The Origins and Evolution of the Market for Mortgage-Backed Securities

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Abstract

The first mortgage-backed security (MBS) was issued in 1968. Thereafter, the MBS market grew rapidly with outstanding issuances exceeding $9 trillion by 2010. The growth in the MBS market was accompanied by numerous innovations such as collateralized mortgage obligations (CMOs) and the emergence of private label alternatives to MBS issued by government-sponsored entities. We trace the evolution of the MBS market and we review debates surrounding such questions as whether the MBS market has reduced the cost of housing finance, whether the MBS market is a market for lemons, and what role, if any, MBS played in the run-up and subsequent decline of home prices during the decade of the 2000s. We also detail the evolution of models for MBS valuation as developed by academics and practitioners.

1. INTRODUCTION

In the preface to the first *Annual Review of Financial Economics* Andrew Lo and Robert Merton observe that one of the most exciting aspects of financial economics as it has evolved over the past 50 years is the constant interplay between theory and practice (Lo & Merton 2009). The evolution of the market for mortgage-backed securities (MBS) is a prime example of this interplay. From the issuance of the first pass-through MBS in 1968 to the present, financial economists have worked hand in hand with institutional market makers to design new security structures, to develop pricing models to value those structures, and to experiment with econometric methods for analyzing large-scale databases. Indeed, it might even be argued that, for better or worse, the evolution of the market for MBS might not have been possible in the absence of the interplay between the theory and practice of financial economics.

We insert the caveat "for better or worse" because more than one observer has attributed the difficulties experienced by the U.S. banking sector during 2006–2009 to the complexities inherent in MBS. These observers have further argued that it was precisely the failure of supposedly sophisticated financial models that led to these difficulties. We trace, in broad strokes, the evolution of the MBS market from 1968 through 2010. The evolution has been marked by numerous innovations. Further, innovations in the MBS market have had spillover effects that have translated into innovations elsewhere. For example, the first ever financial futures contract, initiated in 1974, had as its underlying asset the Government National Mortgage Association (GNMA) MBS. As of 2011, trading in financial futures comprised more than 90% of the total volume of all futures contracts traded in the United States. Similarly, other types of asset-backed securities (ABS) including securities backed by credit card debts, automobile loans, student loans, and equipment leases have followed the blueprint laid by MBS.

Innovations have also occurred within the MBS market. These have taken one of two forms. The first is in the structure of MBS. The second is in the type of underlying collateral. As regards structure, collateralized mortgage obligations (CMOs), the first of which was issued in 1983, allocate the cash flows from the MBS into tranches that allow investors to choose among a wide array of payoff patterns.

As regards collateral, the MBS market can be divided into two sectors: agency and nonagency (or private label) MBS. The agency market includes MBS sponsored by GNMA, the Federal National Mortgage Association (FNMA), and the Federal Home Loan Mortgage Corporation (FHLMC). The agencies are collectively known as government-sponsored mortgage enterprises (GSEs). Only loans that meet certain criteria are acceptable for securitization under the auspices of the GSEs. Such loans are referred to as conforming. All others are known as nonconforming loans. Among the nonconforming loans are so-called subprime and Alt-A loans (collectively nonprime loans). It is MBS supported by this latter set of loans that has been the subject of much recent research.

A presumption supporting the intervention of the federal government into the MBS market is that securitization reduces the cost and increases the availability of mortgage credit. Whether that presumption is justified is the subject of a set of literature that attempts to empirically evaluate this question. On this point, as on many others, the literature is not settled. If anything, with the extreme difficulties confronted by the GSEs

and the MBS market during 2006–2009, the presumption that securitization has had a beneficial impact on housing markets is even more fiercely debated.

Difficulties experienced by the MBS market are the subject of continuing debates. One argument is that certain lenders with an operating strategy of originating and securitizing loans allowed their credit standards to slip, and the decline in standards was aided by credit rating agencies (CRAs) that inflated CMO ratings. Some critics have asserted that investors were duped into buying MBS supported by weak loans. The evidence on these points is far from conclusive. Indeed, the evidence appears to be that investors recognized the potential for increased risk embedded in certain securitized loans and, ex ante, demanded a higher yield for that risk. Ex post, given the rate of defaults and losses actually experienced, the yield was not high enough, but that does not mean that investors were duped.

Mathematical models for the valuation of MBS offerings have also come under attack. In particular, some critics have argued that model inadequacies allowed banks and other investors to take on risk that they could not manage. We, thus, give attention to the evolution of such models for valuing MBS.

In general terms, two types of models have been developed. The first of these is the structural models founded on the no-arbitrage principles of Modigliani & Miller (1958) as applied to option pricing by Black & Scholes (1973) and Merton (1973) coupled with models of the term structure of interest rates developed by Vasicek (1977), Cox et al. (1985), and Heath et al. (1992). Structural models assume that mortgagors optimize their borrowing decisions (i.e., the decision to make a monthly payment, to pay off their loan, or to default) at each point in time throughout the life of their loan subject to certain market frictions. The result of these optimizing decisions is a stream of cash flows (i.e., interest and principal payments) to MBS investors.

A second type of model is commonly referred to as reduced form. These models also have as their starting point a no-arbitrage condition, and they are also based on one of the popular models of the term structure of interest rates. However, reduced form models diverge from structural models in that econometric estimates for payoff patterns based on historical data are used to specify the cash flows to MBS investors.

