 1992, Arbitrage with Holding Costs: A Utility-Based Approach. *The Journal of Finance*, 47(4), 1283-1302.

US Bank, not dated, Trust Services. Retrieved 2016 from https://usbtrustgateway.usbank.com

Vayanos, Dimitri, and Pierre-Olivier Weill, 2008. A Search-Based Theory of the On-the-Run Phenomenon. *The Journal of Finance*, 63(3), 1361-1398.

Whetton, Michiko, 2005, Synthetic ABS 101: PAUG and ABX.HE. Nomura Securities.

Table I: Regression of Weekly Spread Changes in the Bond and ABCDS Markets by Credit Rating

*Panel A: Bond Spreads*

| | AAA | AA | A | BBB | BBB- |
|---|---|---|---|---|---|
| Lag ΔBond Spread | 0.499*** | 0.529*** | 0.477*** | 0.564*** | 0.507*** |
| Reporting Gap | -0.227** | 0.192 | -47.780*** | -6.159 | -42.79** |
| Δ Distance-to-Stepdown | 0.726 | 2.971 | -10.960 | -580.900 | 84.130 |
| Squared Δ Distance-to-Stepdown | 2.765 | -10.700 | 20.900 | -897.800 | 187.100 |
| Acceleration | -0.114** | -0.660 | -3.170 | 3.788 | 4.736 |
| Δ Subordination | -0.005 | 0.075 | -5.323* | -4.605 | -3.600 |
| Loss Tranche | 0.027 | 1.765** | 0.080 | 17.650*** | 11.080* |
| Short Interest Ratio | 0.000 | 0.0343* | -0.297* | -0.079 | -0.155 |
| Counter party risk | 0.001*** | 0.0169*** | -0.003 | 0.013 | 0.061* |
| Funding Cost | -0.026 | 1.019*** | -1.584 | -1.252 | 3.868 |
| S&P 500 | 0.416** | 1.387 | 11.680 | 25.660 | 32.720 |
| Δ Spot | 0.003 | -2.372*** | 0.830 | 2.178 | -5.977 |
| Δ Slope | 0.102*** | -1.150*** | 1.220 | -9.002* | -10.940*** |
| Constant | 0.049 | -2.629*** | 29.77*** | 3.051 | 7.385* |
| Observations | 13,174 | 13,100 | 11,080 | 7,958 | 7,299 |
| Number of bonds | 79 | 80 | 80 | 80 | 80 |
| Adjusted R-squared | 0.697 | 0.771 | 0.68 | 0.756 | 0.745 |

*Panel B: ABCDS Spreads*

| | AAA | AA | A | BBB | BBB- |
|---|---|---|---|---|---|
| Lag ΔABCDS Spread | -0.143*** | -0.144*** | -0.609*** | 2.991*** | -0.196*** |
| Reporting Gap | -0.753 | -2.788 | -31.830 | 3,879.00 | -8.036 |
| Δ Distance-to-Stepdown | 5.912 | 25.060 | 106.300 | 16,181.00 | -967.4*** |
| Squared Δ Distance-to-Stepdown | 10.750 | -51.090 | 36.400 | 22,299.00 | 3443.000 |
| Acceleration Breach | 0.003 | -0.497 | 13.420 | -521.700 | -1.900 |
| Δ Subordination | 0.037 | 0.487 | -4.454 | 415.600 | 3.543 |
| Loss Tranche | 0.330 | -1.581 | 6.074 | 1,999.00* | 12.950*** |
| Short Interest Ratio | 0.016* | -0.032 | -1.295 | -4.869 | 0.056 |
| Counter party risk | 0.006*** | 0.005 | -0.560 | -1.000 | 0.028* |
| Funding Cost | -0.145 | -0.845 | 6.404 | -259.000 | -2.980*** |
| S&P 500 | -11.630*** | -7.626 | 187.400 | 8,457.00 | -5.414 |
| Δ Spot | 0.338 | 2.877 | -37.820 | -716.500 | 1.293 |
| Δ Slope | 0.363 | 3.621* | -50.440 | -297.800 | -5.756 |
| Constant | -0.567 | 2.269 | 54.270 | -212.200 | -1.694 |
| Observations | 11,862 | 12,091 | 10,519 | 7,781 | 6,998 |
| Number of bonds | 75 | 77 | 77 | 76 | 75 |
| Adjusted R-squared | 0.019 | 0.014 | 0.366 | 0.493 | 0.031 |

This table reports results for the fixed-effects panel regression of weekly changes (Wed-to-Wed) in spreads of the bond and ABCDS from July 2007-December 2010. All t-statistics are corrected for AR(1) errors, following Baltagi and Wu (1999). Bond spread is the difference between yield to maturity and 1 month LIBOR. ABCDS is the spread on the ABCDS contract. ΔSubordination is the month to month change in the subordination percent for each bond. Acceleration breach is an indicator variable defined as 1 if the current overcollateralization amount is less than the target amount and 0 otherwise. Dist.-to-stepdown trigger is the difference between a threshold percent and the percent of aggregate losses. Change controls for changes in trigger distance while the Squared ΔDist.-to-Stepdown accounts for the acceleration of changes in trigger distance. Gap is the coefficient of variation of aggregate loss data from three MBS deal level data sources. Short Interest Ratio serves as a proxy for insurance demand imbalances and is the change in the market ratio of the market value of shares sold short to the average daily trading volume over the month for the financial services ETF (Ticker: XLF). Counterparty Risk is a proxy for risk associated with the seller of an ABDS contract failing to uphold its contractual obligations. Funding Cost is the difference between 3 month LIBOR and the general collateral repo rate. S&P 500 Return is calculated as the percent change in the price of the S&P 500 index over the month. ΔSpot Rate is the month to month change in the 1-year CMT rate. ΔSlope is the change in the slope, which is defined as the difference between the 10-year CMT rate and the 1-year CMT rate. $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

Table II: Regression of Weekly Spread Changes in the ABCDS Portfolios and the ABX Index by Credit Rating

*Panel A: ABCDS Portfolio Spreads*

| | AAA | AA | A | BBB | BBB- |
|---|---|---|---|---|---|
| Lag ΔPort ABCDS Spread | -0.064 | -0.154*** | -0.600*** | -0.473*** | -0.230*** |
| Reporting Gap | 0.207 | -5.315 | -18.720 | -22.660 | -13.840 |
| Δ Distance-to-Stepdown | 21.480 | 136.300* | -121.600 | -283.300 | -144.800 |
| Squared Δ Distance-to-Stepdown | 343.500 | 1,529.0 | -1,178.0 | 6,551.0 | -2,959.0 |
| Δ Subordination | 0.423 | 0.854 | -8.140 | 103.300 | -6.069 |
| Short Interest Ratio | 0.007 | -0.057 | 0.127 | -0.537 | 0.095 |
| Counter party risk | 0.004 | 0.002 | 0.034 | -0.055 | 0.036 |
| Funding Cost | -0.238 | -0.831 | -2.104 | 9.423 | -1.395 |
| S&P 500 | -11.880*** | -3.433 | 99.950 | 215.200 | 14.380 |
| ΔSpot | 0.442 | 2.713 | 5.404 | -35.070 | 4.264 |
| ΔSlope | 0.389 | 4.313 | 8.183 | -13.550 | -2.873 |
| Constant | -0.485 | 4.065 | 0.925 | 13.870 | -0.165 |
| Observations | 650 | 659 | 660 | 660 | 660 |
| R-squared | 0.014 | 0.013 | 0.348 | 0.212 | 0.041 |

*Panel B: ABX Spreads*

| | AAA | AA | A | BBB | BBB- |
|---|---|---|---|---|---|
| Lag ΔABX Spread | -0.194*** | -0.050 | -0.150*** | -0.368*** | -0.367*** |
| Reporting Gap | 0.237 | -3.795* | -18.230*** | -54.290 | -67.620** |
| Δ Distance-to-Stepdown | 62.170*** | 61.090* | -42.220 | -62.440 | 85.500 |
| Squared Δ Distance-to-Stepdown | 1,186*** | 3,280*** | 2,004* | 366.400 | -8,717.00 |
| Δ Subordination | 0.429 | 1.629** | 3.007 | 14.160 | -13.960 |
| Short Interest Ratio | 0.0200* | -0.009 | -0.001 | 0.031 | -0.070 |
| Counter party risk | 0.008*** | 0.002 | 0.016 | 0.070 | 0.047 |
| Funding Cost | 0.078 | -0.861** | -4.454*** | -15.18** | -17.50*** |
| S&P 500 | -15.160*** | -35.750*** | -110.90*** | -440.50*** | -421.00*** |
| ΔSpot | -0.647 | 1.019 | 7.904* | 65.70** | 67.00*** |
| ΔSlope | -1.388*** | -1.502 | -6.213** | -61.27*** | -33.65** |
| Constant | -1.480*** | 2.100 | 7.252* | 15.500 | 23.610 |
| Observations | 651 | 651 | 651 | 651 | 648 |
| R-squared | 0.263 | 0.093 | 0.122 | 0.184 | 0.189 |

This table reports results for the fixed-effects panel regression of weekly changes (Wed-to-Wed) in spreads of the bond and ABCDS from July 2007-December 2010 grouped by initial bond credit rating. All t-statistics are corrected for AR(1) errors, following Baltagi and Wu (1999). All ABX level explanatory variables are the outstanding factor-adjusted equally weighted averages for the referenced cash bonds in the ABX index. ΔSubordination is the month to month change in the subordination percent. Distance-to-stepdown trigger is the difference between a threshold percent and the percent of aggregate losses. ΔDist-to-stepdown controls for changes in trigger distance while the squared ΔDist.-to-stepdown accounts for the acceleration of changes in trigger distance. Gap is the coefficient of variation of aggregate loss data from three MBS deal-level data sources. Short Interest Ratio serves as a proxy for insurance demand imbalances and is the ratio of the market value of shares sold short to the average daily trading volume over the month for the financial services ETF (Ticker: XLF). Counter party risk is the average of the CDS spreads for the ABX market makers. Funding cost is the difference between 3 month LIBOR and the general collateral repo rate. S&P 500 return is the percent change in the price of the S&P 500 index over the month. ΔSpot is the month to month change in the 1-year CMT rate. ΔSlope is the change in the slope, which is defined as the difference between the 10-year CMT rate and the 1-year CMT rate. *p<0.10, **p<0.05, and ***p<0.01.

Table III: Summary Statistics for Variables for Mispricing and Arbitrage Regressions

| **Variable** | **Mean** | **St. Dev.** | **Min.** | **Max.** | **N** |
|---|---|---|---|---|---|
| Basis (%) | -103.02 | 684.42 | -9,839.61 | 1,419.46 | 11,924 |
| ABCDS Spread (%) | 70.50 | 77.70 | 0.25 | 2,497.20 | 12,328 |
| Bond Spread (%) | 165.84 | 676.92 | -560.24 | 9,960.67 | 12,837 |
| Reporting Gap | 0.38 | 0.26 | 0.00 | 1.56 | 13,045 |
| Δ Dist-to-Stepdown | 0.00 | 0.02 | -0.63 | 0.62 | 12,816 |
| Sq. Δ Dist-to-Stepdown | 0.00 | 0.01 | 0.00 | 0.39 | 12,816 |
| Acceleration Breach | 0.85 | 0.36 | 0.00 | 1.00 | 13,215 |
| Δ Sub Pct. | -0.03 | 0.73 | -27.60 | 28.05 | 12,816 |
| Loss Tranche | 0.09 | 0.29 | 0.00 | 1.00 | 13,197 |
| ABX Tracking Error (%) | 2.02 | 72.11 | -170.82 | 671.14 | 837 |
| ABX Reporting Gap | 0.40 | 0.22 | 0.03 | 0.89 | 840 |
| ABX Δ Subordination (%) | 0.00 | 0.00 | -0.01 | 0.02 | 820 |
| ABX Δ Dist-to-Stepdown | 0.00 | 0.01 | -0.10 | 0.10 | 820 |
| ABX Sq. Δ Dist-to-Stepdown | 0.00 | 0.00 | 0.00 | 0.01 | 820 |
| Short Interest Ratio | 18.98 | 12.15 | 3.46 | 49.07 | 41 |
| Counterparty Risk | 136.00 | 55.83 | 42.61 | 297.65 | 41 |
| Funding Cost | 0.40 | 0.64 | -0.55 | 2.74 | 41 |
| S&P500 Return | -0.34 | 6.05 | -16.94 | 9.39 | 40 |
| Δ Spot | -0.11 | 0.30 | -1.23 | 0.37 | 40 |
| Δ Slope | 0.07 | 0.29 | -0.64 | 0.86 | 40 |

This table presents the summary statistics used in the analysis of basis from July 2007-December 2010 grouped by initial bond credit rating. Basis is calculated as the difference between the ABCDS spread and the bond spread (yield to maturity (YTM) over 1 month LIBOR) on a MBS bond. ΔSubordination Pct is the month to month change in the subordination percent for each bond. Acceleration feature is an indicator variable, defined as 1 if the current OC amount is less than the target and 0 otherwise. Dist.-to-Stepdown Trigger is the difference between a threshold percent and the percent of aggregate losses. Gap is the coefficient of variation of aggregate loss data from three MBS deal level data sources. ABX Tracking Error is the difference between the ABX index and its corresponding portfolio of single-name ABCDS contracts. All ABX level credit explanatory variables are calculated on the ABCDS portfolio level by taking a bond weighted average of the referenced bonds of the corresponding ABX subindex for each variable. Short Interest Ratio serves as a proxy for insurance demand imbalances and is the change in the market ratio of the market value of shares sold short to the average daily trading volume over the month for the financial services ETF (Ticker: XLF). Counterparty Risk is a proxy for risk associated with the seller of an ABDS contract failing to uphold its contractual obligations. Funding Cost is the difference between 3 month LIBOR and the general collateral repo rate. S&P 500 Return is calculated as the percent change in the price of the S&P 500 index over the month. ΔSpot Rate is the month to month change in the 1-year CMT rate. ΔSlope is the change in the slope, which is defined as the difference between the 10-year CMT rate and the 1-year CMT rate.

Table IV.

