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Underwriting versus economy: a new approach to decomposing mortgage losses

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This paper presents some stylized facts about the role of mortgage underwriting standards in the current market crisis. The observations are based on an ex post analysis of 136 residential mortgage-backed transactions that were issued between 2002 and 2007. Disentangling the time-varying effects of changes in economic factors, such as home prices, from the time-varying effects of underwriting standards can pose challenges, particularly given the effects of the loan prepayment option common in the US market. This study uses a new simulation tool to model mortgage losses related to conditional prepayment probability, conditional default probability and conditional loss given default. The simulation experiments suggest that introducing an additional factor, based on publicly available underwriting surveys, permits the model to capture better the unusually poor performance of late-vintage subprime mortgages, while also producing reasonable estimates for earlier vintages. This exogenous factor also permits the separation of the effects of economic factors from those of underwriting standards. The results suggest that while the economic downturn is the dominant driver of projected subprime losses, a portion of losses is attributable to the quality of underwriting at the time of origination. The paper presents coarse estimates of effect size by vintage.

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1 INTRODUCTION

Recent events in the mortgage market have led market participants and observers to discuss the role of underwriting standards in the current market crisis. This paper presents some stylized facts based on a series of *ex post* simulation experiments that were conducted using loan-by-loan data on 136 subprime mortgage pools underlying US residential mortgage-backed securities (RMBSs) issued between 2002 and 2007. The goal of these experiments is to provide some sense of the degree to which shifts in underwriting standards and the changing economic environment affect subsequent pool performance. In order to accomplish this decomposition, an instrument based on the transformation of a readily available Federal Reserve (hereafter simply referred to as "Fed") series is used that exogenizes underwriting explicitly. This exogeneity is particularly convenient in settings where underwriting standards and the future state of the economy are evolving in tandem, as it permits a separation of these two effects. An attractive feature of this measure is that it can be observed in real time, and thus may be useful for forecasting subsequent mortgage performance for newly originated mortgages before any performance history is available on the mortgages.

While these findings are stylized, the experiments suggest that underwriting quality is an important contributor to abnormal pool loss levels, though it contributes far less than the dramatic changes in the economy do. Underwriting quality can lead directly to losses, as in the case of higher default rates for borrowers, or can affect losses in conjunction with declines in the economy, as in the case of a loan-to-value (LTV) ratio that turns out to be higher than reported due to more lenient verification standards, but that becomes more important as home prices decline further, increasing the LTV.

To give some sense of the results, one set of experiments suggests that from 2005 Q4 to 2007 Q1 (considered by many to include some of the poorest quality vintages), about 33%, in *relative* terms,[1] of the abnormal losses could be explained either by the direct impact of underwriting quality or by the indirect effect of underwriting quality that became evident in declining economic conditions. (*Abnormal losses* are defined more fully in what follows.)

At first glance, it would appear that statistics describing declining pool quality, in terms of measures such as average FICO scores or combined loan-to-value (CLTV), would be sufficient measures of underwriting quality. However, recent research in this area suggests that such may not be the case. For example, Demyanyk and Van Hemert (2008) point out that relative risk associated with given CLTV levels have, by these authors' measures, increased during the period 2001 to 2007. Said differently, the same value of CLTV implied different risk in different vintages. They develop a model of expected loan performance based on CLTV and other common factors

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[1] Note that this is relative to the total amount of the abnormal losses, the rest of which are attributable to declines in the economy in this analysis.

and measure deviations over time of realized performance from expected performance. Based on this model, they go on to assert that "loan quality – adjusted for observed characteristics and macroeconomic circumstances – deteriorated monotonically between 2001 and 2007". This is true despite their remark that observed loan characteristics were not sufficiently different compared with those over the prior five years to explain the performance.

A number of other papers attempt to link the increased losses on subprime mortgage loans in 2006 and 2007 to the increase in securitization and the resulting decrease in underwriting rigor among some market participants. Mian and Sufi (2008) construct a supply and demand argument and then use detailed zip-code level data to show that the sharp increase in mortgage defaults occurred in zip codes with disproportionately large numbers of subprime borrowers as of 1996. These zip codes subsequently experienced unprecedented relative growth in mortgage credit (pent-up demand) despite sharply declining relative income growth. Through arguments that eliminate income growth or the expectation of higher house prices as potential reasons for the sharp growth in mortgage credit, the authors provide some evidence, which they characterize as suggestive, that greater moral hazard on the part of originators may be the cause of the decline in the underwriting conditions.