Many avenues of inquiry remain for future research. Mathematical models may have lost some of their luster by virtue of their alleged failures during the recession of 2006–2009. Nevertheless, investors require models of some sort to evaluate risks and possible returns. Development of better models is undoubtedly an area ripe for research. The sorting out of factors that led to the crash of the MBS market during 2006–2009 is also likely to require further investigation with an emphasis on policy implications. Perhaps the greatest policy question is what to do with the behemoth GSEs that have been taken into government conservatorship. The question is: What role, if any, should the federal government play in the market for securitized mortgage loans? Further research is, indeed, warranted.

We proceed as follows. Section 2 describes the origins of mortgage banking and the mortgage securitization process. Section 3 reviews literature regarding whether the MBS market has reduced the cost and increased the availability of housing finance. Section 4 reviews literature devoted to the difficulties experienced by the MBS market during 2006–2009. Section 5 reviews MBS valuation models developed by academics and practitioners. Section 6 concludes.

2. MORTGAGE BANKING, FEDERAL AGENCIES, AND MORTGAGE SECURITIZATION

2.1. Origins of Mortgage Banking

A mortgage loan is a financial claim in which the mortgagor borrows money and uses real property as collateral against default. A mortgage banker is a lender who makes the loan. According to Frederiksen (1894), since at least the 1850s, mortgage bankers in the United States, typically located in the Midwest, have originated mortgage loans and sold the rights to receive principal and interest payments on the loans to distant investors.

Early mortgages were typically adjustable rate loans that were secured by farm property and matured in three to five years. Interestingly, the early mortgage bankers were known as mortgage guarantee houses because they guaranteed the payment of interest and principal payments of the loans they originated and sold to investors.

In most instances, investors expected to hold the loans to maturity because there was no secondary market for trading mortgage loans. According to Klaman (1959), this model of mortgage banking prevailed more or less intact until the early 1930s. With the collapse of real estate prices that accompanied the onset of the Great Depression of the 1930s, the mortgage guarantee houses were unable to redeem their outstanding mortgage bonds and largely disappeared as a source of funds for real estate markets, at least temporarily.

2.2. Government-Sponsored Mortgage Enterprises

In 1933 and 1944, respectively, the U.S. government established the Federal Housing Administration (FHA) mortgage insurance program and the Veterans Administration (VA) mortgage guarantee program. Both programs provided federal government guarantees for mortgage investors, and the two programs effectively established the long-term, fixed-rate, fully amortizing mortgage loan as the norm in lieu of the non-amortizing floating rate three-to-five year loans that prevailed previously (Green & Wachter 2005). In 1938, during the years between the initiations of these two programs, the federal government established FNMA (1966).

In 1968, FNMA was privatized as a shareholder-owned entity with the right to buy and sell both government-sponsored and non-government-sponsored loans so long as the loans met certain guidelines. Much like the mortgage guarantee houses of the late 1800s, FNMA issued bonds to support its loan purchases. When FNMA was privatized, the federal government established GNMA and two years later FHLMC. As with FNMA, FHLMC was established as a shareholder-owned corporation with no explicit federal government guarantee, although most investors viewed FNMA and FHLMC bonds as having an implicit government guarantee (Frame & White 2007), a view that was substantiated in 2008 when both entities were placed into conservatorship under the auspices of the U.S. government.

GNMA has a slightly different charter. At its inception, GNMA was chartered to issue MBS supported by FHA and VA mortgage loans and to further guarantee the timely payment of interest and principal on any loans used to support a GNMA MBS.

2.3. Early Mortgage-Backed Securities

Fabozzi & Modigliani (1992, p. 20) note that GNMA provided assistance in the form of a guarantee for a privately issued MBS as early as 1968. The first MBS offering by GNMA

itself was in 1970 with a face value of $70 million. Investors who bought a fraction of the security received a pro rata share of any monthly payments and principal from the underlying loans. Loans underlying the GNMA security were originated by mortgage bankers and, following issuance of the security, the mortgage originators typically retained the rights (and the obligation) to service the loans. With certain modest variations, this model of the originator, issuer, seller, servicer, and investor of an MBS has remained largely intact through the present time.

FHLMC and FNMA issued their first MBS in 1971 and 1981, respectively. As with the initial GNMA issuances, these were simple pass-through securities in which investors received a pro rata fraction of monthly principal and interest payments from the underlying loans.

2.4. Collateralized Mortgage Obligations

The first multiclass MBS (or CMO) was issued by FHLMC in 1983 with FNMA issuing its first CMO in 1985 (Roll 1987a,b). The initial multiclass CMOs were structured such that the first tranche received all principal payments (plus appropriate interest) from the underlying loans until the principal amount of the tranche was fully retired. Once the first tranche was retired, all of the principal payments were paid to the second tranche until that tranche was fully retired and so on until all of the loans were paid off. During the period in which the tranches were being retired in order of priority, each of the tranches received its pro rata share of the monthly interest payments based on the remaining amount of principal outstanding in the tranche and the tranche's stated coupon interest rate. Such structures were named sequential pay bonds.

2.5. Interest Rate Risk and Prepayment Risk

The risks confronted by investors in MBS come in two forms: interest rate risk and credit (or default) risk. Given that the earliest MBS were either guaranteed by the federal government or one of the GSEs, credit risk was recognized but played a relatively little role in early research regarding the MBS market. The more consequential risk was interest rate risk. Because of the structure of mortgage loans, interest rate risk can have a complex effect on the payments and the pricing of even simple pass-through securities.

Because of their long maturities, fixed-rate 30-year mortgages are susceptible to the customary risk of any fixed-rate, long-term bond. If rates rise dramatically, the price of the bond can decline dramatically and the investor can suffer significant losses in value. However, fixed-rate mortgage loans, especially FHA and VA loans and most GSE conforming loans, can be fully paid off at any time without cost. Thus, if interest rates decline, mortgagors have an incentive to pay off their loans early so as to refinance into a lower rate loan. This ability to pay off the loan prior to maturity is called the borrower's prepayment option. Thus, investors in MBS bear two types of interest rate risk. If rates rise, the value of their investment declines. If rates fall (such that the value of a fixed-rate bond would increase), the mortgagor has the option to prepay the underlying loans. The former risk is interest rate risk and the latter risk is prepayment risk.