Panel A. Cross-Correlation Table for Variables included in the Monthly Basis Regressions

| | Basis | Lagged Basis | Reporting Gap | ΔDist-to-Stepdown | Sq. ΔDist-to-Stepdown | Accel. Breach | Δ Sub. | Loss Tranche | Short Interest Ratio | Counter-party Risk | Funding Cost | S&P500 Return | ΔSpot | ΔSlope |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Basis | 1.00 | | | | | | | | | | | | | |
| Lagged Basis | 0.96 | 1.00 | | | | | | | | | | | | |
| Reporting Gap | -0.23 | -0.24 | 1.00 | | | | | | | | | | | |
| Δ Dist-to-Stepdown | -0.04 | -0.04 | 0.17 | 1.00 | | | | | | | | | | |
| Sq. Δ Dist-to-Stepdown | 0.00 | 0.00 | 0.02 | -0.67 | 1.00 | | | | | | | | | |
| Acceleration Breach | 0.07 | 0.07 | -0.01 | 0.17 | -0.02 | 1.00 | | | | | | | | |
| Δ Subordination | -0.06 | -0.05 | 0.28 | -0.18 | 0.01 | -0.10 | 1.00 | | | | | | | |
| Loss Tranche | -0.18 | -0.16 | 0.06 | -0.04 | 0.02 | -0.04 | 0.06 | 1.00 | | | | | | |
| Short Interest Ratio | 0.06 | 0.06 | -0.20 | 0.21 | -0.01 | 0.25 | -0.34 | -0.06 | 1.00 | | | | | |
| Counterparty Risk | -0.03 | -0.02 | 0.08 | -0.21 | 0.01 | -0.16 | 0.27 | 0.03 | -0.76 | 1.00 | | | | |
| Funding Cost | 0.01 | 0.02 | -0.05 | -0.20 | 0.00 | -0.09 | 0.16 | -0.02 | -0.54 | 0.58 | 1.00 | | | |
| S&P500 Return | -0.05 | -0.05 | 0.13 | 0.04 | 0.02 | -0.08 | -0.01 | 0.02 | 0.27 | -0.24 | -0.44 | 1.00 | | |
| Δ Spot | -0.04 | -0.05 | 0.17 | -0.05 | 0.01 | -0.08 | 0.18 | 0.04 | 0.13 | 0.02 | -0.20 | 0.29 | 1.00 | |
| Δ Slope | 0.02 | 0.02 | -0.13 | 0.01 | 0.01 | 0.03 | -0.13 | -0.05 | -0.03 | -0.07 | 0.09 | -0.09 | -0.42 | 1.00 |

Panel B. Cross-Correlation Table for Variables included in the Monthly Tracking Error Regressions

| | Tracking Error | Lagged Tracking Error | ABX Reporting Gap | ABX Δ Dist-to-Stepdown | ABX Sq. ΔDist-to-Stepdown | ABX Δsub. | Short Interest Ratio | Counter-party Risk | Funding Cost | S&P500 Return | ΔSpot | ΔSlope |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABX Tracking Error | 1.00 | | | | | | | | | | | |
| Lagged ABX Tracking Error | 0.90 | 1.00 | | | | | | | | | | |
| ABX Reporting Gap | -0.03 | -0.01 | 1.00 | | | | | | | | | |
| ABX ΔDist-to-Stepdown | -0.11 | -0.11 | 0.09 | 1.00 | | | | | | | | |
| ABX Sq. ΔDist-to-Stepdown | 0.03 | 0.03 | 0.04 | -0.08 | 1.00 | | | | | | | |
| ABX ΔSubordination | -0.10 | -0.14 | -0.10 | 0.15 | -0.14 | 1.00 | | | | | | |
| Short Interest Ratio | 0.02 | -0.06 | -0.26 | 0.08 | -0.13 | 0.42 | 1.00 | | | | | |
| Counterparty Risk | 0.18 | 0.22 | 0.12 | -0.07 | 0.14 | -0.25 | -0.73 | 1.00 | | | | |
| Funding Cost | 0.26 | 0.36 | -0.06 | -0.12 | 0.09 | -0.13 | -0.48 | 0.56 | 1.00 | | | |
| S&P500 Return | 0.16 | 0.19 | -0.14 | -0.03 | -0.13 | 0.08 | -0.02 | 0.21 | 0.39 | 1.00 | | |
| ΔSpot | -0.09 | -0.12 | 0.21 | 0.00 | 0.09 | -0.16 | 0.04 | 0.06 | -0.17 | -0.45 | 1.00 | |
| ΔSlope | 0.07 | 0.12 | -0.14 | -0.12 | 0.05 | 0.02 | -0.04 | -0.02 | 0.28 | 0.26 | -0.46 | 1.00 |

Table V.

Panel A: Regression Analysis of Month End Basis

| | AAA | AA | A | BBB | BBB- |
|---|---|---|---|---|---|
| Lagged Basis | 0.729*** | 0.910*** | 0.997*** | 0.926*** | 0.609*** |
| Reporting Gap | 1.198 | -9.371 | 50.120*** | -27.79 | -1,057*** |
| Δ Dist-to-Stepdown | -143.300*** | 11.81 | -213.60 | 411.40 | 224.90 |
| Sq. Δ Dist-to-Stepdown | -373.700* | 751 | -1,197 | 30,906 | 242,380 |
| Acceleration Breach | -0.192 | 0.831 | 2.861 | 12.56 | 60.02 |
| Δ Subordination | 0.112 | -1.83 | -8.269** | -5.271 | -52.94 |
| Loss Tranche | -1.74 | -8.563** | -42.050*** | -49.44*** | -165.600*** |
| Short Interest Ratio | -0.074** | -0.180 | 0.940*** | 1.893*** | 3.774** |
| Counterparty Risk | 0.016*** | -0.049*** | 0.0497 | 0.380*** | 0.248 |
| Funding Cost | -1.267*** | -5.548*** | 0.0536 | -14.24*** | -15.080 |
| S&P500 Return | -0.156*** | -0.425*** | -0.105 | -0.455 | -4.891** |
| Δ Spot | 3.299*** | 8.406*** | -4.074 | -24.970*** | -63.640 |
| Δ Slope | 0.562 | 2.30 | -13.30** | 2.450 | -32.240 |
| Constant | 2.453 | 12.630** | -45.57*** | -100.300*** | 89.640 |
| | | | | | |
| Observations | 2,511 | 2,585 | 2,239 | 1,626 | 1,507 |
| Number of bonds | 75 | 77 | 77 | 76 | 74 |
| Adjusted R-squared | 0.556 | 0.791 | 0.987 | 0.892 | 0.457 |

Panel B: Regression Analysis of Month End Tracking Error

| | **AAA** | **AA** | **A** | **BBB** | **BBB-** |
|---|---|---|---|---|---|
| Lagged ABX Tracking Error | 0.794*** | 0.348*** | 0.620*** | 0.611*** | 0.703*** |
| ABX Reporting Gap | -9.484* | -47.100*** | -97.410*** | -185.800** | -174.800** |
| ABX Δ Dist-to-Stepdown | 28.800 | -150.900 | -40.450 | -258.900 | 97.850 |
| ABX Sq. Δ Dist-to-Stepdown | 1,134 | 1,333 | 1,582 | 1,875 | -32,452 |
| ABX Δ Subordination | -554.770*** | -1,233*** | -210.80 | 367.50 | -441.00 |
| Short Interest Ratio | 0.058 | -0.135 | 0.252 | 0.872 | 0.74 |
| Counterparty Risk | 0.0109 | 0.0417 | 0.165*** | 0.419*** | 0.205* |
| Funding Cost | 0.456 | 0.78 | -4.21 | -12 | -15.390* |
| S&P500 Return | -0.0449 | 0.311 | -0.733 | 1.673 | 0.389 |
| Δ Spot | -1.844 | 1.345 | -2.405 | -3.358 | -1.792 |
| Δ Slope | -1.368 | -9.390*** | -7.316 | -4.947 | -0.105 |
| Constant | 1.494 | 24.51*** | 14.610 | 2.364 | 25.620 |
| | | | | | |
| Observations | 153 | 155 | 156 | 156 | 156 |
| Adjusted R-squared | 0.696 | 0.435 | 0.597 | 0.517 | 0.58 |

This table reports results for the fixed-effects panel regression of month-end basis grouped by initial bond credit rating in Panel A and tracking error by index rating in Panel B from July 2007-December 2010. Initial credit rating is used because the bonds included in the ABX subindexes were chosen based on the initial credit rating of the bond. If any bond was subsequently downgraded, the ABX subindex was not altered to reflect the change. All t-statistics are corrected for AR(1) errors, following Baltagi and Wu (1999). Basis approximates the mispricing between the cash and credit derivative markets and is calculated as the difference between the ABCDS spread and the bond spread (yield to maturity (YTM) over 1 month LIBOR) on a MBS bond. Δ Sub Pct. is the month to month change in the subordination percent for each bond. Acceleration breach is an indicator variable, which is defined as 1 if the current overcollateralization amount is less than the target amount and 0 otherwise. Dist.-to-Loss Trigger is the difference between a threshold percent and the percent of aggregate losses. Change controls for changes in trigger distance while the Squared ΔDist.-to-Loss accounts for the acceleration of changes in trigger distance. In Panel B, all ABX level credit explanatory variables are the outstanding factor-adjusted equally weighted averages for the referenced cash bonds in the ABX index. Reporting Gap is the coefficient of variation of aggregate loss data from three MBS deal level data sources. Short Interest Ratio serves as a proxy for insurance demand imbalances and is the change in the market ratio of the market value of shares sold short to the average daily trading volume over the month for the financial services ETF (Ticker: XLF). Counterparty Risk is a proxy for risk associated with the seller of an ABDS contract failing to uphold its contractual obligations. Funding Cost is the difference between 3 month LIBOR and the general collateral repo rate. S&P 500 Return is calculated as the percent change in the price of the S&P 500 index over the month. ΔSpot Rate is the month to month change in the 1-year CMT rate. ΔSlope is the change in the slope, which is defined as the difference between the 10-year CMT rate and the 1-year CMT rate. *p<0.10, **p<0.05, ***p<0.01.

Table VI: Principal Component Analysis on Model Residuals

| **Bonds** | **First** | **Second** | **Adjusted R2** | **Unexplained Portion** | **Potential Impact** |
|---|---|---|---|---|---|
| AAA | 0.282 | 0.265 | 0.697 | 0.303 | 0.086 |
| AA | 0.306 | 0.207 | 0.771 | 0.229 | 0.070 |
| A | 0.507 | 0.300 | 0.680 | 0.320 | 0.162 |
| BBB | 0.517 | 0.263 | 0.756 | 0.244 | 0.126 |
| BBB- | 0.691 | 0.139 | 0.745 | 0.255 | 0.176 |

| **ABCDS** | **First** | **Second** | **Adjusted R2** | **Unexplained Portion** | **Potential Impact** |
|---|---|---|---|---|---|
| AAA | 0.342 | 0.126 | 0.019 | 0.981 | 0.336 |
| AA | 0.400 | 0.110 | 0.014 | 0.986 | 0.394 |
| A | 0.662 | 0.127 | 0.366 | 0.634 | 0.420 |
| BBB | 0.495 | 0.243 | 0.493 | 0.507 | 0.251 |
| BBB- | 0.230 | 0.176 | 0.031 | 0.969 | 0.222 |

| **Port ABCDS** | **First** | **Second** | **Adjusted R2** | **Unexplained Portion** | **Potential Impact** |
|---|---|---|---|---|---|
| AAA | 0.556 | 0.293 | 0.014 | 0.986 | 0.548 |
| AA | 0.744 | 0.225 | 0.013 | 0.987 | 0.735 |
| A | 0.579 | 0.398 | 0.348 | 0.652 | 0.378 |
| BBB | 0.993 | 0.004 | 0.212 | 0.788 | 0.782 |
| BBB- | 0.388 | 0.323 | 0.041 | 0.959 | 0.372 |

| **ABX** | **First** | **Second** | **Adjusted R2** | **Unexplained Portion** | **Potential Impact** |
|---|---|---|---|---|---|
| AAA | 0.877 | 0.063 | 0.263 | 0.737 | 0.646 |
| AA | 0.740 | 0.145 | 0.093 | 0.907 | 0.672 |
| A | 0.828 | 0.111 | 0.122 | 0.878 | 0.727 |
| BBB | 0.947 | 0.049 | 0.184 | 0.816 | 0.773 |
| BBB- | 0.942 | 0.054 | 0.189 | 0.811 | 0.764 |

This table presents the results from principal component analysis on the covariances of the residuals from the credit risk models in Tables XII and XIII. We use the combined residuals, which is the sum of the fixed-effects error component and the overall error. First and Second show how much of the variance in residuals is explained by the first and second principal components, respectively. Adjusted R2's are from the credit risk models in Tables XII and XIII. The unexplained portion is 1 minus R2, which approximately represents how much of the variation in the credit spreads lies outside of the credit risk model. Potential impact is the unexplained portion of variation multiplied by the first principal component. This is a simplified measurement of how much of the unexplained portion may be explained by the systematic factor, which is represented by the first principal component. Using our interpretation that the systematic factor is noise trading supply and demand shocks, this is the potential impact of noise traders on credit risk pricing.