Keys *et al* (2007) also provide evidence of differential underwriting standards using a large loan-level data set. They relate this decline to moral hazard introduced as a result of securitization. Using the industry rule of thumb that loans to borrowers having a FICO score of 620+ are more likely to be securitized than otherwise, the authors demonstrate that losses on loans with FICO scores just below 620 (low securitization probability) have substantially lower default rates than those with FICO scores of 621 (just above the cut-off and therefore having higher securitization probability). Because the FICO scores (which the authors assume to be a proxy for credit quality) are quite close, the lower default rates on unsecuritized (retained) mortgages suggest that additional screening may have been done for the loans that had a lower probability of securitization. In other words, lenders appeared less likely to scrutinize the soft characteristics of a borrower with a FICO score of 620+ given the substantially higher probability that the loan would be securitized. In a related article, Dell'Ariccia *et al* (2008) focus on a number of explanations for poor performance of subprime loans, one of which relates to the securitization rate within different Metropolitan Statistical Areas. The authors provide some evidence that lending standards (as measured primarily by mortgage application denial rates) declined more in areas with higher mortgage securitization rates. Rajan *et al* (2008) examine the incentives for lenders to seek and evaluate "soft" information in addition to the measures used for securitization (eg, FICO score, CLTV, etc). Using an approach that is similar in concept to that of Demyanyk and Van Hemert (2008), they assert that statistical default models fitted in a low securitization period that use standard financial factors systematically underpredict default for borrowers in a high securitization period in environments in which the underwriters begin not to screen for valuable soft information.

In addition to the failure of lenders to monitor soft information about borrowers, evidence has also begun to appear supporting the incidence of outright fraud (Federal Bureau of Investigation (2008)). Drawing on a number of third-party sources, the authors report that between 30% and 70% of early payment defaults may be linked to borrower misrepresentation on loan applications. Further they report that the list of the top 10 states with the highest mortgage foreclosure rates also contained 7 of the top 10 states for reported mortgage fraud.

While these studies provide suggestive evidence of reduced underwriting quality for residential mortgages and link this to increased loss rates, it would be useful to characterize more precisely the impact of this behavior. In light (*ex post*) of the role of underwriting standards in influencing losses, whether due to loosening standards by banks or other behaviors by participants in the mortgage granting process, it is useful not only to estimate the impact of this change in underwriting quality on subsequent pool losses but also to determine the relative contribution to losses from underwriting conditions compared with the relative contribution from the economic environment.

Disentangling the effects of changes in key economic factors, such as home prices and the effects of underwriting standards, poses identification issues since both are time varying and endogenous to a model. In a study that is closest in objective to this one, Anderson *et al* (2008) use aggregate foreclosure data to estimate the differential role played by underwriting and changes in the economy to explain aggregate foreclosure levels. These authors estimate a model of aggregate foreclosures based on average pool-level loan quality statistics and a proprietary index of the "favorability of the economic environment" for subprime borrowers. By including a fixed effect for each vintage, they develop an (endogenous) index of implied vintage effects not explained by the quality of the mortgages or the state of the economy. They interpret this fixed effect as a measure of underwriting quality and report that in their model, underwriting quality explains about half of the increased foreclosures experienced in recent subprime vintages, while the economic downturn explains the remaining half.

The experiments presented here differ from Anderson *et al* (2008) in three important ways. Firstly, the index proposed by Anderson *et al* is necessarily a lagging one. The use of fixed effects implies the need to observe foreclosures in the periods *following* a particular vintage in order to assess the effect of underwriting during that vintage. For example, in order to estimate the underwriting quality of the 2009 Q3 vintage one would need to wait until the performance of loans originated in 2009 Q3 became available, which could take a year or more (though once the mortgages were seasoned, economic forecasts could be used to project losses from that point forward). In contrast, the instrument used here, which is described more fully in Section 3, is a real-time measure that can be observed almost concurrently with the origination of the loans affected by underwriting quality. Secondly, the metric is a *direct* measure of underwriting quality that is exogenous to the data, rather than an endogenous one inferred from fixed effects or divergence between model and realized performance (which may be explained by a number of variables). As such, it is less likely to be contaminated by other economic factors. Finally, this metric is used in the study of *loan-level* rather than aggregate data. As a result, the model used here explicitly incorporates the behavior associated with different loan structures and borrower incentives in addition to the heterogeneous nature of many mortgage pools, which often contain loans from a number of underwriting periods.

The presence of inherent optionality associated with mortgage loans in the US market, which entitle the borrower to prepay the mortgage at any time, can confound inferences based on aggregate pool-level data. This is because portfolio-level summary statistics do not typically provide enough high-resolution information about the structure of the loans in the portfolio to account for features such as prepayment optionality. For example, when low foreclosure rates are observed in a portfolio over time, it is unclear whether these rates are low because the inherent default risk of the pool (unconditional default probability) is low or because a high prepayment rate for certain types of loans or borrowers allowed risky borrowers to prepay before they would have defaulted (conditional default probability) in a particular state of the world. Though foreclosure rates might appear the same in both cases, in the second case, observed foreclosure rates could jump suddenly if prepayment were no longer available or attractive to borrowers (due to, for example, increased interest rates).