The original notion behind the establishment of the GSEs was that a national mortgage market would reduce the cost of home ownership by creating a more liquid mortgage market. The creation of MBS was a further step along this path. The argument customarily

advanced is that tradable MBS attract a wider set of investors to the mortgage market, which, in turn, reduces the cost of housing finance.

The creation of CMOs was yet another step in that direction. Specifically, the idea was that some investors were reluctant to become active in the MBS market because their long-term maturities coupled with the mortgagor's prepayment option means that the actual maturity of the security is unknown and can be quite long term, thereby exposing a potential investor to substantial interest rate risk, while at the same time exposing the investor to a great deal of uncertainty as to the actual maturity date of the security. Sequential pay CMOs were thought to be a way of overcoming the disadvantages of simple MBS in that an investor who preferred a shorter-term security could buy an early tranche, whereas one who was willing to bear more risk (possibly in return for a higher yield) would be attracted to the later pay tranches.

However, even with sequential pay tranches, there remains considerable uncertainty as to when the early pay tranches will be paid off. To reduce this uncertainty further, tranches were created that specified a range within which early payoffs would be directed to the first pay tranche with excess payoffs being directed to later tranches. Such tranches were labeled planned amortization class (PAC) or targeted amortization class (TAC) bonds.

But even these bonds bear interest rate risk, as the underlying mortgages are fixed-rate loans. An increase in rates is likely to slow prepayments and depress the value of even short-term PAC and TAC tranches. To reduce interest rate risk even further, floating rate bonds were introduced. But because the underlying loans are fixed rate, the creation of a floating rate bond meant that another tranche with a rate that moves opposite of the floating rate was required. This gave rise to inverse floating rate tranches. In concert with the creation of other types of tranches, securities were created in which one tranche received only the interest from the mortgages (interest only bonds or IOs), which meant the creation of a security that received only principal (principal only bonds or POs).

However, creating one tranche that bears less risk does not mean that the risk disappears. It just means that the risk is shifted to another tranche. The less risky tranches are subject to less prepayment and interest rate risk than are MBS pass-throughs, which means that other tranches are more subject to prepayment and interest rate risk. At their peak, some CMOs were issued with as many as 40–50 different tranches with some bearing extreme interest rate and prepayment risk.

2.6. Credit Risk

The early CMOs were all backed by GSE insured or guaranteed mortgages. For these MBS, there was little concern about defaults of the underlying loans. The mid- to late 1990s saw the emergence of private label CMOs. Investors in private label CMOs bear the risk that the mortgagors on the underlying loans will default. Arguably, this risk is compounded because most private label CMOs are supported by mortgage loans that do not meet the GSE criteria of conforming loans. Many of these fall into the category of nonprime loans.

CMOs with default risk are structured so as to provide credit protection to the senior tranches if the underlying loans default. The more senior tranches have greater protection than the more subordinated tranches. In many structures, the most credit sensitive tranches, the residuals (or equity tranches), are retained by the loan originators. But, as the events of 2006–2009 show, even with a senior tranche, the investor bears credit risk when enough of the underlying loans default.

2.7. Volume of Originations and Securitizations

To give some indication of the growth in MBS, in 1996, total MBS issuances were less than $500 million, and private label offerings accounted for 10% of the total. Two years later MBS issuances had more than doubled, to more than $1 trillion, and private label offerings had increased by roughly a factor of four. However, the period of rapid growth was not over. Total MBS issuances reached an all-time high of nearly $3.2 trillion in 2003. Moreover, private label issuances continued to increase and reached their all-time high of more than $900 million in 2006, which marked the beginning of the recession of 2006–2009.

To give some indication of the dramatic adjustments that occurred during the recession, during 2008, the volume for private label issuances shrank to $45 million, or roughly 5% of the peak year amount. The total market for MBS issuances has made a partial recovery: During 2009, total MBS issuances were nearly $2 trillion, but the market for private label offerings shrank even further to roughly $30 million.

3. SECURITIZATION AND THE COST AND AVAILABILITY OF MORTGAGE CREDIT

3.1. Overview

The most widely cited impetus for the creation of the GSEs and the establishment of their MBS programs is the national goal of assisting individuals and families in buying homes. The idea is that MBS, especially those with a government guarantee, can be traded in an anonymous market in which investors need not search for information about ultimate borrowers. This reduction in search cost on the part of investors, or so it is argued, reduces the cost of mortgage financing, which, in turn, provides greater access at lower cost to potential home owners.

The offsetting argument is that at least two of the GSEs are owned by shareholders. If the management of the GSEs acts in the interests of their shareholders, whatever value is created by the GSEs' securitization activities will be passed on to shareholders in the form of higher dividends and stock prices. Thus, whether the GSEs' MBS programs actually have reduced the cost of mortgage credit and increased home ownership are empirical questions.

3.2. Cost of Mortgage Credit

One of the earliest studies to examine the impact of the GSEs' MBS programs on the cost of mortgage credit is Hendershott & Shilling (1989). They observe that between 1977 and 1987, the interval during which FNMA and FHLMC became active in the MBS market, the percentage of conforming loans that were securitized by FNMA and FHLMC increased from less than 5% to more than 50%. One of the factors that determine whether a loan is eligible for securitization by the GSEs is the size of the loan. Hendershott & Shilling examine loans originated in California in 1978 and in 1986 that were conforming on all dimensions except size. Loans that exceed the GSE limit are referred to as jumbo loans. Hendershott & Shilling report that, after controlling for other factors, yields of conforming loans were 15 to 30 basis points less than those of jumbo loans. They conclude that the potential for securitization reduces the cost of mortgage financing.