Table VII

Vector Error Correction Model for Price Discovery and Information Flow from Remittance Reports

*Panel A: Mean and Median Error Correction & Remittance Report Coefficients by Subindex*

| **2006-1** | **Available** | **Coint** | **Mean λ1** | **Median λ1** | **Mean λ2** | **Median λ2** | **Mean β1** | **Median β1** | **Mean β2** | **Median β2** |
|---|---|---|---|---|---|---|---|---|---|---|
| AAA | 18 | 18 | -0.0016 | -0.0006 | 0.0000 | -0.0001 | -0.3880 | -0.1536 | 0.0013 | 0.0009 |
| AA | 17 | 17 | -0.0104 | -0.0041 | 0.0000 | -0.0001 | -2.1490 | -0.4521 | 0.3198 | -0.0028 |
| A | 19 | 18 | -0.0354 | -0.0219 | -0.0111 | -0.0009 | 58.5754 | -0.7461 | -1.0699 | -0.0065 |
| BBB | 19 | 13 | -0.0394 | -0.0360 | -0.0272 | -0.0012 | 1.5333 | 1.2389 | -7.0439 | 0.0616 |
| BBB- | 19 | 10 | -0.0421 | -0.0246 | 0.0138 | 0.0000 | 2.0326 | 2.8339 | 2.7633 | -1.9156 |

| **2006-2** | **Available** | **Coint** | **Mean λ1** | **Median λ1** | **Mean λ2** | **Median λ2** | **Mean β1** | **Median β1** | **Mean β2** | **Median β2** |
|---|---|---|---|---|---|---|---|---|---|---|
| AAA | 18 | 18 | -0.0014 | -0.0012 | -0.0001 | -0.0001 | -0.1223 | -0.1210 | -0.0043 | -0.0043 |
| AA | 20 | 19 | -0.0172 | -0.0115 | 0.0003 | -0.0008 | 0.2377 | 0.0074 | 0.3608 | 0.1601 |
| A | 19 | 17 | -0.0207 | -0.0224 | -0.0011 | -0.0029 | 0.4500 | 0.2327 | 2.7763 | 1.9448 |
| BBB | 19 | 6 | 0.1491 | -0.0295 | 0.0369 | 0.0206 | -483.6628 | -0.4867 | 0.6825 | 0.2503 |
| BBB- | 18 | 3 | -0.0505 | -0.0367 | 0.0094 | 0.0150 | 2.5738 | 2.2694 | 1.5180 | 0.0959 |

| **2007-1** | **Available** | **Coint** | **Mean λ1** | **Median λ1** | **Mean λ2** | **Median λ2** | **Mean β1** | **Median β1** | **Mean β2** | **Median β2** |
|---|---|---|---|---|---|---|---|---|---|---|
| AAA | 20 | 20 | -0.0009 | -0.0007 | -0.0001 | -0.0001 | -0.0665 | -0.0741 | 0.0167 | -0.0062 |
| AA | 20 | 20 | -0.0077 | -0.0056 | 0.0001 | -0.0005 | -0.2203 | -0.2705 | 0.3186 | 0.3020 |
| A | 19 | 15 | -0.0971 | -0.0256 | 0.0006 | -0.0004 | -30.8940 | 0.1336 | 0.2528 | 0.1069 |
| BBB | 18 | 4 | -0.0389 | -0.0269 | -0.0014 | -0.0008 | 0.4888 | -0.5284 | 0.5072 | 0.5896 |
| BBB- | 20 | 5 | -0.0562 | -0.0567 | 0.0291 | 0.0049 | 1.4514 | 1.7137 | -0.9047 | 0.8237 |

| **2007-2** | **Available** | **Coint** | **Mean λ1** | **Median λ1** | **Mean λ2** | **Median λ2** | **Mean β1** | **Median β1** | **Mean β2** | **Median β2** |
|---|---|---|---|---|---|---|---|---|---|---|
| AAA | 20 | 20 | -0.0022 | -0.0013 | 0.0000 | -0.0001 | -0.0351 | -0.0174 | 0.0349 | 0.0112 |
| AA | 20 | 19 | -0.0045 | -0.0010 | -0.0005 | -0.0004 | -0.0560 | -0.0430 | 0.5043 | 0.7116 |
| A | 20 | 16 | -0.0320 | -0.0302 | -0.0001 | -0.0021 | 0.9725 | 0.3269 | 0.8702 | 0.8912 |
| BBB | 20 | 5 | -0.0110 | -0.0074 | -0.0037 | -0.0052 | 0.3400 | 0.0171 | 1.2147 | 1.2507 |
| BBB- | 18 | 6 | -0.0161 | -0.0192 | 0.0015 | 0.0015 | -0.2513 | -0.4282 | 0.3045 | 0.1851 |

Panel A reports the number of ABCDS-bond relationships that are cointegrated using the Johansen et al. (2000) testing procedure out of the number available in the data, the mean and median speed of adjustment coefficients from the modified VECM, which includes an indicator variable for report date, which is equal to 1 for the days before, on, and after the report is released for only the cointegrated relationships. β1 shows the response to the report in the ABCDS market, and β2 shows the response in the bond market. A positive (negative) coefficient indicates a negative (positive) response because the dependent variable is the change in spreads, not prices

Table VII Cont.

*Panel B: Market Contributions to Price Discovery*

| 2006-1 | Only Bond Market ($\lambda1<0$) | Only CDS Market ($\lambda2>0$) | Both Markets ($\lambda1<0$ and $\lambda2>0$) | Ambiguous ($\lambda1>0$ or $\lambda2<0$) | Neither |
|---|---|---|---|---|---|
| AAA | 5 | 0 | 0 | 1 | 12 |
| AA | 6 | 0 | 0 | 4 | 7 |
| A | 11 | 0 | 1 | 4 | 2 |
| BBB | 8 | 0 | 2 | 3 | 0 |
| BBB- | 9 | 0 | 0 | 1 | 0 |
| **2006-2** | **Only Bond Market ($\lambda1<0$)** | **Only CDS Market ($\lambda2>0$)** | **Both Markets ($\lambda1<0$ and $\lambda2>0$)** | **Ambiguous ($\lambda1>0$ or $\lambda2<0$)** | **Neither** |
| AAA | 0 | 0 | 0 | 6 | 12 |
| AA | 15 | 0 | 0 | 1 | 3 |
| A | 12 | 0 | 0 | 1 | 3 |
| BBB | 2 | 1 | 1 | 1 | 1 |
| BBB- | 2 | 0 | 0 | 0 | 1 |
| **2007-1** | **Only Bond Market ($\lambda1<0$)** | **Only CDS Market ($\lambda2>0$)** | **Both Markets ($\lambda1<0$ and $\lambda2>0$)** | **Ambiguous ($\lambda1>0$ or $\lambda2<0$)** | **Neither** |
| AAA | 0 | 0 | 0 | 7 | 13 |
| AA | 12 | 0 | 0 | 1 | 7 |
| A | 11 | 1 | 0 | 2 | 1 |
| BBB | 3 | 0 | 0 | 0 | 1 |
| BBB- | 2 | 0 | 2 | 0 | 1 |
| **2007-2** | **Only Bond Market ($\lambda1<0$)** | **Only CDS Market ($\lambda2>0$)** | **Both Markets ($\lambda1<0$ and $\lambda2>0$)** | **Ambiguous ($\lambda1>0$ or $\lambda2<0$)** | **Neither** |
| AAA | 1 | 0 | 0 | 3 | 16 |
| AA | 4 | 0 | 0 | 1 | 14 |
| A | 14 | 0 | 0 | 0 | 2 |
| BBB | 4 | 0 | 0 | 0 | 1 |
| BBB- | 3 | 1 | 0 | 0 | 1 |

Panel B shows a count of the speed of adjustment coefficients from the VECM model that are significant at the 10% level. Column 2 is a count of all of the relationships where only λ1 is significant and negative, indicating price discovery occurs in the bond market. Column 3 is a count of all of the relationships where only λ2 is signficant and positive, indicating price discovery occurs in the CDS market. Column 4 is a count of all the relationships where both λ1 and λ2 are significant, which suggests that both markets share in price discovery. Column 5 is a count of all of the relationships where either coefficient is significant, but has the wrong sign. Lastly, column 6 is a count of all relationships where neither sign is significant.

Table VII Cont.

*Panel C: Hasbrouck and Granger-Gonzalo Measures for Relationships with Both Markets Playing*

| **2006-1** | **Both Markets (λ1<0 and λ2>0)** | **Dominant CDS Market Discovery (Lower Bound >0.5 & GG>0.5)** | **Conflicting Results** |
|---|---|---|---|
| AAA | 0 | 0 | 0 |
| AA | 0 | 0 | 0 |
| A | 1 | 0 | 1 |
| BBB | 2 | 1 | 1 |
| BBB- | 0 | 0 | 0 |

| **2006-2** | **Both Markets (λ1<0 and λ2>0)** | **Dominant CDS Market Discovery (Lower Bound >0.5 & GG>0.5)** | **Conflicting Results** |
|---|---|---|---|
| AAA | 0 | 0 | 0 |
| AA | 0 | 0 | 0 |
| A | 0 | 0 | 0 |
| BBB | 1 | 0 | 1 |
| BBB- | 0 | 0 | 0 |

| **2007-1** | **Both Markets (λ1<0 and λ2>0)** | **Dominant CDS Market Discovery (Lower Bound >0.5 & GG>0.5)** | **Conflicting Results** |
|---|---|---|---|
| AAA | 0 | 0 | 0 |
| AA | 0 | 0 | 0 |
| A | 0 | 0 | 0 |
| BBB | 0 | 0 | 0 |
| BBB- | 2 | 0 | 2 |

| **2007-2** | **Both Markets (λ1<0 and λ2>0)** | **Dominant CDS Market Discovery (Lower Bound >0.5 & GG>0.5)** | **Conflicting Results** |
|---|---|---|---|
| AAA | 0 | 0 | 0 |
| AA | 0 | 0 | 0 |
| A | 0 | 0 | 0 |
| BBB | 0 | 0 | 0 |
| BBB- | 0 | 0 | 0 |

Panel C represents the Hasbrouck and Granger-Gonzalo results to see which market dominants price discovery. The ABCDS market would be considered the dominant market if either variable is over 0.5. If both measures how the CDS market as dominant, then it is counted in column 3. If the measures provide conflicting results, it is show in column 4.

Table VII Cont.

*Panel D: Report Date Modification*

| 2006-1 | CDS Market Response Only Positive: ($\beta1<0$) | Negative: ($\beta1>0$) | Bond Market Response Only Positive: ($\beta2<0$) | Negative: ($\beta2>0$) | Both | Respond Same Pos. | Neg. | Respond Differently Pos/Neg | Neg/Pos |
|---|---|---|---|---|---|---|---|---|---|
| AAA | 8 | 0 | 0 | 1 | 0 | | | | |
| AA | 6 | 0 | 0 | 1 | 0 | | | | |
| A | 3 | 0 | 3 | 2 | 0 | | | | |
| BBB | 0 | 1 | 3 | 3 | 1 | | 1 | | |
| BBB- | 1 | 1 | 1 | 0 | 2 | | 1 | | 1 |

| 2006-2 | CDS Market Response Only Positive: ($\beta1<0$) | Negative: ($\beta1>0$) | Bond Market Response Only Positive: ($\beta2<0$) | Negative: ($\beta2>0$) | Both | Respond Same Pos. | Neg. | Respond Differently Pos/Neg | Neg/Pos |
|---|---|---|---|---|---|---|---|---|---|
| AAA | 1 | 1 | 1 | 2 | 0 | | | | |
| AA | 1 | 1 | 0 | 3 | 1 | | 1 | | |
| A | 0 | 2 | 0 | 6 | 1 | | 1 | | |
| BBB | 0 | 2 | 0 | 3 | 0 | | | | |
| BBB- | 0 | 3 | 0 | 3 | 1 | | | | 1 |

| 2007-1 | CDS Market Response Only Positive: ($\beta1<0$) | Negative: ($\beta1>0$) | Bond Market Response Only Positive: ($\beta2<0$) | Negative: ($\beta2>0$) | Both | Respond Same Pos. | Neg. | Respond Differently Pos/Neg | Neg/Pos |
|---|---|---|---|---|---|---|---|---|---|
| AAA | 0 | 0 | 0 | 2 | 0 | | | | |
| AA | 4 | 0 | 0 | 7 | 0 | | | | |
| A | 0 | 0 | 1 | 2 | 1 | | | 1 | |
| BBB | 0 | 1 | 0 | 10 | 1 | | 1 | | |
| BBB- | 0 | 2 | 0 | 4 | 2 | | 2 | | |

| 2007-2 | CDS Market Response Only Positive: ($\beta1<0$) | Negative: ($\beta1>0$) | Bond Market Response Only Positive: ($\beta2<0$) | Negative: ($\beta2>0$) | Both | Respond Same Pos. | Neg. | Respond Differently Pos/Neg | Neg/Pos |
|---|---|---|---|---|---|---|---|---|---|
| AAA | 1 | 0 | 0 | 6 | 0 | | | | |
| AA | 0 | 0 | 0 | 11 | 1 | | | 1 | |
| A | 0 | 1 | 0 | 8 | 2 | | 2 | | |
| BBB | 0 | 0 | 0 | 9 | 1 | | 1 | | |
| BBB- | 1 | 1 | 0 | 5 | 1 | | 1 | | |

Panel D presents a summary of each market's response to the information contained in the remittance reports. Columns 2 and 3 show the results if the ABCDS market is the only one to respond, which means only β1 is significant. Column 2 shows a count of positive responses, and Column 3 shows negative responses. Columns 4 and 5 show the results if the bond market is the only one to respond, which means only β2 is significant. If the response is positive, then it is recorded in Column 4 and if the response is negative, then it is recorded in Column 5. If both markets respond, meaning both β1 and β2 are significant, then Columns 7 and 8 show the results if they are the same, both positive or both negative, respectively. Lastly, Columns 9 and 10 show if the markets respond differently to the informtion release. Column 9 (10) shows a count when the ABCDS market responds positively (negatively), but the bond market responds negatively (positively).