In addition to the prepayment behavior, it can be important to consider the joint distributions of factors rather than the marginal summaries provided at the pool level. For example, consider two pools with identical mean CLTVs and identical percentages of high- and low-documentation loans. In one pool all borrowers have the same CLTV, while in the other, the borrowers are clustered into high- and low-CLTV groups. In the second pool, it also turns out that the highest CLTV loans are also those that are made to the low-documentation borrowers, while the low CLTV loans are all made to full-documentation borrowers. The second pool may have a different risk profile from the first, particularly in stress cases. However, without detailed loan-level information, it is often not possible to ascertain whether in the second pool the risk associated with higher leverage is compounded by low documentation while in the first pool it is not.

The experiments reported in this paper make use of a newly introduced simulation tool that utilizes loan- and borrower-specific attributes to decompose mortgage losses into those related to conditional prepayment probability, those related to conditional default probability and those related to conditional loss given default (LGD). This decomposition permits the introduction of an additional factor, related only to underwriting quality at the time of origination, which differentially affects loss-related behavior. Importantly, this approach exogenizes underwriting quality rather than inferring it from subsequent performance (as in, for example, Anderson *et al* (2008), Mian and Sufi (2008) or Rajan *et al* (2008)). Thus, it is possible to explicitly characterize the levels of underwriting quality at the time loans were originated and use these levels to decompose pool losses directly rather than inferring underwriting quality indirectly from the performance itself.

This paper makes a first attempt at using loan-by-loan data and tools that reflect the optionality inherent in loans of different types in order to gauge the effect of underwriting versus the effect of changes in the economy on loan losses.

The informal nature of the experiments reported here must be emphasized. The authors hope that these preliminary findings will encourage other researchers to explore this phenomenon further and also provide some initial directional guidance to market participants interested in these effects. Because the paper's goal is to provide stylized observations rather than rigorous mathematical results, the models used are not discussed in detail. However, the next section provides some background information in order to put the experiments into context. Interested readers can find more detail on the models in Kothari and Forster (2008).

The remainder of this paper is structured as follows. The next section describes the structure of the commercial model used in the experiments. Section 3 describes the factor used to measure underwriting quality in different vintages and presents some evidence that it provides information not present in either loan- and borrower-level measures of portfolio quality or measures of the state of the macroeconomy. Section 4 describes the design of the experiments and the data used in them. Section 5 presents the main results of the paper and Section 6 presents some conclusions and directions for future work.

2 THE MODEL AND DATA

A new portfolio-based simulation tool called "Moody's mortgage metrics" was used for the experiments. A fuller description of the tool can be found in Kothari and Forster (2008).[2] The tool was released in November 2008. To provide context for these experiments, this section gives a brief description of this portfolio tool.

2.1 Model overview

Losses in a mortgage pool can be conceptually explained through two dominant measures of loss: the probability of default and the severity of losses in the event of default. However, in addition to these processes, understanding the prepayment behavior of borrowers, given the type of mortgage they hold, is also helpful in

[2] Note that in the experiments that follow, the core model is used without the supplementation of the originator assessment, servicer quality rating or third-party review analytics described in Kothari and Forster (2008).

understanding pool losses. A shift in prepayment rates does not change an individual borrower's credit quality. However, the exposure of a particular mortgage pool to risky borrowers is reduced by prepayments since borrowers that prepay cannot default in the current pool.

The simulator used in the experiments is a portfolio tool that assesses the credit risk of subprime residential mortgage portfolios by explicitly modeling the prepayment, default and severity behavior of individual mortgages as a function of the loan characteristics and the values of macroeconomic factors (at the state and Metropolitan Statistical Area level). The simulator uses a multi-step Monte Carlo engine to simulate possible economic paths. For each of the loans in a mortgage portfolio, loan-level models calculate default and prepayment probabilities each quarter over a 10-year projection period. Defaults and prepayments are simulated based on these probabilities and for loans that default, severity (LGD) is also calculated conditional on the loan-level and macroeconomic factors. The simulated losses for all loans in the portfolio are aggregated to obtain pool-level losses in each of the simulated economic paths, thereby producing a distribution of losses. Thus, pool losses are a result of the correlated behaviors (default, prepayment and severity) associated with loan-level characteristics (loan structure, borrower type, etc) as well as with macroeconomic factors.

The remainder of this section gives a high-level outline of the main features of the specific components of the simulator.