Kolari et al. (1998) conduct a cointegration analysis using data for the interval 1985–1995. Their dependent variable is the yield spread between residential mortgage

loans and treasury securities and their key independent variable is the fraction of all mortgage loans securitized during a quarter. They conclude that a 10% increase in the fraction of loans securitized led to a 20–basis point decline in mortgage rates.

Ambrose et al. (2001) take a slightly different perspective on the jumbo/conforming rate differential than Hendershott & Shilling (1989). They observe that mortgage rates are a function of the volatility of the underlying asset, a characteristic for which Hendershott & Shilling had not controlled. Using data from the Dallas, Texas area, Ambrose et al. estimate the volatility of properties underlying jumbo and non-jumbo loans. They find that properties underlying jumbo loans have a higher volatility than those underlying conforming loans. After taking into account this difference in volatilities, they attribute a maximum yield differential of 16 basis points to the GSE's activities.

Naranjo & Toevs (2002) note that the GSEs' activities can be separated into purchases and securitizations, and that earlier studies did not clearly distinguish between the effects of the two. Naranjo & Toevs use a cointegration analysis along with data on conforming and nonconforming loan originations from 1986–1998 to separate these two effects. They conclude that both GSE purchases and securitizations have an effect on the jumbo/non-jumbo rate difference, which they estimate to be 21 basis points, but that purchases have a much larger effect than do securitizations.

Ambrose et al. (2005) take a broader perspective of the conforming/nonconforming yield differential. They note that nonconforming loans may differ from conforming loans on dimensions other than loan size. They use loan-level data for loans originated during 1995–1997 and include loan and borrower characteristics in their analysis. They find that the implied spread, at 9 basis points, is much lower than identified by earlier studies.

Todd (2001) uses an average FHLMC new mortgage rate and aggregate securitization volume for the period of 1984–1995. As a separate analysis, he examines CMO issuance activity. He finds no relation between mortgage rates and securitization activity regardless of whether he considers securitizations in the aggregate or CMOs separately. However, in a further analysis, he finds a significant relation between origination fees and securitization activity, but that the effect of CMO activity, per se, has no effect beyond that of simple securitization. He concludes that GSE securitizations significantly reduce mortgagor upfront fees.

Lehnert et al. (2008) use a vector autoregressive approach with data on mortgage rates and GSE purchase and MBS issuance activities over the 1993–2005 period. They ask whether GSE activity leads to reductions in mortgage rates in time series data. In contrast to prior studies, they find no effect of GSE securitizations on mortgage rates.

3.3. Availability of Mortgage Credit

In 1969, the year just prior to the issuance of the first GSE MBS, the rate of owner-occupied homes in the United States stood at 64.3%. As of 1993, the rate stood at 64.0%. On that basis, mortgage securitizations had essentially no impact on the rate of home ownership. However, beginning in 1994 the rate of U.S. home ownership increased year after year, reaching a peak of 69% in 2005–2006 before declining to 67.4% in 2009. It was over this interval that nonprime mortgage securitizations flourished (1994–2006) and then nearly disappeared (2007–2009).

Thus, MBS, per se, appear to have had no effect on home ownership in the United States, but nonprime MBS appear to have been associated with a significant increase in home ownership. Several studies examine this connection in greater detail.

Gabriel & Rosenthal (2006) use Home Mortgage Disclosure Act and census tract data to study the relation between loan denial rates and secondary mortgage market purchases during 1992–2002. Their results do not strictly apply to securitization per se because they include all secondary loan purchases as their independent variable. They note, however, that the rate of home ownership increased from 64.1% to 67.5% over this period, that the fraction of loans in low-income neighborhoods sold into the secondary market increased from 33% to 81%, and that the fraction of loans among minority neighborhoods sold into the secondary market experienced similar increases.

After controlling for other factors, Gabriel & Rosenthal (2006) find that increases in secondary market activity are associated with a significant decline in loan denial rates. They conclude that secondary mortgage market activity significantly expanded the supply of mortgage credit.

Studies by both Nadauld & Sherlund (2009) (N&S) and Mian & Sufi (2009) are concerned directly with whether securitization led to an increase in nonprime lending. Both employ Home Mortgage Disclosure Act data and compare credit standards and securitizations at the ZIP code level, where ZIP codes are classified as prime and nonprime. N&S study the years 1997–2007. Mian & Sufi study the years 1992–2006. N&S find that investment banks that securitized loans were significantly more likely to purchase loans in nonprime ZIP codes than in prime ZIP codes. Mian & Sufi find that the rate of loans securitized from nonprime ZIP codes was significantly greater than the rate of loans securitized from prime ZIP codes, that this relationship was especially strong during 2002–2005, and that the relationship was primarily due to private label securitizations. Both studies also find that the ZIP codes with the greatest fraction of nonprime securitizations experienced higher default rates during 2006–2007. Both studies conclude that nonprime private label MBS expanded the supply of credit during the early 2000s and was associated with higher default rates during 2006–2007.

4. THE MORTGAGE-BACKED SECURITY MARKET AND THE RECESSION OF 2006–2009

4.1. Overview

Various studies have examined the role of securitization in the run-up of house prices leading up to 2006 and the subsequent decline in house prices through the year 2009, along with the coincidental increase in mortgage delinquencies, defaults and foreclosures, and the failure of major U.S. banks.