Table VIII: Modified VECM Analysis: Market Contributions to Price Discovery for the ABCDS and ABX Markets

| **Index** | **λ1** | **t-stat** | **λ2** | **t-stat** | **β1** | **t-stat** | **β2** | **t-stat** | **lower** | **mid** | **upper** | **GG** | **ABX Dom? HAS** | **ABX Dom? GG** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABX.HE.AAA.06-1 | -0.001 | -1.527 | 0.000 | -0.042 | -12.217** | -2.395 | -7.207 | -0.277 | 0.00 | 0.01 | 0.01 | -0.17 | 0 | 0 |
| ABX.HE.AA.06-1 | -0.005** | -2.413 | 0.021 | 1.535 | -72.796*** | -4.721 | -93.868 | -0.832 | 0.29 | 0.29 | 0.29 | 0.82 | 0 | 1 |
| ABX.HE.A.06-1 | -0.007 | -1.349 | 0.081*** | 3.963 | -450.827*** | -4.921 | -282.235 | -0.813 | 0.89 | 0.89 | 0.90 | 0.92 | 1 | 1 |
| ABX.HE.BBB.06-1 | -0.023*** | -2.581 | 0.003 | 0.776 | -2,960.03*** | -4.359 | 343.724 | 1.072 | 0.08 | 0.09 | 0.09 | 0.12 | 0 | 0 |
| ABX.HE.BBB-.06-1 | -0.018** | -2.288 | 0.009 | 1.410 | -3,154.09*** | -5.614 | 523.047 | 1.227 | 0.27 | 0.28 | 0.29 | 0.32 | 0 | 0 |

| **Index** | **λ1** | **t-stat** | **λ2** | **t-stat** | **β1** | **t-stat** | **β2** | **t-stat** | **lower** | **mid** | **upper** | **GG** | **ABX Dom? HAS** | **ABX Dom? GG** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABX.HE.AAA.06-2 | -0.001 | -1.502 | 0.002 | 0.422 | -8.716 | -1.325 | 28.279 | 0.552 | 0.07 | 0.09 | 0.11 | 0.69 | 0 | 1 |
| ABX.HE.AA.06-2 | -0.012*** | -2.744 | 0.069*** | 2.799 | -128.038*** | -4.546 | 195.923 | 1.244 | 0.49 | 0.51 | 0.53 | 0.85 | 0 | 1 |
| ABX.HE.A.06-2 | -0.003 | -0.772 | 0.028** | 2.037 | -282.601*** | -5.188 | 47.485 | 0.233 | 0.87 | 0.87 | 0.88 | 0.91 | 1 | 1 |
| ABX.HE.BBB.06-2 | -0.001 | -0.660 | 0.356*** | 5.635 | -389.955*** | -6.757 | -5,018*** | -2.666 | 0.99 | 0.99 | 0.99 | 1.00 | 1 | 1 |
| ABX.HE.BBB-.06-2 | 0.000 | -0.077 | 0.027** | 2.109 | -445.740*** | -8.352 | 209.930 | 0.749 | 1.00 | 1.00 | 1.00 | 0.99 | 1 | 1 |

| **Index** | **λ1** | **t-stat** | **λ2** | **t-stat** | **β1** | **t-stat** | **β2** | **t-stat** | **lower** | **mid** | **upper** | **GG** | **ABX Dom? HAS** | **ABX Dom? GG** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABX.HE.AAA.07-1 | -0.001 | -1.593 | 0.002 | 0.399 | -3.573 | -0.675 | 17.887 | 0.385 | 0.06 | 0.06 | 0.07 | 0.69 | 0 | 1 |
| ABX.HE.AA.07-1 | -0.006** | -2.232 | 0.033* | 1.673 | -67.71*** | -4.363 | 48.777 | 0.424 | 0.36 | 0.36 | 0.37 | 0.85 | 0 | 1 |
| ABX.HE.A.07-1 | 0.000 | -0.328 | 0.342*** | 7.307 | -129.505*** | -5.832 | -999.093 | -1.436 | 1.00 | 1.00 | 1.00 | 1.00 | 1 | 1 |
| ABX.HE.BBB.07-1 | 0.000 | -0.048 | 0.039** | 2.325 | -172.137*** | -6.739 | 286.980 | 1.029 | 1.00 | 1.00 | 1.00 | 1.00 | 1 | 1 |
| ABX.HE.BBB-.07-1 | 0.000 | 0.018 | 0.055*** | 2.858 | -202.359*** | -7.019 | 380.941 | 1.133 | 1.00 | 1.00 | 1.00 | 1.00 | 1 | 1 |

| **Index** | **λ1** | **t-stat** | **λ2** | **t-stat** | **β1** | **t-stat** | **β2** | **t-stat** | **lower** | **mid** | **upper** | **GG** | **ABX Dom? HAS** | **ABX Dom? GG** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABX.HE.AAA.07-2 | -0.001 | -1.509 | 0.007 | 0.846 | -2.140 | -0.439 | 77.343 | 0.930 | 0.23 | 0.25 | 0.26 | 0.91 | 0 | 1 |
| ABX.HE.AA.07-2 | -0.002 | -1.184 | 0.023 | 1.438 | -54.36*** | -4.341 | 52.381 | 0.505 | 0.59 | 0.60 | 0.60 | 0.91 | 1 | 1 |
| ABX.HE.A.07-2 | 0.000 | 0.246 | 0.051*** | 2.581 | -99.017*** | -5.726 | 207.578 | 0.806 | 0.99 | 0.99 | 0.99 | 1.01 | 1 | 1 |
| ABX.HE.BBB.07-2 | 0.000 | 0.125 | 0.028* | 1.918 | -136.757*** | -5.616 | 45.762 | 0.222 | 1.00 | 1.00 | 1.00 | 1.01 | 1 | 1 |
| ABX.HE.BBB-.07-2 | 0.001 | 0.745 | 0.064*** | 3.155 | -120.615*** | -4.772 | 102.895 | 0.353 | 0.95 | 0.95 | 0.95 | 1.02 | 1 | 1 |

This table presents the speed of adjustment coefficients from the modified VECM between the ABX and its coresponding ABCDS portfolio.If price discovery occurs in the ABCDS portfolio (ABX), then λ1 ( λ2) should be negative (positive) and significant. If information from the remittance report flows to the ABX or the ABCDS portfolio, it is captured by β1 and β2, respectively. A positive (negative) response would have a negative (positive) coefficient because the dependent is change in spreads in the respective markets. We also present the lower, middle, and upper measures for the Hasbrouck measures, following Blanco, Brennan, and Marsh (2005). The last two columns show whether price discovery is dominant in the ABX based on the Hasbrouck measures (Column 10) and the Granger-Gonzalo measure (Column 11).

## Appendix A: RMBS Performance Data Differences between Remittance Reports and Major Data Vendors and their Impact for RMBS Research

Most researchers believe that RMBS data is homogenous and complete. Nothing could be further from the truth. In fact, different RMBS deals report different fields, and sometimes the same fields computed different ways, in different report formats that can change across time. Imerman, Lee, and Mason 2015 showed that to be true for loan-level date. The fact is also true for aggregate deal-level data, as well.

Reported RMBS data is not governed by GAAP, falling in the small-loan reporting exemption so that while what is reported is supposed to be accurate, the method of calculation and completeness and consistency of reporting is left to the parties to the securitization in charge of such reporting (typically some combination of the Servicer, the Securities Administrator, and the Trustee). This paper sheds light on common errors and inaccuracies data that affect the results of past and future studies, particularly those using ABSNet and Blackbox Logic LLC databases.

The information that most academics and industry professionals use for standard collateral performance measures (e.g. 60 plus day or 90 plus-day delinquencies or net cumulative losses) is found in both vendor databases and deal remittance reports, so it is easily compared and authenticated. We collected and compared data from both sources in the analysis below and find substantial differences between the two.

We find discernable patterns of inaccurate data in vendor databases. It appears that vendors sometimes have systematic problems mapping their standardized fields to the remittance reports. That could be the result of changes in report formats (e.g. moving cumulative losses from the beginning of the report to the end of the report) or file types (e.g. changing from CSV to XLSX files).

Those reporting differences have important implications for academic and industry research. Obviously, the performance of MBS is a function of cash flow priorities, which can be altered by the performance of the underlying mortgages so that the results of any study utilizing inaccurate data may be biased and caution should be exercised in interpreting the results. But researchers also need to be aware that industry participants that use faulty data or models, such as a default probability model, expose themselves, clients, and perhaps the market to undue and excessive risk which may cause confusion and panic.

Our conclusions should not be interpreted as alleging the trust data is incorrectly reported. We do not want to imply that the trust reporting is wrong, just that the industry has struggled (and continues to struggle) to apply consistent rules across securitizations that can be used to report data across deals to a degree of homogeneity that can be used address in the aggregate interesting research questions about the crisis. Just because you have a lot of data does not mean that it is constructed on a sufficiently reliable basis to be used for comparisons that can answer important questions about the financial crisis.

Below we enumerate the details of vendor reporting in more detail.

## I. Background on the Data and Analysis

The present paper provides direct comparisons with ABSNet. ABSNet is a product of Moody's Analytics.[48] It provides data on more than 200,000 ABS/MBS traded securities and loan-level data for U.S. non-agency and European RMBS transactions and is one of the most common MBS performance databases used by investors.[49] Initial deal and tranche characteristic data is obtained from the prospectus and supplemental prospectus for each deal and ongoing monthly performance data is collected from the monthly remittance reports from the trustee. The exact method (e.g. manually entered or textual analysis) that ABSNet uses to compile data is unknown.

In order to focus on the most widely-traded Cash RMBS, we collected "total pool" level collateral performance data from ABSNet for the 80 deals in the ABX Indexes using from January 2006 to December 2010.[50] The Bloomberg Names of the 80 deals are presented in Table I, sorted by ABX vintage. The first ABX was launched on January 19, 2006, containing deals issued in the latter half of 2005. The last was launched in July 2007, containing deals issued in the first half of 2007.

---

[48] It was previously owned by Lewtan Technologies.

[49] Principia Partners 2012 Survey

[50] It is not uncommon for a deal to have multiple mortgage groups (or pools). Most of the time the investor report will identify performance statistics on the "Total Pool" and then breakout the numbers for each group. For these deals, ABSNet will retain a data on the "total pool" and for any subgroup, such as "Group 1" or "Group 2." For completeness, we also compared individually referenced pools for the AAA tranches in the ABX index since the performance of these tranches should be the most sensitive to changes in the cash flow waterfall and found many of the same inconsistencies that are outlined in this paper.

We analyze the period of 2006 t0 2011. Because of the staggered ABX launches, however, the first ABX vintage is the only one to have a complete 60 months of history. In this Appendix, we refer to the deals in the first ABX vintage as the oldest deals in the sample. The number of months in the history of each deal can be found in Table I. The deals in the fourth vintage have the shortest history, and we will commonly refer to these deals as the youngest.

For purposes of this study, we focus on a select number of variables, which include beginning and ending pool balance, scheduled principal, repurchases, delinquencies (30-day, 60-day, 90-day, and 90 plus-day), real estate owned, foreclosed, and bankruptcy loan balances, liquidations, current gain and loss amounts, cumulative realized losses, and loss severities. To construct a dataset of correct data, we first downloaded total pool data for the selected fields listed above for each of the 80 ABX deals in Excel format. Then, we manually checked each data entry field against the monthly remittance reports from January 2006 to December 2010. Those reports are available through ABSNet or Bloomberg in PDF format, or directly from the trustee's website and may be available in either a PDF or spreadsheet, depending on the trustee.[51]

[TABLE I]

ABSNet provides a glossary of data fields that we use as our guide.[52] For example, according to the ABSNet definition, their cumulative realized losses data field reports losses on a net basis. That is, gross cumulative losses are adjusted by any subsequent recoveries or losses. Following that definition, we compared ABSNet with net cumulative realized losses from the remittance reports. The information in the remittance reports is based on definitions set forth in the deal's pooling and servicing agreement (PSA), prospectus, and/or prospectus supplement, if any such definitions are provided. To strive for consistency, we matched the line item definitions for each deal to ensure that the data was recorded correctly from the remittance reports to ABSNet.

There are two common data problems in the ABSNet database for the extended sample period: omitted and misreported variables.

---

[51] US Bank, BNY Mellon, and WellsFargo CTSLink websites have investor report information available in PDF and XLS formats, and loan level data in CSV, all of which require a login but access is free. Deutsche Bank has monthly statements in PDF format and loan level data in XLS. It also has monthly statement details in RST (rich structured text) format, which requires a special software to read and open. Deutsche Bank is the only one that does not require a login.
[52] URL: http://www.absnet.net/ABSNet/glossary/Index

## II. Reporting Omissions

The easier of the two to recognize is omissions. A visual inspection should locate any omitted variables. If a data field was omitted, we looked at the remittance reports to determine if data is a.) not available or b.) available, but just not recorded in ABSNet.

We offer two main findings related to omissions. First, there seems to be a systematic pattern for omitted observations, which is directly related to trustee. For the sample group there are seven trustees: CTSLink Wells Fargo, Deutsche Bank, GMAC-RFC, LaSalle Bank/Bank of America,[53] JP Morgan, US Bank, and Citigroup.

Second, there appear to be two specific dates for which ABSNet will begin recording data, despite the fact that the data is available in the trustee reports. For most of these deals, ABSNet data begins on either March 2008 or October 2008, which means that for 26 months (43.3% of the sample period) or 33 months (55% of the sample period) there is no data. The majority of these observations are for the current liquidations and current gain and loss fields. For the cumulative counterparts of these fields, cumulative liquidations and cumulative realized losses, most if not all dates will be missing.[54]

For most data fields, the information was available in the reports and just not retained by ABSNet, with the exception of 90-day delinquencies. The majority of the time 90-day delinquencies was omitted because the information could not be located in the remittance report for either the entire sample period or part of it.

One common reason why 90-day delinquencies are omitted is that there is no definition for 90-day delinquent in the deal documents. However, for some deals, 90-day delinquencies would not be recorded at the beginning of the period, but then would be later on. As a result, these deals would have partial observations for the sample period.

---

[53] Bank of America acquired LaSalle Bank in 2007, which is in the middle of the sample period.

[54] One may be inclined to sum up current liquidations and gain and loss amounts to find the cumulative values, and while that may be an appropriate strategy for liquidations, it is not for cumulative realized losses. The main reason for this is that ABSNet records the current principal portion of losses for the current gain and loss amounts, but the cumulative realized losses is the total loss on loans, which includes the interest portion. If the current gain and losses were taken in aggregate it would underestimate the actual cumulative realized loss, so this is not a strategy that should be pursued.

It is important to note that while definitions do not change over the life of the deal, reporting formats would occasionally change for various reasons, which would introduce new items or split current items into a more detailed format. For example, a deal may report two categories of delinquencies: 30-day and 60+ day. Each group following the definition in the deal documents. Then after several months, the reports may add additional categories, such as 90-day, 150-day, or 180+ day. None of which would be defined in the deal documents.

Other deals report delinquencies in standard 30-, 60- and 90 plus-day delinquent buckets, while others will report more detail and break down the delinquencies even further by including 90-, 120-, 150-, and 180 plus-day buckets. As a result, when the 90-day field is missing, it is typically because the trustee only reports 90-day plus.

The majority of the omissions concern: repurchases, 90-day delinquency, both current and cumulative liquidations, current gain/loss amount, and cumulative realized losses. The problem is less pervasive for scheduled principal and 90-day plus delinquency. There are complete observations for four data fields: 30- and 60- Day delinquencies, foreclosed loans, and real estate owned mortgage balances.