To give some indication of home price changes and the associated implications for MBS, according to the Case-Shiller House Price Index, home prices increased nationwide by more than 80% from the beginning of 1996 through July of 2006 and then declined by more than 30% through the end of 2009. Over the 2006–2009 period, the rate of prime home mortgage foreclosures increased more than sixfold and the prices of AA-rated nonprime CMO tranches originated in 2006 declined by 70% with prices of AAA tranches falling by 20%. Finally, this interval witnessed the demise of the major investment banks Bear Stearns, Lehman Brothers, and Merrill Lynch, along with major mortgage

originator/servicers including Countrywide, Downey, and IndyMac. The demise of each of these was attributed to their involvement in the MBS market.

4.2. The Role of Adverse Selection

A persistent question is whether the MBS market is a market for lemons. One perspective is that investors recognize the incentives for issuers to securitize poorer quality loans and adjust prices so as to be compensated for bearing the risk of adverse selection. A more sinister perspective is that investors are unaware of issuers' incentives and are, thus, duped into buying low quality MBS without adequate compensation. A variation on this sinister perspective is that during the 2000–2006 era, CRAs that were responsible for certifying the quality of tranches of private label CMOs, either explicitly or implicitly, colluded with issuers and awarded inflated ratings to lesser quality MBS, thereby further misleading investors.

Downing et al. (2009) address the question of whether the MBS market is a market for lemons by examining individual pools of FHLMC MBS that were created over the 1991–2002 period. They focus on prepayment risk and find that MBS used to create CMOs tend to perform worse from the investor's perspective (i.e., mortgagors exercise their prepayment option more aggressively in MBS used to create CMOs) than those that remain in the original MBS form. They compare the actual MBS yields with estimated appropriate yields for MBS used to create CMOs and conclude that the yields are consistent with market participants recognizing the potential lemons problem.

Purnanandam (2011) notes that some banks specialize in originating mortgage loans with the intent to securitize them. This mode of operation has been labeled the originate-to-distribute (OTD) model. Purnanandam studies banks according to their degree of involvement in the OTD market during 2006–2008. He concludes that banks more heavily involved in the OTD market originate lower quality loans and interprets this as evidence that the OTD model embeds weaker incentives for lenders to screen loans with the result that the OTD model contributed to the increase in nonprime defaults during 2007–2009.

Dell'Ariccia et al. (2008) study nonprime loans originated during 2000–2006. They conclude that lending standards declined among nonprime lenders and that the decline was greater for loans originated in geographic areas where mortgage securitizations were greater.

Keys et al. (2010) exploit an oft cited rule of thumb to address the question of whether securitization affected lending standards. They propose that a credit score of 620 can be viewed as a proxy for whether a nonprime loan is likely to be used to support an MBS. All else equal, loans with scores just above that level are more likely to be securitized than loans with scores just below that level. Holding constant all other observable factors, they find that securitized loans with scores just above 620 are significantly more likely to default than nonsecuritized loans with scores just below this level. They conclude that the potential for securitization reduces lenders' incentives to screen borrowers. A shortcoming of the studies by Purnanandam, Dell'Ariccia et al., and Keys et al. is that none addresses the question as to whether investors recognized and priced the potential for adverse selection into MBS.

Krainer & Laderman (2009) study mortgage loans originated in California during 2000–2007. They find that loans securitized in private label MBS default at a higher rate than loans either held in the originator's portfolio or loans securitized by one of the GSEs.

However, they also find that such loans provided a premium yield. This result is consistent with investors recognizing that such loans present the investor with greater risk. That is, investors recognize the lemons problem in MBS and adjust prices. These authors note, however, that, in the absence of a well-established pricing model, they cannot determine whether the price adjustment was too high or too low.

Demyanyk & Van Hemert (2011) focus on the nonprime mortgages originated during 2001–2007. They do not consider the role of securitization per se. However, they note that during this period of hypergrowth in the nonprime MBS market, nonprime loan quality deteriorated. They further observe that issuers and investors for MBS appear to have been aware of this phenomenon insofar as the yield spread on high risk loans widened relative to the yield spread of low risk loans.

Demiroglu & James (2009) (D&J) directly examine the question of whether the adverse selection potential in MBS was priced by investors. D&J classify investors in MBS according to distance from the originator where distance is measured in terms of affiliation with the originator—the less the affiliation, the greater the distance.

D&J find that loan performance is worse (i.e., defaults and losses are greater) the greater the distance of the investor from the originator. They also find that distance matters for price: After controlling for other factors, yields are higher for deals with greater distance from the originator. The implication of D&J is that investors were not duped in that investors required higher yields as the risk of adverse selection increased.

4.3. The Role of the Credit Rating Agencies

The U.S. market for credit ratings of publicly traded securities is dominated by three CRAs. Moody's Investor Service, Standard & Poor's Financial Services, and Fitch Ratings rate debt securities according to the likelihood of default and recovery in the case of default. CMOs backed by GSE-sponsored MBS are not rated because the securities are supported by an explicit or implicit federal government guarantee. Thus, for many years, CRAs played no role in the issuance of MBS or CMOs. However, during the late 1990s and especially during the early 2000s, as the volume of private label CMOs expanded, the CRAs were called upon to rate the credit quality of CMO tranches.

One claim is that the CRAs worked with private label issuers to maximize the fraction of each CMO rated AAA or AA. Further, it has been claimed that as the share of non-GSE MBS increased, the CRAs' profits began to depend largely upon rating such issuances with the result that CRA standards declined during the early 2000s. It has been further asserted that the decline in standards allowed some regulated entities to deliberately take on increased risk as a form of regulatory arbitrage (Stanton & Wallace 2010) and/or induced some investors to take on risk with which they were unprepared to deal. Several studies investigate at least the first part of these claims.

Mathis et al. (2009) study nonprime CMOs issued during 2000–2008. They report that, for the 2000–2006 period, after controlling for characteristics of the underlying loans, the fraction of nonprime CMO tranches rated AAA increased. As with Mathis et al., Ashcraft et al. (2010) study nonprime securitizations. Their analysis encompasses the 2001–2007 period. Ignoring other factors, Ashcraft et al. find that the fraction of securitizations rated AAA actually declined from 2001 through the end of 2004 and then remained flat through mid-2007. Even after adjusting for other factors, the fraction of the deals rated AAA declined between 2001 and 2004. However, between 2005 and mid-2007, after adjusting

for other factors, the fraction of deals rated AAA increased. They further find that nonprime MBS issued between 2006 and 2007 experienced higher delinquencies and defaults. These two studies are consistent with a decline in rating standards by the CRAs. Two questions remain, however. First, even if there was a decline in ratings standards, were the ratings too low to begin with? The second, and more important, question is whether investors relied exclusively on ratings in buying MBS tranches? That is, did investors recognize the potential decline in ratings standards, if there was any, and price the tranches accordingly?

To address that question, Adelino (2009) investigates whether yield spreads of CMO tranches predicted future performance of the tranches after taking into account credit rating. He analyzes yield spreads of tranches issued during 2003–2007. He finds that, after controlling for credit ratings, CMO yield spreads have predictive power for future tranche performance. In short, investors relied on information in addition to ratings when buying CMOs. He does note an exception to his findings, which is that investors' discriminatory power appears to have been at work primarily across lower rated tranches. Within AAA-rated tranches, yield spreads appear to have had little predictive power for future performance.

He et al. (2010) directly address one of the key questions concerning the role of CRAs. In particular, the pay-for-rating method in which issuers pay the rating agencies to rate their issuances has been cited as leading to an incentive problem wherein the CRAs are potentially rewarded for inflated ratings by the issuer that bring more business to the CRA. Using CMOs issued during 2000–2006, He et al. determine that CMOs issued by frequent issuers were given higher ratings than CMOs issued by less frequent issuers. Further, they find that yields of frequent issuers were lower than those of less frequent issuers during 2001–2003, but this pattern reversed during 2004–2006. They interpret this to mean that by 2004, investors had come to recognize the potential for drift in CRA ratings and priced the securities accordingly.

In sum, no later than 2003, the evidence suggests that investors became concerned about ratings drift and priced that into the yields on CMOs.

5. MORTGAGE-BACKED SECURITY VALUATION MODELS

5.1. Overview

MBS are complex securities. CMOs that shift risk among tranches are even more so. This complexity gave rise to a demand for methods of analyzing the securities. This demand was met by the creation of valuation models.

The earliest models, both structural and reduced form, focused on interest rate and prepayment risk because the MBS were guaranteed by the federal government and had little default risk. To the extent that default played a role, it had a secondary importance in that it meant that the investor received the earlier-than-expected payment of principal that occurs when a guaranteed loan defaults. As private label MBS came to play a larger role, default risk came to play a larger role in the valuation of MBS.

The literature on structural models is more fully developed and detailed than is the literature on reduced form models. That is because structural models have largely been the domain of academics whose profession demands publication of their work. In contrast, reduced form models have largely been the domain of Wall Street analysts

whose profession demands that their work remain proprietary. That is not to say that Wall Street analysts do not publish papers based on their models. However, the papers are scant on details, thus requiring a certain amount of inference to discern the inner workings.

Further, reduced form models require significant time series data to estimate the coefficients of the mortgage termination models that determine the cash flows to MBS investors. Such data were not readily available in the mid-1980s. Indeed, even into the early 2000s, high quality time series data encompassed only 20 years. Whether even those data provided sufficient variation in key economic variables to permit reliable calculation of the relation between economic fundamentals and mortgage terminations is an open question.

5.2. Early Models

The earliest published structural model for analysis of GNMA MBS appears to be Dunn & McConnell (1981a,b) (D&M). They exploit the fact that each GNMA MBS is backed by a pool of nearly identical mortgages. Thus, they value the MBS as if it were a single loan. They further assume that mortgagors prepay (i.e., call) their loans in either of two ways. First, if interest rates decline such that the value of the loan if not called would exceed its face value, the mortgagor immediately prepays at par. They refer to these as optimal prepayments. They are optimal in that they represent value maximizing decisions by mortgagors. Thus, prepayments are highly sensitive to interest rates. Second, some mortgagors are assumed to prepay for exogenous reasons, such as moving for a new job, even if doing so means paying off a loan that has a below market interest rate. They refer to these as suboptimal prepayments.

To value the MBS, D&M assume that the term structure of interest rates is determined by a single stochastic short-term interest rate that follows a mean reverting process. They invoke the no-arbitrage conditions of Cox et al. (1985) and the hedging arguments of Black & Scholes (1973) and Merton (1973) to arrive at a fundamental pricing equation that can be solved numerically. The solution involves a dynamic backward optimization technique in which the mortgagor maximizes his wealth with respect to his loan at the next-to-last period and then moves backward in time following an optimal call policy. The optimal call policy generates the stream of cash flows, which are then discounted to determine the risk-adjusted value of the MBS.

With this model, D&M demonstrate the effect of the shape of the term structure, remaining term to maturity, and suboptimal prepayments on MBS values. D&M report that the value of a callable MBS in which mortgagors follow the optimal call policy is always less than the value of an otherwise comparable non-callable treasury bond. However, suboptimal prepayments increase the value of the MBS because a suboptimal prepayment means that the investor is receiving the face value of the MBS when the market value is less than face value.