Figure 1 graphically depicts our two conclusions for the four data fields. In the Figure, all 80 deals are separated first by trustee, which can be found in the top row of the Figure, and then by vintage. This allows for comparison of deals within trustees across time and for comparison within trustees and issuers (i.e. same shelf name). In the Figure, not all data fields are presented. Only the fields with the most omitted variables are represented. Some deals have more than one field, so there are a few shelf names with multiple fields listed. For example, under the GMAC-RFC trustee, in the third vintage the RASC shelf name has both current gain and loss and cumulative realized losses listed because both have a significant number of months missing. Further, by looking at the RASC shelf name in fourth vintage (located directly to the left), the pattern of omitted

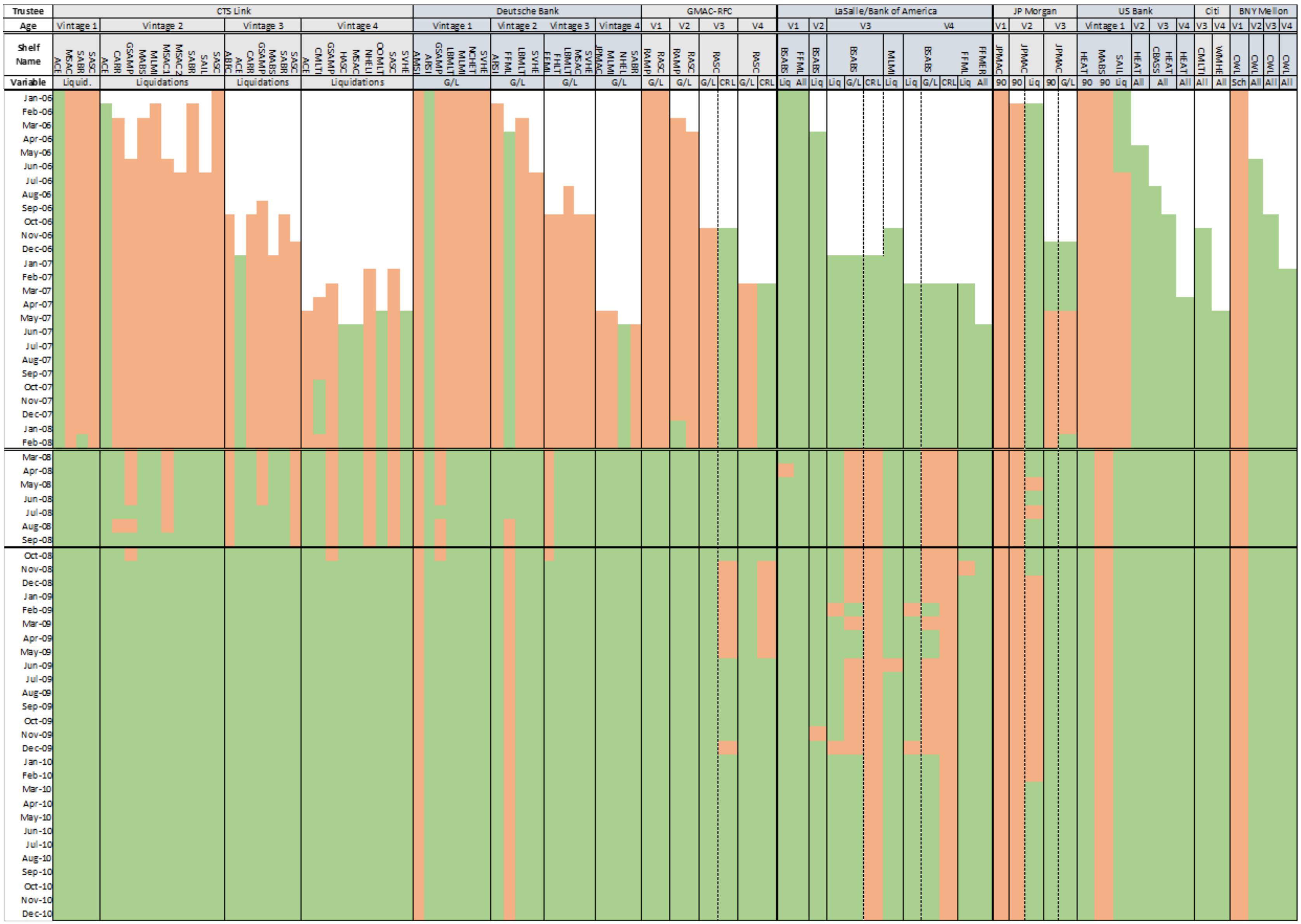



Figure 1: Graphical depiction of omitted variables within ABSNet grouped by Trustee

the

variables between RASC deals becomes apparent. Both are missing the same months, with the exception of an extra month in late 2009 for the younger of the two RASC deals.

Twenty deals have Deutsche Bank (DB) listed as a trustee, and the problem data fields for these are 90-day delinquent, current gain/loss amount, and cumulative realized loss. The 90-day delinquent field is easily explainable for the 7 oldest deals in the sample group, which are those included in the first ABX vintage. For these deals, the monthly investor reports only breakdown delinquencies into three categories: 30-, 60-, and 90 plus-days delinquent. There is no way to determine the outstanding balance of the 90-day delinquent loans. For the rest of the deals, DB changes the way it reports in late 2007 early 2008 to include a further breakdown of delinquencies, so that investors could see categories of late payments ranging from 1 month to 20 months. Even after the reporting change (i.e. when the data becomes available), ABSNet fails to record the 90-day delinquent category for 7 deals but does record it for 3 deals.

For current gain and loss and cumulative realized losses, the 20 DB deals have discernable patterns in ABSNet omissions. For most of the deals, cumulative realized losses are missing for the entire sample period, but current gain and loss amounts are only missing until 2008 (with the exception of three deals: AMSI 2005-R11, which is completely missing and ARSI 2005-W2 and NHEL 2007-2, both of which have no missing data). Of the 17 remaining deals, 14 are missing current gain and loss amounts until February 2008. ABSNet begins consistently recording for two deals in November 2008 (FFML 2006-FF4 and FFML 2006-FF13). The older of the two FFML deals has current gain and loss amount from the beginning of the deal history until August 2008. Then two months are missing, and data is reported again. For the other FFML deal, the patterns are consistent with all the other deals missing data. That is, data is missing from inception or beginning of sample period, until ABSNet begins recording. And lastly, for one deal (GSAMP 2005-HE4) data retention is nonexistent until June 2008. Then it is sporadic from July 2008 until October 2008, after which data is consistently recorded.

The patterns in omitted observations are less apparent for the rest of the trustees. For GMAC-RFC trusteed deals, there are missing observations for 90 plus-day delinquencies, cumulative liquidations, and current gain and loss. Ninety plus-day and cumulative liquidations are limited to the two oldest deals, which are those in the first ABX vintage. The delinquency category varies for these two deals. For one, data is only missing for the first two months, and for the other it is missing until February 2008. For both of these older deals, all of the cumulative liquidations are missing.

Current gain and loss is the most widespread problem that occurs for all GMAC-RFC trusteed deals across all four ABX vintages. Five of the six deals are recorded beginning March 2008. The other deal begins two months earlier on January 2008. Cumulative realized loss omissions are limited to the youngest deals, those in the third and fourth ABX vintages, and occur later in the life of the deal. More specifically, data for November 2008 through May 2009 are missing. Cumulative realized losses get larger throughout the life of a deal, so this "back loading" of missing data points could potentially bias any results in studies that use this data field.

GMAC-RFC trusteed deals have rampant misreporting, which will be described in more detail later, but for now, we will note that although current gain and loss and cumulative realized returns seem to be the only ones omitted, current and cumulative liquidations are misreported, so one may be better off considering them missing.

For the 8 deals with LaSalle/Bank of America, the omission patterns are almost nonexistent, but there appear to be consistencies within certain shelves. Of the First Franklin Mortgage Loan Trust (FFML) deals, the oldest one has no missing data and the youngest one has only one date missing. There are four Bear Stearns shelf deals (BSABS). The oldest two, one from the first ABX vintage and the other from the second vintage, have scheduled principal, current and cumulative liquidation missing for one date (albeit, they are different dates: April 2008 and November 2008, respectively) out of the whole sample period. But for the two youngest BSABS deals, the same dates are missing for the same variables. This pattern is easily identified in Figure 1. As evident in the table, for the two BSABS deals in Vintages 3 and 4, the Figure has three variables for each deal, and the same observations are missing across the deals.

There are 7 deals with US Bank as trustee. Only the three oldest deals, which are in the first ABX vintage, have omitted variables. Of these only one deal, SAIL 2005-HE3, has omitted observations for current liquidations, which are missing until February 2008, or 26 months.

Three of the JP Morgan Acquisition Corporation (JPMAC) deals have JP Morgan as the trustee. There is no pattern for missing data. The oldest deal, JMPAC 2005-OPT1 has no missing data, except for 90-day delinquencies, but the remittance report only reports 30-, 60- and 90 plus-day categories. The deal in the second vintage has missing observations for liquidations, but the dates are sporadic and are "back loaded" toward the end of the sample. While the youngest of the deals has missing observations for current gain and loss amounts and is missing at the front end of the sample.

## III. Reporting Errors

Reporting errors are more difficult to identify without manually checking each field, but we have developed some potential diagnostic checks that will make locating some misreported fields easier. After we check each field, we compare the corrected data to the original ABSNet data. The difference between the correct data and the ABSNet data would be considered "misreporting." A positive number would indicate that ABSNet is underreporting the true balance, whereas a negative number would mean that ABSNet is over reporting the true balance. Misreporting is less of a widespread problem than omissions, but the misreporting that exists occurs often enough and is of large enough magnitude that it should be a concern to any users of this data.

Most errors seem to be a consequence of the lack of consistent or standardized definitions for many of the performance data. For example, some deals – particularly those that did not allow modifications – report current gain or loss as the loss on the principal portion of only liquidated loans, while others report it as the principal of liquidated *and modified* loans. Given the increase in modifications throughout the financial crisis, those deals that include modified loan losses may report higher current gain and loss amounts than those that only report liquidated loan losses. In order to tell what the deal is reporting, investors must refer back to the deal documents for the precise definition for each line-item and then forensically account for whether the trustee is reporting the item consistently with that definition across time. The high degree of heterogeneity within deals in regard to their structure, credit enhancements, pool characteristics, and deal definitions in conjunction with the lack of standardized reporting for collateral performance increases the probability that relevant information will not be provided to investors in the vendor format.

## IV. Reporting Errors for Individual Fields

Given the complexities of MBS and the difficulties in discerning trustee reports, ABSNet does a remarkable job of constructing the database. ABSNet attempts to clean and standardized some of the performance data. For many of the fields, such as single month mortality (SMM) and constant prepayment rate (CPR), ABSNet has a "Reported" version to denote which came from the investor reports and a "Current" version to denote the version that has been calculated by ABSNet using a formula. ABSNet provides a glossary on their website, so that users can find the definition of each variable and how some of the variables were calculated.

In constructing a database on the collateral performance of the underlying mortgages of MBS from trustee reports, it is important to accurately record the information. For researchers and investors using ABSNet, the asymmetric information problem is further exacerbated by the fact that ABSNet misreports some of the data fields. Investors and researchers use the data to make inferences, so any inaccuracies may lead to inconsistent results.

In this section, we will describe some of the major misreporting problems by data field. Again, the following sections may appear tedious and technical, but there are three important results. First, most of these misreporting problems seem to be related to specific servicers, namely GMAC-RFC and JP Morgan. Second, there are enough inaccuracies that are considerable in size that it should be of concern to any researcher utilizing the data, especially if their sample includes deals with the aforementioned trustees. Third, given the nature of some of the misreporting, we provide guidance in identifying some of the inaccuracies that does not involve doing a month-to-month comparison with trustee reports.

1. Beginning and Ending Pool Balances

There are numerous instances where ABSNet erroneously records the wrong pool balance amounts. This is a serious problem since the majority of the collateral performance measures used are as a percent of ending pool balance.[55] Many of these errors can be found by looking at the single month mortality rate, calculated as

$$SMM = \frac{(BegBal - EndBal - Sched.Principal)}{(BegBal - Sched.Principal)}$$

[55] For example, 30-day delinquent percent is the ratio of outstanding principal of loans which are 30-days delinquent to ending pool balance.

A negative number is generally a red flag that pool balances are misreported. For example, the SMM rate on March 2009 for BSABS 2006-HE10 using the ABSNet data is -114.28%. Upon further investigation, one would see that both the beginning and ending pool balances are misreported. Once corrected, SMM rate becomes 2.39%. A less extreme example is JPMAC 2006-CH2. For November 2010, the SMM rate is -0.10%, which occurs because ABSNet records the beginning pool balance as the ending pool balance, so the two are equal.

This method will also help detect the beginning of misreporting. For example, for MABS 2005-NC2, a deal with US Bank investor reporting services as trustee, ABSNet begins the sample period by recording the ending pool balance correctly. Then after October 2009, ABSNet adds REO properties to the mortgage balance, which results in an increase of approximately $40 million. The SMM was only negative for one month, but it provides a starting point for further examination of the data.

While this is a simple method of detection, it should be noted that a negative number will not always indicate misreporting. For deals with prefunding accounts, the ending balance for a period may become larger than the beginning if loans are added to the trust during the prefunding period.

Another form of ending pool balance misreporting can be found in all of the 30 deals with CTSLink investor reporting services. ABSNet records the *scheduled* pool balances as the beginning and ending balances instead of the *actual* pool balances. Generally, this underreports the balance. The three oldest ACE deals were the only ones that were partially recorded correctly in ABSNet. Both ACE 2005-HE7 and ACE 2006-NC3 were correct until May 2007 and ACE 2006-NC1 was correct until July 2009. For all other deals, the balances were wrong for the entire sample period.

2. Liquidations

Misreporting for liquidations appears to be limited to GMAC-RFC remittance reports. For the six deals included in the ABX Indexes for which GMAC-RFC was the servicer and U.S. Bank was the Trustee, liquidation numbers were wrong for most of the sample period. Misreporting occurred for all of 2006, 2007, and for part, if not for most, of 2008. One deal's liquidation data was corrected in January 2008 (RAMP 2006 NC2), and the remaining five were corrected later that same year in November 2008.

For most deals in ABSNet, liquidation amount is the outstanding principal balance of the loans liquidated in the current period. During the misreported months for the GMAC-RFC deals, this number appears, more often than not, to be calculated as the total net realized loss of principal and future interest from liquidated loans. This type of calculation grossly underreports the balance of liquidations because liquidations should be the principal amount of the loans in question, not just the net loss portion.

For example, in the December 26, 2007 report for RASC 2006-KS9, the balance of liquidated loans is $4,503,387, but the liquidation amount reported in ABSNet is $1,720,999, which is the amount of total net realized loss for the month, which includes the principal and interest portion of loss. Recording liquidations this way underreports the true balance of liquidations by $2,782,388, which is a sizeable amount.

The average monthly underreporting for current and cumulative liquidations over the sample period for the six GMAC-RFC deals are presented in panels two and three of Table II, respectively. Misreporting is defined as the true balance less the reported amount. A positive number would indicate that the true balance is larger than the reported value or in other words, ABSNet underreported the observation. Likewise, a negative number would mean that the true balance is less than the reported value, so ABSNet over reported.