Brennan & Schwartz (1985) (B&S) observe that a single-factor model is limited in its ability to capture the shape of the term structure. They develop a model for GNMA MBS based on a two-factor model where the two factors are a short-term rate and a long-term rate, each of which is governed by a separate stochastic process. As with D&M they compare numerically calculated values of the GNMA MBS with those of treasury bonds. B&S find that, with a more robust model of the term structure, implied prices of GNMAs can sometimes be above those of otherwise comparable treasuries even when mortgagors follow an optimal call policy.

The models of D&M and B&S are unarguably simplified versions of actuality. Nevertheless, this basic form, in which borrowers follow wealth maximizing option exercise strategies, continues to underlie later structural models.

One feature of the D&M and B&S models that demonstrates their shortcomings is that, because mortgagors are assumed to follow a wealth maximization prepayment strategy, MBS can never sell at prices above par. However, GNMA MBS do trade at prices above par. Thus, perhaps the greatest virtue of these early models was to emphasize that, even in their simplest form, valuation of MBS is not a simple undertaking.

In their conclusions, B&S make the observation that Green & Shoven (1986) estimate a hazard model of mortgage terminations in which the empirically determined prepayment rate is a function of the current market interest rate. B&S propose that such a model could be incorporated within an equilibrium model of the term structure. In doing so, they point the way toward the development of reduced form models in which prepayments are determined by an empirical relation between interest rates and the mortgagor's propensity to prepay rather than by an assumed wealth maximizing option exercise strategy.

Kau et al. (1990, 1992, 1994) (KKME) extend the option-based models to the valuation of mortgage loans. The KKME models are not immediately applicable to MBS in that one of the key dimensions introduced by KKME is default risk. From the perspective of an investor in a GSE MBS, default and prepayment are indistinguishable. However, the KKME models do have direct implications for private label MBS that flourished during 2000–2006.

KKME incorporate default risk by introducing a stochastic house price as a state variable (along with a stochastic interest rate). Their insight is that default can be viewed as a put option held by the mortgagor. If the house price declines far enough, the mortgagor will rationally exercise this option. Thus, a mortgage embeds two options: the option to call the loan when interest rates decline and the option to put the house to the mortgagee when house prices decline.

Schwartz & Torous (1989, 1992) follow the B&S suggestion to construct a reduced form model in which an empirical prepayment function is estimated. They use GNMA MBS pool-level prepayment data for the years 1978–1987 and incorporate this function into the B&S two-factor model. They estimate the prepayment probability as a function of four variables: mortgage age, the remaining pool balance, season of the year, and the spread between the coupon rate of the mortgages and the current market rate. Among other features, this model produces MBS values that exceed par.

The research cited up to this point considers models only for simple MBS and only research that has appeared in scholarly journals. In symbiotic parallel with this research, there evolved an extensive set of research conducted by Wall Street investment houses. Initially this research centered on static yield analysis as opposed to the dynamic models formulated by academics. The key difference is that the static analysis assumes that prepayments follow a deterministic path. This deterministic path is specified as a percentage of an historical average prepayment rate. The models were used to conduct scenario analysis in which the cash flows of the security were shown under different what if scenarios. Excellent examples of this research can be found in the 3rd and 4th editions of *The Handbook of Mortgage-Backed Securities*, edited by Fabozzi (1992, 1995). The list of firms whose researchers contributed papers includes Goldman Sachs, Prudential Securities, Morgan Stanley, Smith Breeden Associates, Bear Stearns, Lehman Brothers, and others.

It was not that investment firms were not aware of the virtues of dynamic models; it was that by the mid-1980s, the demands for modeling had outstripped the simple MBS valuation models, as CMOs came to dominate new issuances. The simple structural models were not capable of handling these complex instruments. The reduced form models were limited by the need for data to estimate the historical relation between mortgage terminations and interest rates. Reliable and accessible data on mortgage terminations, whether through prepayment or default, were, at best, available for 10 years and those data were available only at the pool level. Thus, scenario analysis was the fallback option.

However, by the mid-1980s the importance of prepayment and default data for the analysis of MBS had become increasingly apparent and such data began to be collected. The need to collect and manipulate large databases coincided with the arrival of powerful computers. The arrival of powerful computers allowed for the application of sophisticated econometric techniques to identify the relationship between millions of monthly observations on MBS payoffs and defaults, individual loan characteristics (such as age and geographic locale), and interest rates.

5.3. More Recent Models

Part of the reason for the divergence between the academic treatment of MBS valuation and Wall Street modeling is that structural models could not be readily adapted to analysis of CMOs because the structural models are solved by starting at the end of the security's life and moving backward in time. This solution technique does not allow for path dependency in cash flows. However, cash flows to CMO tranches are highly path dependent. Consider a simple sequential pay CMO. The cash flow in any period to a tranche depends upon whether the tranche has received sufficient cash flow to have been fully paid off. However, that cannot be known unless the cash flows to the tranche are known from every prior period, and that cannot be known unless the prepayment or default decision of each mortgagor is known from prior periods, information not available under the backward solution techniques used in structural models. Reduced form models are solved with forward Monte Carlo simulation that does allow for memory.

McConnell & Singh (1993) present a representative reduced form model for CMO analysis. They employ the B&S two-factor model of the term structure along with the Schwartz & Torous (1989) prepayment function to demonstrate how a structural model can be used to value sequential pay, PAC, TAC, IO, PO, floating rate, inverse floating rate, and residual tranches for default-free CMOs. The McConnell & Singh model is representative because during the late 1980s and early 1990s, Wall Street firms were pouring millions of dollars into computer technology and assemblage of databases to develop such models. Much of this effort was devoted to estimating more reliable prepayment functions to incorporate into the Monte Carlo solution techniques. Representative discussions of such efforts are available in Patruno (1994), Deng et al. (2000), and Pavlov (2001).

Wall Street analysts discovered that their models yielded values far different from market prices. To adapt to this discomforting observation, Wall Street analysts added a constant term to the risk-free discount rate used in determining CMO tranche values. This constant term came to be called the option-adjusted spread (OAS) and the models came to be called OAS models. Because model values were typically greater than observed market prices, this term was typically positive and came to be used as a metric for determining whether a specific tranche was a good buy.

Whether such usage is legitimate is an issue of contention. The question is whether the models are correct. If so, then any OAS that differs from zero implies that the tranche is over- or undervalued and represents either a buying or selling signal. Alternatively, if the market price is correct, the OAS merely represents the size of the model error. Brown (1999) describes how the OAS can be used to measure excess return possibilities. Kupiec & Kah (1999) make the case for viewing the OAS as a measure of model error.

Limitations of structural models in certain applications did not mean that development of such models ceased either by academics or by Wall Street practitioners. Davidson et al. (1988) and Stanton (1995) developed structural models that allow for heterogeneity across mortgagors. Both models assume that mortgagors confront frictions in their refinancing choices. These frictions act as a drag on a mortgagors' refinancing such that mortgagors do not pay off their loans as soon as the current market rate drops below the coupon rate of their loans. Furthermore, these refinancing frictions vary across mortgagors (Dunn & Spatt 2005). Thus, each mortgagor within a pool follows a wealth maximizing option exercise strategy subject to a refinancing cost. To make the models tractable, mortgagors are assumed to belong to a finite set of refinancing cost categories. Among other features, the models allow for MBS prices to rise above par value because of the delay in refinancing by some borrowers.

McConnell & Singh (1994) show how the Stanton model can be applied to CMO valuation. Their approach involves a two-step procedure. In the first step, optimal prepayment boundaries are determined for each refinancing cost category of mortgagor using a backward solution technique. In the second step, the prepayment boundaries are used in conjunction with a forward Monte Carlo simulation to value each CMO tranche. This approach allows for optimal option exercise decisions and also allows for the path dependency required to value CMO tranches. Bennett et al. (2000) propose a methodology for estimating refinancing thresholds for classes of mortgagors.

Longstaff (2005) observes that, when making their prepayment decisions, mortgagors consider future prepayment possibilities. He, thus, develops a recursive structural valuation model that takes into account all lifetime costs of refinancing. He tests the implied model values for GNMA pass-throughs against observed prices. He concludes that the model performs well.

Downing et al. (2005) extend Stanton's rational pricing model to incorporate default probabilities. However, the cash flows to the mortgagor are assumed to be risk free as the model is applied to GSE MBS. They incorporate default as a function of a stochastic house price with default occurring when the house price falls sufficiently far so as to be optimal for the mortgagor to exercise the put option described by KKME. Downing et al. test the model against the prices of FHLMC pass-through MBS from the 1991–2002 period and conclude that the model fits the data better than a single-factor structural model.

Dunsky & Ho (2007) (D&H) present a reduced form model for the valuation of private label MBS. D&H estimate an econometric prepayment/default function using loans originated during 1995–2006. They find that the traditional factors of seasonality, mortgage age, and interest rates are important determinants of prepayment and that mortgagor credit score, loan-to-value ratio, and unpaid balance are important determinants of default. D&H use their model to calculate implied OASs assuming various rates of recovery on defaulted loans. D&H find that the implied OAS is highly dependent upon the assumed recovery rate on defaulted loans.

Given the high levels of default on nonprime loans and the importance of recovery rates for their valuation, Hayre & Saraf (2008) consider factors that affect recovery rates. They find that original loan-to-value ratio, age, size and type of loan, geographic location, and house price appreciation/depreciation are significant factors in explaining loan recovery rates. These factors can be embedded within a reduced form valuation model.

6. CONCLUSION

We began by acknowledging that the interplay between theory and practice has been an enduring feature of the MBS story. We noted that essential components for the foundation of theoretical models were either already in place or were in the process of development at the time of the earliest MBS offerings. However, the interplay of theory and practice did not end with these early foundations. On the contrary, the early academic contributions merely set the stage for even more extensive interactions.

The specific form of early MBS offerings by GNMA enabled researchers to focus the emerging analytic tools on issues of special significance for practitioners. Dramatic growth of the MBS market, in terms of both the total dollar volume of offerings and the variety and complexity of those offerings, in turn presented challenges for further efforts to capture the essential features of specific forms of MBS offerings. As a result, new sets of tools, including reduced form models, were developed as essential supplements to traditional structural models. Moreover, both forms of modeling efforts presented ever increasing demands for relevant data that were required to implement the models.

The interplay of theory and practice has even affected critical analysis of the MBS market itself. Questions have been raised on such issues as whether the development of the MBS market has lowered the effective borrowing cost for homeowners. Policy makers have even questioned the extent to which growth in the complexity of the MBS market played a role in the rapid rise and subsequent decline in housing values that occurred during the 1990s and early 2000s.

Juries are still out for many such questions. Yet even critics of the MBS market must surely concede that it was no small undertaking to create a financial structure to provide financings for homeownership at a level in excess of $2 trillion per year. Such success does not imply that mistakes were not made or that the MBS market is ideal. On the contrary, if history taught us anything, it is that the MBS market, and sibling markets for other forms of ABS, will continue to evolve, and the interplay of theory and practice will continue to play an essential role in that process.

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