[TABLE II]

Misreporting is worse for RASC shelf deals, with the exception of the youngest deal, RASC 2007 KS-2. This is to be expected because ABSNet corrected the misreporting in for this deal after October 2008, so there was misreported data for only 20 of the deal's 46-month history in the sample period whereas the older deals had considerable more. RAMP 2005 EFC-4 and RASC 2005 KS-11 had 34 of 60 months of misreported data; RAMP 2006 NC2 was the deal which was corrected the earliest, so it only had 23 of 58 months of misreported data; RASC 2006 KS-3 was misreported for 31 of 57 months; and RASC 2006 KS-9 was misreported for 24 of 50 months. In short, for deals with the highest average monthly misreporting, misreporting occurred in 48% or more of the deals history within the sample. For the two deals with the lowest average misreporting, misreporting was only experienced 43% or less of the time.

Since liquidations were misreported, cumulative liquidations were as well, which can be seen in the third panel of Table II. Notice that the two oldest deals, RAMP 2005 EFC-4 and RASC 2005 KS-11, appear to not be misreported. This is not the case, per se. Instead of ABSNet misreporting this data field, these observations are completely omitted as mentioned in the previous section. The rest of the deals show the same pattern as the liquidation data field.

The negative values in the minimum field come from the months where there are none or minimal subsequent recoveries on liquidated loans, so that total net realized loss includes most, if not all of the principal amount. In which case the majority of the misreporting comes from the future interest loss portion of those loans. To illustrate this, Figure 2 is an excerpt from the Loss and Recovery Statement in the August 2006 report for RAMP 2006 NC2. This is the first month for which this deal recorded a liquidation. The only liquidation is a charged-off of 9 loans of which all of the principal balances were classified as losses plus future interest. For this month ABSNet recorded the cumulative liquidation amount as the total realized loss of $669,964.46, which includes the principal and interest portion of the loss. The actual liquidation amount should only be the principal balance of the charged-off loan, which is $631,957.15. The difference between the actual and the misreported cumulative liquidation is $38,007.31 (i.e. the interest portion of loss), which is the minimum amount found in Table II.

**Figure 2: August 2006 Loss and Recovery Statement for RAMP 2006 NC2**

GMAC RFC

Statement to Certificateholder

Residential Asset Mtge Products, 2006-NC2
August 25, 2006

| | | | | | | |
|---|---|---|---|---|---|---|
| Deal Totals: | Loss Count | 0 | 9 | 0 | 0 | 9 |
| | Beginning Aggregate Scheduled Balance | 0.00 | 631,957.15 | 0.00 | 0.00 | 631,957.15 |
| | Principal Portion of Loss | 0.00 | 631,957.15 | 0.00 | 0.00 | 631,957.15 |
| | Interest Portion of Loss | 0.00 | 38,007.31 | 0.00 | 0.00 | 38,007.31 |
| | Total Realized Loss | 0.00 | 669,964.46 | 0.00 | 0.00 | 669,964.46 |

A red flag for this type of misreporting can be found in the loss severities. Current loss severity is calculated as the ratio of current gain or loss to current liquidation, while the cumulative loss severity is cumulative realized losses to cumulative liquidations.[56] Severities indicate how much loss is recorded

[56] $Current\ loss\ severity = \frac{Current\ gain/loss}{current\ liquidation}$ and $Cumulative\ loss\ severity = \frac{Cumulative\ net\ realized\ loss}{Cumulative\ liquidations}$

per liquidated dollar. When the liquidation field is reporting the realized losses, the severities will be in the 80-100% range.

**Figure 3: Current-Loss Severity Graph for RASC 2006 KS-9**

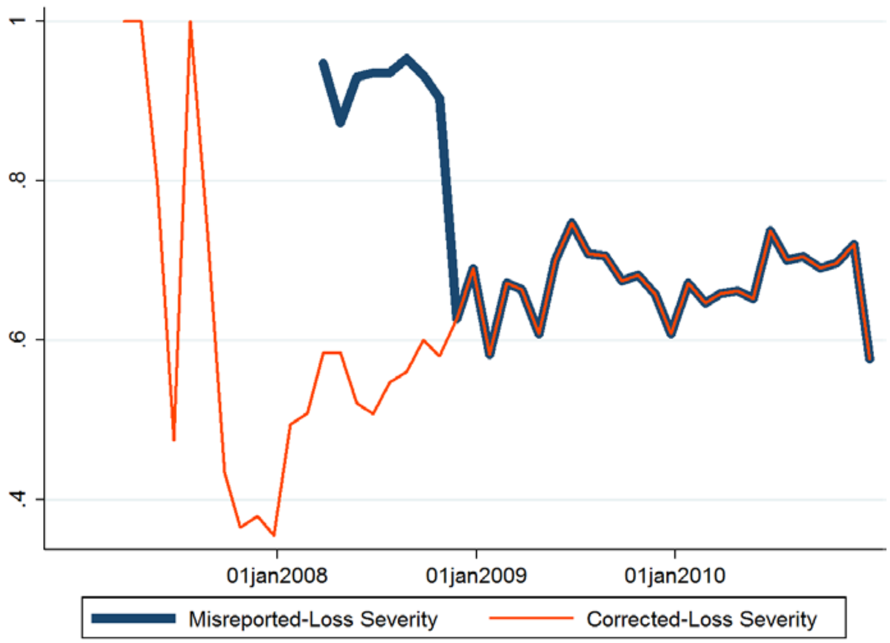



Figure 3 graphs the misreported and corrected loss severities for the RASC 2006 KS-9 deal, which is in the third ABX vintage. If there is misreporting, depicted as the blue line, then current loss severities will be within the 80-95% range. When liquidations are recorded correctly, the current loss severity, represented by the red line, drops to the 40-70% range after the first few months. Current gain or loss amounts are omitted until March 2008 for the data taken directly from ABSNet, which is why the misreported loss severity does not exist until midway through the graph. Despite this omission, it is easy to see that the misreported loss severity is well above its corrected counterpart.

3. Cumulative Realized Losses

According to the glossary, ABSNet reports the cumulative realized loss amount per month as the net loss, which adjusts for any subsequent losses or recoveries. MBS investors are concerned with net losses, rather than gross losses, because any additional recoveries or losses will affect the cash flow waterfall, which may adversely impact junior tranche holders more than senior.

Even though ABSNet states it reports the net loss, there are many instances where does not. This, again, seems to be dependent the trustee investor reporting service. For the deals in this sample, there are two ways losses are reported in the remittance reports. They can be reported either as simply net realized losses, or in two line items: gross realized losses and subsequent recoveries/losses. In the latter case, one can take the difference of the two line items to calculated net realized losses.

Misreporting in ABSNet typically occurs when the net realized loss is not a single line item in the remittance report, but instead split into two parts: gross losses and subsequent recoveries/losses. For example, all Deutsche Bank investor reports have separate line items for "cumulative realized losses" and cumulative subsequent recoveries.[57] ABSNet reports the cumulative realized loss, which are from the reports and are gross, without adjusting for the subsequent recoveries and losses.

The simple adjustment for this would be to take the cumulative realized loss reported in ABSNet and subtract cumulative recoveries, which is also a data field in ABSNet. The main problem with this is that ABSNet does not consistently report the recoveries, making this an unreliable approach. The only remaining option is to manually record the current and cumulative recoveries, however, another problem arises.

For many of the older deals that use Deutsche Bank trustee reporting services, subsequent recoveries cannot be found in the remittance report until 2007, typically some time during the second half.[58] In the month they first appear, there are two line items, current and cumulative recoveries. These are never the equal, indicating that there were prior recoveries that were not reported in the previous months. Then there are instances when recoveries are never reported.[59]

For deals with LaSalle Bank/ Bank of America reports, cumulative realized losses are reported as gross in ABSNet, but the remittance reports consistently report all subsequent recoveries, so calculating net losses is possible, although the process may be time consuming. Deals with CTSlink, Citigroup, BNY Mellon and US Bank reporting services are reported on a net basis consistently.

57 The subsequent recoveries are on a net basis. That is, subsequent recoveries less any subsequent additional losses.
58 For example, for DB deals in the first ABX vintage, recoveries show up for ARSI 2005-W2, GSAMP 2005-HE4, and LBMLT 2005-WL2 in the November 2007 report, and for NCHET 2005-4 and SVHE 2005-4 in the July 2007 and June 2008 reports.
59 JPMAC 2007-CH3 and MLMI 2007 MLN1, both of which are in the fourth ABX vintage

ABSNet is inconsistent in how the JP Morgan deals are recorded. Instead of constantly reporting on a gross or net basis, ABSNet switches back and forth between the two. For example, in July 2008 for the JPMAC 2006 CH-2 deal, ABSNet reports cumulative loss as the gross loss, and the very next month reports it as the net loss. Compared to the opposite method, July is over reported by $35,225, and August is underreported by $45,781. The randomly occurs throughout the history of these deals.

For the GMAC-RFC deals, there is not a single methodology that ABSNet appears to use. Instead it seems to be an ad hoc calculation of different items. GMAC-RFC investor reports break down realized losses by types: liquidations, charge-offs, servicing modifications and bankruptcies. For at least part of the sample period, it appears that for some of the GMAC-RFC deals, losses may be calculated as simply liquidations and charge-offs, while for other deals, modifications are included. There is no systematic approach for deciphering how ABSNet records cumulative realized losses or when they change to the appropriate method without comparing the ABSNet data directly with the investor reports on a month by month basis.

The fourth panel in Table II presents the summary statistics for the misreporting in cumulative realized loss amount. As is evident by this table, there is no discernable pattern for how ABSNet reports this line item. For example, RAMP 2005 EFC-4 shows that there is an average underreporting of $173,329, whereas RASC 2006 KS-3 shows an average over reporting of $253,737. It should be noted that for the youngest two GMAC-RFC deals, RASC 2006 KS-9 and RASC 2007 KS-2, there are 8 and 7 months of cumulative realized loss data missing, respectively.

## V. Collateral Performance Consistency as a Data Screen

One way of isolating reporting errors is to cross-tabulate consistency across reported data fields. As an example, we examine seven collateral performance measures: SMM, percentages of 30-day, 60-day, and 90 plus-day delinquencies, foreclosed, real estate owned (REO) loans, and loss rates. SMM is measured as described above in the misreporting section. The delinquencies, foreclosures, and REO measures are calculated as a ratio to ending pool balance, and loss rate is the ratio of net cumulative realized loss to the original pool balance.

Here we measure the collateral performance variables as changes. For example, 30-day delinquent rate is calculated as the ratio of the balance of loans that are classified as 30-days delinquent to the ending pool balance of the deal. As a result, the 30-day delinquent variable in our analysis will be the change in that ratio or rate. Table III reports the summary statistics of the collateral performance measures in levels (or rates) associated with the 20 deals in each of the ABX vintages. The first set of statistics are for the corrected data and the next set is the data directly from ABSNet.

The differences in the number of observations between datasets is a direct result of the omitted observations found in the ABSNet database. The majority of omissions are related to the cumulative realized losses. For the first vintage, there are 364 missing months or approximately 30% of the observations across the 20 deals over the 5-year sample period.[60] For the second, third, and fourth vintages, the number is considerably less at 191, 292, and 133 months, respectively.

The impact of incorrect beginning and ending pool balances shows up in the SMM summary statistics. The second vintage (ABX 2006-2) is the only one that did not have significant problems with pool balances. For this vintage, the sample variances are equal and there are no differences in means. Further, the samples have similar kurtosis and skewness. The other three vintages tell a dramatically different story. The large negative numbers in the minimum column for the ABSNet change the shape of the distribution in that it is skewed negatively and has a large kurtosis. Although, both dataset have kurtosis greater than 3, which means higher peaks and thinner tails than a normal distribution, the ABSNet data has significantly larger kurtosis. Higher peaks and thinner tails means that most of the observations are clustered around the mean and there is not a lot of variation between observations.

The last three columns in Table III present the results from a differences-in-means test between the datasets. None of the variances of the SMM are equal at the 5% significance level for the three vintages with rampant misreporting in the pool balances, which should have been expected based on how the misreported balances changed the shape of the distribution based on kurtosis and skewness measures. But despite this, the means between databases are insignificantly different.

[TABLE III]

[60] There are 1,200 months of observations, which is 60 months for each of the 20 deals.

The third vintage, ABX 2007-1, has the most differences between datasets. The sample means for the 30, 60, and 90 plus-day delinquency, foreclosure and loss rates are all statistically different at the 10% level. Further, the magnitude of the difference is quite substantial. For the delinquencies and foreclosure rates, the means are lower for the corrected data, with the largest decrease coming from the 90-day plus bucket and the foreclosures. However, the loss rate is 78 basis points larger for the corrected sample.

The only other variable that is statistically different across sets is the loss rate for the second vintage, ABX 2006-2. It is 56 basis points larger in the corrected data than in the ABSNet data. These increases in loss rates can be attributed to two reasons. First, this variable is the one with the most omitted observations. When ABSNet reports fails to report current gain or loss at any time then as a byproduct the cumulative realized losses are missing for any period following. By looking at Figure 1, it obvious that for many of the CTSLink, DB, and GMAC deals, the front end of the sample period has numerous missing observations until February 2008. This means, that cumulative realized losses will be missing for the entire sample period. For the two BSABS deals with LaSalle/Bank of America reporting in the second and third vintages, current gain or loss is missing at the back end of the sample period.

The second reason the loss rate is higher in the corrected data may have to do with the fact that ABSNet reports some cumulative losses on a net basis and other on a gross basis. When losses are on a net basis, subsequent recoveries and subsequent losses are taken into account. If a loan experiences a subsequent recovery, then the realized loss will decrease for the period. If any additional losses are incurred, then realized losses will decrease. Deals with mortgages that were originated in late 2006 and early 2007 experienced more subsequent losses than recoveries, contributing to cumulative realized losses.

## VI. The Importance of Reporting to Deal Performance – Distance-to-Delinquency Trigger Example

To give an idea of why all this matters, we provide the details of the methodology used in constructing the distance-to- delinquency trigger measure.

**Figure 4: Distance to Delinquency Trigger across ABX Vintages**

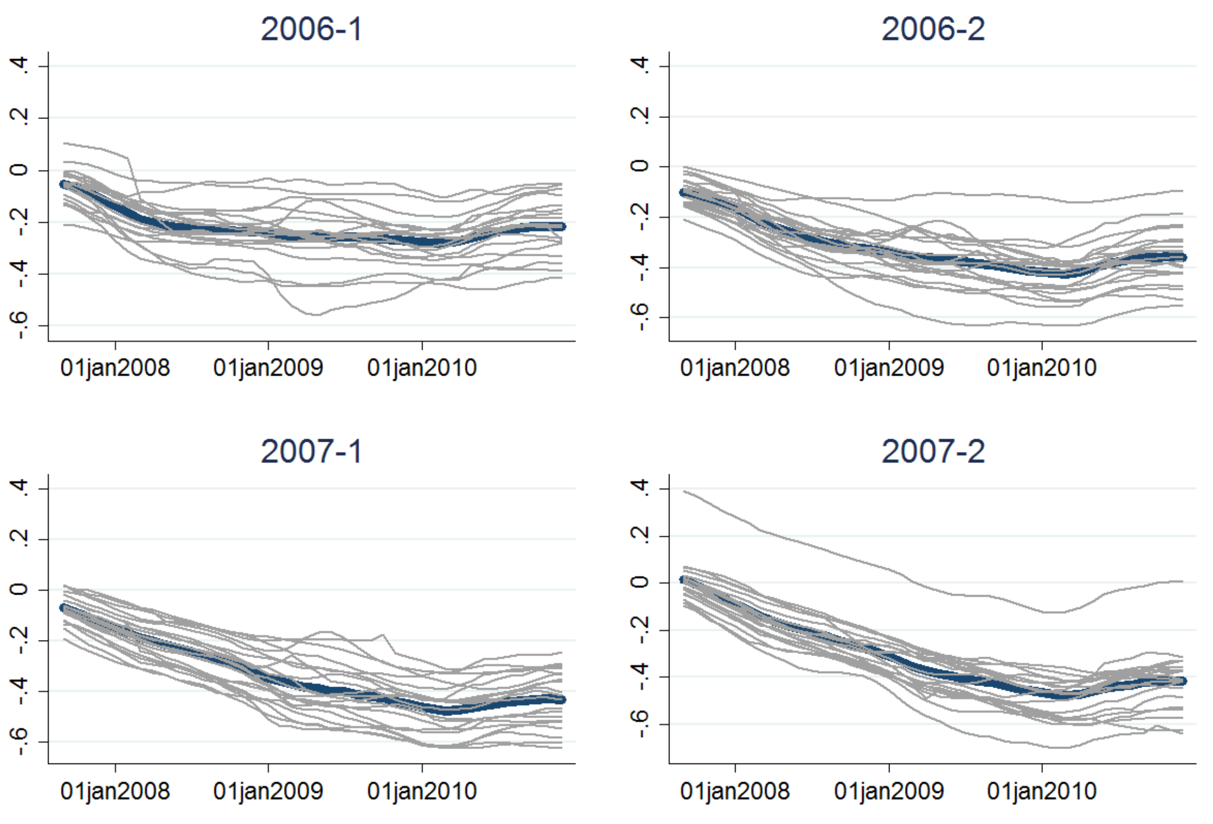



Figure 4 graphs changes in the delinquency trigger measure across vintages. This variable may indicate changes in delinquency and foreclosure management. During the financial crisis, foreclosure moratoria in several large states postponed the reclassification of delinquencies into other categories such as foreclosure (Keys, et al. 2012). For the first vintage, distance-to-delinquency remains fairly flat and stable across all deals, suggesting predictable delinquency management. However, for the other vintages, there is a downward trend that gets steeper with each successive vintage, indicating that liquidation and foreclosure were being postponed, swelling the proportion of 60+ day delinquent loans.

The distance-to-delinquency trigger variable is calculated as the difference between a threshold value and the actual percent of delinquencies; this is represented by Equation (1). We examined each deal's prospectus, supplement, and pooling and servicing agreement (PSA) and collected the percentages and percent schedules for thresholds, depending on the type of threshold, documenting the definition for the credit enhancement percent if it applied to a deal's trigger definition.[61] We used these definitions to construct a threshold percent for each deal $i$ and each month $t$ to give us $Threshold_{i,t}$ and percent of delinquent loans for each deal $i$ and each month $t$ to give us $DQ\ Percent_{i,t}$

$$\text{Distance-to-}DQ\,Trigger_{i,t} = \left(Threshold_{i,t} - DQ\ Percent_{i,t}\right) \tag{1}$$

We identified 8 different definitions on how a loan is classified as 60 plus day DQ based on the wording and grammatical usage in the pooling and servicing agreements (PSA). These are listed in Table IV and are all different combinations of loans that have payments which are late by 2 months or more, in foreclosure (FCL), in bankruptcy (BK), or real-estate owned (REO). Only definition 6 includes loan modifications.

[TABLE IV]

Consistent across all deals was that the delinquency trigger is based on the balance of 60 plus day DQ loans, but one problem encountered when developing this measure is in how the remittance reports report delinquency data. While it is convenient to think of 30, 60, 90+ day delinquencies, REO, foreclosures, and bankrupt loans as 6 separate buckets, they are not actually classified this way. This is why in Table IV some definitions will have a type of loan in parenthesis to distinguish that these must also be 60-days or more delinquent. For example, in definition 3, bankrupt loans are in parenthesis, indicating that these types of loans will only be included in the delinquency percentage if they are also classified as 60-days or more delinquent. A loan that is in bankruptcy that is classified as 30-days delinquent would not be included.

Some remittance reports will stratify all of the loans into well-defined groups while others provide minimum information about the loans and their classification.[62] To overcome the data challenge with loan classification, we used loan level data available from ABSNet to calculate the 60+ day delinquency balances based on the definition of each deal. Two deals were not contained within

[61] It may be important to note that some deals referred to this percent by various names, such as senior enhancement percent or required percent.

[62] For example, reports via CTSLink Wells Fargo are generally consistent in breaking down the groups into all possible subcategories.

ABSNet (CBASS 2006-CB6 and MABS 2005-NC2). Three deals (FFMER 2007-2, FFML 2007-FF1, and WMHE 2007-HE2), all of which are components of the fourth ABX vintage, had no account balances for loans during the sample period. For all of the deals with loan level omissions, we used deal level remittance report data to calculate the 60-day plus balances, which we choose as definition 5, regardless of method set forth in the prospectus because of the lack of granularity of the deal level data.[63]

For any deal that has data from ABSNet, but is missing observations for a few months, we replaced the missing observations with the deal level Distribution Report data and used definition 5. The majority of these missing months come within the first year of a deal, so the chosen definition should not overestimate the balance of 60+ day delinquencies by a large magnitude because these are the months when foreclosures and real estate owned properties as a total of the overall deal will be the lowest.

The majority of deals follow the first three definitions. 37 deals use Definition 1; 10 deals use Definition 2; and 16 deals use Definition 16. Definition 1 is the total of loans that are just 60-days or more behind, which includes loans that are also either FCL, BK, or REO. This means loans that may be classified as FCL, BK, or REO, but not 60-days or more DQ, will not be included. Whereas, Definition 2 will include FCL, BK, and REO regardless of their DQ status. Comparatively speaking, deals using Definition 2 compared to Definition 1 will have a higher balance of 60 plus day DQ loans. Definition 3 consists of loans that are 60 plus day DQ, BK loans which are also classified as 60 plus day DQ, and all FCL and REO loans regardless of DQ status.

Of the remaining definitions: 3 deals use definition 4; 4 deals use definition 5; 2 deals use definition 6; 5 deals use definition 7; and 3 deals use definition 8. Definition 4 includes loans just classified as 60 plus day DQ as well as FCL and REO loans which are also classified as 60 plus day DQ, but excludes all BK loans.

Definition 5 includes 60 plus day DQ loans and all FCL and REO loans, regardless of DQ classification, but excludes all BK loans. Definition 5 includes loans which are solely classified as 60

[63] Definition 5 is the balance of 60+ day delinquencies, all foreclosure, and all real estate owned properties. This definition excludes bankruptcies.

plus day DQ as well as those that are classified as 60 plus day DQ and also in one of the following categories: REO, BK, FCL, and modifications that have occurred within the last 12 months. Definition 7 includes loans that are 60 plus day DQ only, those which are both 60 plus day DQ and in foreclosure, all loans in bankruptcy, and all REO loans. Definition 8 includes all loans which are classified as 60 plus day DQ, classified as both 60 plus day DQ and FCL, classified as both 60 plus day DQ and BK, and all REO loans.

We also found differences in the calculation of the ratio of delinquent loans to beginning pool balance across deals. There were 4 distinct methods, which are listed in Table IV. The first is the most straightforward and is used by 31 deals. It is simply the ratio of the DQ principal balance to beginning pool balance. The 2nd method takes the rolling three month average of the DQ principal balance and divides by the beginning pool balance and is used by 21 deals. The 3rd definition takes the rolling three month average of the simple ratio of DQ principal balance to beginning pool balance and is used by 27 deals. The 4th method is unique in that it is a combination of actual balances and average balance. It takes the rolling three month average of DQ principal and then adds the actual balances of FCL, REO, and BK balances. Only one deal uses this method (CARR 2006-NC1).

The second part of the delinquency trigger is the threshold, which is typically calculated as the product of a specified percentage set forth in the deal documents and a credit enhancement percentage. Across deals, we found 4 enhancement percentage calculation methods. These are listed in Table IV in the last panel.

Method 1 takes the ratio of subordinate certificates[64] to the ending pool balance. 17 deals use this method. Method 2 takes the ratio of all certificates with a lower distribution priority to the certificate currently receiving payments to the ending pool balance. This is the least common method as only 5 deals use it. Method 3 looks at the difference between the ending pool balance and class A certificates and divides by the ending pool balance and is used by 10 deals. Lastly, method 4 is a variation of method 1 and is the most commonly used method. More than half of the deals in the

[64] We documented the definition of subordinated certificates for all deals that defined them to ensure accuracy and consistency. These certificates were generally defined as class M tranches in the deal documents. However, there were some deals that specified both class M and class B certificates as the subordinate tranches.

sample use it (48 out of 80). It looks at the ratio of subordinate certificates plus the overcollateralization amount to ending pool balance.

## VII. Summary and Conclusions

The point of the above is that definitions of the different deal triggers and the performance data that goes into them is complex. In taking RMBS data "off the shelf" from vendor products, researchers, therefore, risk errors and biases as well as potential inaccuracies (for purposes of their study) that may lead to erroneous conclusions. We should not, therefore, take conclusions about RMBS performance at face value without a thorough understanding of the data inputs and the study objectives, merging those appropriately with the accounting principles at use in the trusts being studied.

## REFERENCES

Imerman, Michael B., Joseph R. Mason, and Hong Lee, 2013, Self-reporting under SEC Reg AB and transparency in securitization: evidence from loan-level disclosure of risk factors in RMBS deals. *The Journal of Risk Finance,* 15(4) 334-384.

Keys, Benjamin J., Amit Seru, and Vikrant Vig, 2012, Lender screening and the role of securitization: evidence from prime and subprime mortgage markets. *Review of Financial Studies*, 25, 2071–2108.

Table I: List of BloombergNames and Shelf Registrations for ABX deals by vintage

| *Vintage 1* | | | *Vintage 2* | | | *Vintage 3* | | | *Vintage 4* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **BloombergName** | **Shelf** | **Months** | **BloombergName** | **Shelf** | **Months** | **BloombergName** | **Shelf** | **Months** | **BloombergName** | **Shelf** | **Months** |
| ACE 2005-HE7 | ACE | 60 | ACE 2006-NC1 | ACE | 59 | ABFC 2006-OPT2 | ABFC | 51 | ACE 2007-HE4 | ACE | 44 |
| AMSI 2005-R11 | AMSI | 60 | ARSI 2006-W1 | ARSI | 59 | ACE 2006-NC3 | ACE | 49 | BSABS 2007-HE3 | BSABS | 45 |
| ARSI 2005-W2 | ARSI | 60 | BSABS 2006-HE3 | BSABS | 57 | BSABS 2006-HE10 | BSABS | 48 | CMLTI 2007-AMC2 | CMLTI | 45 |
| BSABS 2005-HE11 | BSABS | 60 | CARR 2006-NC1 | CARR | 58 | CARR 2006-NC4 | CARR | 51 | CWL 2007-1 | CWL | 47 |
| CWL 2005-BC5 | CWL | 60 | CWL 2006-8 | CWL | 54 | CBASS 2006-CB6 | CBASS | 53 | FFMER 2007-2 | FFMER | 44 |
| FFML 2005-FF12 | FFML | 60 | FFML 2006-FF4 | FFML | 57 | CMLTI 2006-WFH3 | CMLTI | 50 | FFML 2007-FF1 | FFML | 47 |
| GSAMP 2005-HE4 | GSAMP | 60 | GSAMP 2006-HE3 | GSAMP | 55 | CWL 2006-18 | CWL | 51 | GSAMP 2007-NC1 | GSAMP | 46 |
| HEAT 2005-8 | HEAT | 60 | HEAT 2006-4 | HEAT | 56 | FFML 2006-FF13 | FFML | 51 | HASC 2007-NC1 | HASC | 43 |
| JPMAC 2005-OPT1 | JPMAC | 60 | JPMAC 2006-FRE1 | JPMAC | 59 | FHLT 2006-3 | FHLT | 51 | HEAT 2007-2 | HEAT | 45 |
| LBMLT 2005-WL2 | LBMLT | 60 | LBMLT 2006-1 | LBMLT | 58 | GSAMP 2006-HE5 | GSAMP | 52 | JPMAC 2007-CH3 | JPMAC | 44 |
| MABS 2005-NC2 | MABS | 60 | MABS 2006-NC1 | MABS | 58 | HEAT 2006-7 | HEAT | 51 | MLMI 2007-MLN1 | MLMI | 44 |
| MLMI 2005-AR1 | MLMI | 60 | MLMI 2006-HE1 | MLMI | 59 | JPMAC 2006-CH2 | JPMAC | 49 | MSAC 2007-NC3 | MSAC | 43 |
| MSAC 2005-HE5 | MSAC | 60 | MSAC 2006-HE2 | MSAC1 | 55 | LBMLT 2006-6 | LBMLT | 53 | NHEL 2007-2 | NHEL | 43 |
| NCHET 2005-4 | NCHET | 60 | MSAC 2006-WMC2 | MSAC2 | 54 | MABS 2006-NC3 | MABS | 48 | NHELI 2007-2 | NHELI | 47 |
| RAMP 2005-EFC4 | RAMP | 60 | RAMP 2006-NC2 | RAMP | 58 | MLMI 2006-HE5 | MLMI | 51 | OOMLT 2007-5 | OOMLT | 44 |
| RASC 2005-KS11 | RASC | 60 | RASC 2006-KS3 | RASC | 57 | MSAC 2006-HE6 | MSAC | 51 | RASC 2007-KS2 | RASC | 46 |
| SABR 2005-HE1 | SABR | 60 | SABR 2006-OP1 | SABR | 59 | RASC 2006-KS9 | RASC | 50 | SABR 2007-BR4 | SABR | 43 |
| SAIL 2005-HE3 | SAIL | 60 | SAIL 2006-4 | SAIL | 54 | SABR 2006-HE2 | SABR | 51 | SASC 2007-BC1 | SASC | 47 |
| SASC 2005-WF4 | SASC | 60 | SASC 2006-WF2 | SASC | 54 | SASC 2006-BC4 | SASC | 49 | SVHE 2007-OPT1 | SVHE | 44 |
| SVHE 2005-4 | SVHE | 60 | SVHE 2006-OPT5 | SVHE | 54 | SVHE 2006-EQ1 | SVHE | 51 | WMHE 2007-HE2 | WMHE | 44 |

This table is a list of the BloombergNames and Shelf registration of the 80 ABX deals by vintage. Month refers to the number of months of data available during the sample period from January 2006-December 2010. The first vintage was launch in January 2006, so it will be the only one which contains deals which have data for the entire sample period. With each index roll, the history of the underlying deals will become shorter.

Table II: Summary Statistics for GMAC-RFC Deal Misreporting

**90 Day DQ**

| Deal Name | Vintage | N | Mean | STD | Min | Max |
|---|---|---|---|---|---|---|
| RAMP 2005 EFC-4 | 1 | 60 | 698,037.45 | 1,404,760.49 | 0.00 | 5,202,978.18 |
| RASC 2005 KS-11 | 1 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| RAMP 2006 NC2 | 2 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| RASC 2006 KS-3 | 2 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| RASC 2006 KS-9 | 3 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| RASC 2007 KS-2 | 4 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |

**Liquidations**

| Deal Name | Vintage | N | Mean | STD | Min | Max |
|---|---|---|---|---|---|---|
| RAMP 2005 EFC-4 | 1 | 58 | 905,556.50 | 2,346,426.38 | -102,673.42 | 16,893,890.83 |
| RASC 2005 KS-11 | 1 | 58 | 1,125,675.43 | 1,599,398.98 | -8,915.57 | 5,792,120.18 |
| RAMP 2006 NC2 | 2 | 58 | 260,266.29 | 640,444.83 | -155,101.12 | 3,253,870.29 |
| RASC 2006 KS-3 | 2 | 57 | 1,047,964.63 | 1,582,847.95 | -113,042.03 | 5,447,329.61 |
| RASC 2006 KS-9 | 3 | 50 | 1,196,980.64 | 2,130,549.90 | -27,769.13 | 8,027,414.93 |
| RASC 2007 KS-2 | 4 | 46 | 643,420.31 | 1,276,847.11 | 0.00 | 4,647,168.28 |

**Cumulative Liquidations**

| Deal Name | Vintage | N | Mean | STD | Min | Max |
|---|---|---|---|---|---|---|
| RAMP 2005 EFC-4* | 1 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| RASC 2005 KS-11* | 1 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| RAMP 2006 NC2 | 2 | 58 | 11,023,834.34 | 6,267,915.25 | -38,007.31 | 15,250,546.03 |
| RASC 2006 KS-3 | 2 | 57 | 36,588,341.21 | 25,467,690.95 | 0.00 | 59,733,983.88 |
| RASC 2006 KS-9 | 3 | 50 | 38,825,727.50 | 25,907,124.07 | -20,765.02 | 59,849,031.91 |
| RASC 2007 KS-2 | 4 | 46 | 19,972,185.33 | 12,573,258.25 | 0.00 | 29,597,334.57 |

**Cumulative Realized Loss**

| Deal Name | Vintage | N | Mean | STD | Min | Max |
|---|---|---|---|---|---|---|
| RAMP 2005 EFC-4 | 1 | 58 | 173,329.19 | 255,592.50 | -267,300.46 | 1,068,083.20 |
| RASC 2005 KS-11 | 1 | 58 | 8,397.75 | 63,984.61 | -218.92 | 487,288.35 |
| RAMP 2006 NC2 | 2 | 58 | 0.00 | 0.00 | 0.00 | 0.00 |
| RASC 2006 KS-3 | 2 | 57 | -253,737.20 | 414,034.35 | -1,103,169.63 | 264.42 |
| RASC 2006 KS-9 | 3 | 42 | 43,168.05 | 279,760.97 | 0.00 | 1,813,058.31 |
| RASC 2007 KS-2 | 4 | 39 | 0.00 | 0.00 | 0.00 | 0.00 |

This table presents the summary statistics for the misreporting found in the GMAC-RFC deals by data field. The deals in the first vintage have the largest number of observations. Then with each vintage roll, the number of potential observations decreases as the newer deals included in each subsequent vintage are issued and reporting begins. Misreporting is calculated as the number in the remittance report less the amount recorded in ABSNet. A positive number would indicate that ABSNet is underreporting the true balance, whereas a negative number would mean that ABSNet is overreporting. *Indicates that there is no misreporting for the deal because the field contains omitted variables for the sample period.

Table III: Summary Statistics and Difference-in-Means Test Results

| ABX 2006-1 | *Remittance Report Data* | | | | | *ABSNet Data* | | | | | *DIM Results* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **Mean** | **Std** | **Min.** | **Max** | **N** | **Mean** | **Std** | **Min.** | **Max** | **DIM** | **p_value** | **EOV** |
| SMM | 1200 | 2.34 | 1.41 | -10.87 | 11.93 | 1134 | 2.31 | 2.06 | -45.09 | 11.93 | 0.03 | 0.73 | No |
| 30 Day DQ (%) | 1200 | 4.43 | 1.57 | 0.00 | 9.94 | 1200 | 4.43 | 1.56 | 0.00 | 9.94 | 0.01 | 0.93 | Yes |
| 60 Day DQ (%) | 1200 | 2.47 | 1.20 | 0.00 | 7.33 | 1200 | 2.47 | 1.20 | 0.00 | 7.33 | 0.00 | 0.96 | Yes |
| 90 Plus Day DQ (%) | 1200 | 6.85 | 7.13 | 0.00 | 37.80 | 1146 | 7.10 | 7.18 | 0.00 | 37.80 | -0.25 | 0.41 | Yes |
| Foreclosed (%) | 1200 | 11.90 | 7.83 | 0.00 | 42.65 | 1200 | 11.88 | 7.83 | 0.00 | 43.06 | 0.02 | 0.99 | Yes |
| Loss Rate | 1200 | 5.07 | 5.44 | 0.00 | 21.01 | 836 | 5.22 | 5.58 | 0.00 | 20.05 | -0.16 | 0.53 | Yes |
| REO (%) | 1200 | 5.13 | 4.61 | 0.00 | 27.33 | 1200 | 5.11 | 4.58 | 0.00 | 27.33 | 0.01 | 0.83 | Yes |

| ABX 2006-2 | *Remittance Report Data* | | | | | *ABSNet Data* | | | | | *DIM Results* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **Mean** | **Std** | **Min.** | **Max** | **N** | **Mean** | **Std** | **Min.** | **Max** | **DIM** | **p_value** | **EOV** |
| SMM | 1080 | 2.09 | 0.96 | -2.49 | 9.39 | 1079 | 2.09 | 0.94 | 0.00 | 9.39 | 0.00 | 1.00 | Yes |
| 30 Day DQ (%) | 1080 | 4.74 | 1.32 | 0.02 | 11.59 | 1080 | 4.76 | 1.33 | 0.02 | 11.59 | -0.01 | 0.82 | Yes |
| 60 Day DQ (%) | 1080 | 2.77 | 1.07 | 0.00 | 8.52 | 1080 | 2.78 | 1.07 | 0.00 | 8.52 | 0.00 | 0.96 | Yes |
| 90 Plus Day DQ (%) | 1080 | 7.71 | 7.52 | 0.00 | 38.14 | 1080 | 7.65 | 7.50 | 0.00 | 38.14 | 0.05 | 0.87 | Yes |
| Foreclosed (%) | 1080 | 14.46 | 8.04 | 0.00 | 37.14 | 1080 | 14.42 | 8.05 | 0.00 | 37.14 | 0.04 | 0.92 | Yes |
| Loss Rate | 1080 | 7.32 | 7.47 | 0.00 | 69.16 | 889 | 6.76 | 6.82 | 0.00 | 23.08 | 0.56 | 0.08 | No |
| REO (%) | 1080 | 6.16 | 4.83 | 0.00 | 24.55 | 1080 | 6.07 | 4.71 | 0.00 | 24.21 | 0.09 | 0.67 | Yes |

| ABX 2007-1 | *Remittance Report Data* | | | | | *ABSNet Data* | | | | | *DIM Results* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **Mean** | **Std** | **Min.** | **Max** | **N** | **Mean** | **Std** | **Min.** | **Max** | **DIM** | **p_value** | **EOV** |
| SMM | 960 | 1.71 | 0.81 | -2.49 | 7.32 | 956 | 1.53 | 4.21 | -114.28 | 54.91 | 0.17 | 0.21 | No |
| 30 Day DQ (%) | 960 | 4.82 | 1.65 | 0.02 | 12.78 | 959 | 5.09 | 1.39 | 0.71 | 18.69 | -0.28 | <0.01 | No |
| 60 Day DQ (%) | 960 | 3.04 | 1.28 | 0.00 | 8.79 | 959 | 3.20 | 1.21 | 0.00 | 14.47 | -0.16 | <0.01 | No |
| 90 Plus Day DQ (%) | 960 | 10.50 | 10.15 | 0.00 | 50.06 | 959 | 11.38 | 10.66 | 0.00 | 50.06 | -0.88 | 0.07 | Yes |
| Foreclosed (%) | 960 | 13.75 | 7.48 | 0.00 | 32.82 | 959 | 14.64 | 7.06 | 0.00 | 32.82 | -0.88 | <0.01 | No |
| Loss Rate | 912 | 8.73 | 8.59 | 0.00 | 36.38 | 668 | 7.73 | 8.07 | 0.00 | 34.97 | 1.00 | 0.02 | No |
| REO (%) | 960 | 5.36 | 4.07 | 0.00 | 22.37 | 959 | 5.41 | 4.02 | 0.00 | 22.46 | -0.05 | 0.80 | Yes |

| ABX 2007-2 | *Remittance Report Data* | | | | | *ABSNet Data* | | | | | *DIM Results* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **Mean** | **Std** | **Min.** | **Max** | **N** | **Mean** | **Std** | **Min.** | **Max** | **DIM** | **p_value** | **EOV** |
| SMM | 840 | 1.45 | 0.74 | -0.01 | 6.86 | 838 | 1.43 | 0.99 | -18.21 | 4.51 | 0.02 | 0.61 | No |
| 30 Day DQ (%) | 840 | 5.47 | 1.30 | 1.41 | 10.74 | 840 | 5.47 | 1.30 | 1.41 | 10.56 | 0.00 | 0.94 | Yes |
| 60 Day DQ (%) | 840 | 3.36 | 1.03 | 0.23 | 7.26 | 840 | 3.36 | 1.03 | 0.23 | 7.26 | 0.00 | 0.95 | Yes |
| 90 Plus Day DQ (%) | 840 | 10.72 | 9.05 | 0.01 | 44.20 | 840 | 10.73 | 9.06 | 0.01 | 44.20 | 0.00 | 0.98 | Yes |
| Foreclosed (%) | 840 | 15.58 | 7.13 | 0.00 | 34.22 | 840 | 15.60 | 7.15 | 0.00 | 34.31 | -0.02 | 0.96 | Yes |
| Loss Rate | 840 | 9.54 | 8.71 | 0.00 | 38.67 | 707 | 9.58 | 8.79 | 0.00 | 38.67 | -0.04 | 0.92 | Yes |
| REO (%) | 840 | 5.05 | 3.81 | 0.00 | 22.74 | 840 | 5.05 | 3.82 | 0.00 | 22.82 | 0.00 | 0.97 | Yes |

Each panel reports the summary statistics for the remittance report data and the data directly from ABSNet for each of the four ABX vintages. The last three columns present the results from a difference-in-means (DIM) test. The equality of variance (EOV) column reports whether the variances are statistically the same based on the results of a folded F-test. "Yes" indicates that the sample variances are not significantly different at the 5% level, while a "No" indicates that the sample variances are significantly different. For the DIM p-values, if the sample variances are statistically different, the p-values are from a pooled t-test; otherwise an unpooled t-test is used.

Table IV: Definitions Used in the Construction of Distance to Trigger Variables

***60 Plus Day Delinquent Definition***

| Def. # | Definition |
|---|---|
| 1 | DQ 60+ (inc. REO, BK, FCL) |
| 2 | DQ 60+, + FCL + REO, + BK |
| 3 | DQ 60+ (inc. BK ) + FCL + REO |
| 4 | DQ 60+ (inc. FCL, REO) (NO BK) |
| 5 | DQ 60+, + FCL + REO (NO BK) |
| 6 | DQ 60+ (inc. REO, BK, FCL, mods w/n 12 months) |
| 7 | DQ 60+ (inc. FCL), +BK, +REO |
| 8 | DQ 60+ (inc. FCL, BK), +REO |

***DQ Ratio Method***

| Def. # | Definition |
|---|---|
| 1 | Ratio |
| 2 | Rolling Balance |
| 3 | Rolling Rate |
| 4 | Average Bal of DQ, Actual Bal of FCL, REO, BK |

***DQ Credit Enhancement Percent Calculation Method***

| Def. # | Definition |
|---|---|
| 1 | Subcerts/Endpool Bal |
| 2 | lower distribution priority certs/end poolbal |
| 3 | (End Pool Bal-Class A)/End poolbal |
| 4 | (subcerts+oc)/endpoolbal |

REO indicates Real Estate Owned. BK means loans in bankruptcy. FCL is for loans in foreclosure. For the DQ 60+ definitions, if in parenthesis, these loans must also be 60 days or more delinquent. If separated by a comma, these loans can just be classified as FCL, BK or REO without consideration of delinquency status.