2.1.1 The economic models: term structure, home price appreciation and unemployment

The risk-free interest rates are simulated using a two-factor Cox–Ingersoll–Ross term-structure model (Cox *et al* (1985)). The subprime market rate (which is important for calculating quantities such as the mortgage premium or incentive of borrowers to refinance for rate reduction) is also simulated as a function of the aggregate borrower-specific characteristics and the prevailing interest rate environment. Home price appreciation (HPA) and unemployment models are autoregressive models (which use the last two quarters of unemployment and home price movement, respectively, as well as the current level of 10-year Treasury Bonds). The simulator uses separate models for national HPA and unemployment, state-level HPA and unemployment and, for many Metropolitan Statistical Areas, Metropolitan Statistical Area-level HPA and unemployment.

2.1.2 Loan-level models

The loan-level models incorporate borrower- and loan-specific factors such as the FICO score, CLTV, documentation type, coupon rate, property type, loan type, loan purpose, loan size, legal jurisdiction, etc. Some factors (eg, CLTV and coupon rate) are updated as economic factors (eg, local home prices and London Interbank Offered Rate (LIBOR), respectively) change.

The models for predicting the two types of loan termination, prepayment and default, share a common probability framework. They are of the class of hazard rate or survival models based on time-to-event data. The implementation uses a Cox hazard model.

Unlike either the prepayment or default processes, the severity (or LGD process) is not described by a probability, but rather by a ratio: the proportion of the total amount of the loan that is lost when a borrower defaults. As a result, the LGD calculations follow a regression approach that assumes that the dependent variable is beta distributed.

2.1.3 Simulation algorithm

The various economic factor and loan-level behavior models are integrated through a multi-step Monte Carlo simulation by using the following (highly summarized) algorithm:

1) For each iteration
    - a) Generate one realization of each economic scenario (40 quarters)
        - i) For each quarter
            - 1) For each non-defaulted, non-prepaid state of the simulated loan
                - a) Determine the loan status this quarter
                    - i) If default
                        - 1) mark loan as defaulted
                        - 2) determine loan-level severity
                        - 3) record a loss
                    - ii) If prepay mark loan as prepaid
            - 2) End for loan
        - ii) End for quarter
        - iii) Sum losses for pool in period 40
    - b) End for economic scenario

2) End for iteration

3) Calculate loss distribution based on the final losses for each pool in each scenario (there will be one point in the distribution for each scenario that represents the pool losses under that scenario).

2.2 The data

The experiments described in the remainder of the paper make use of a data set of mortgage pools from 136 mortgage-backed transactions issued between 2002 and 2007. Particular interest is given to the performance of late-vintage mortgage pools. For the purposes of this paper *late-vintage* pools are defined as those pools in the sample that underlie RMBS transactions originated in 2006 and 2007.

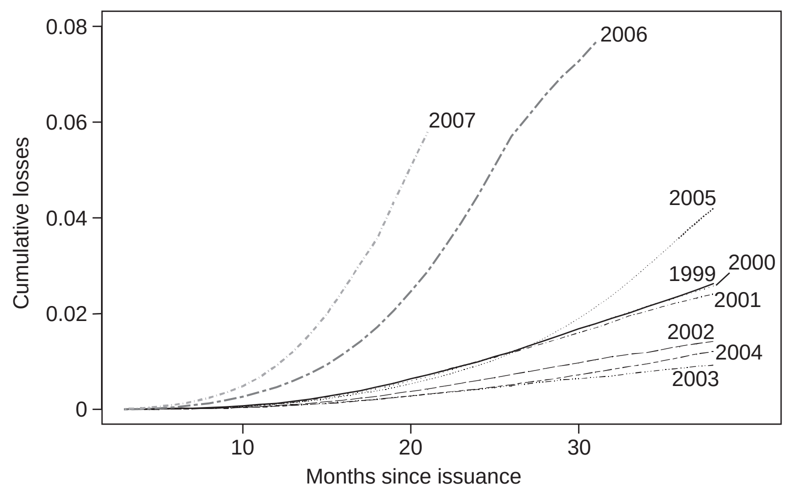
For each transaction, the experimental data set included loan-by-loan information on individual mortgages for all fields that were required in order to run the portfolio simulation. Importantly, in addition to the origination date of the RMBS transaction, each loan record also contained the origination date of the mortgage (often one or more quarters prior to the deal closing date of the RMBS), which allowed the identification of the quarter in which the underwriting environment should be observed for this loan.

In addition to data on the loans at origination for each transaction, lifetime-loss estimates for each transaction were compiled, based on Moody's analysis of current pool performance (see Rocco (2009) for a summary of these estimates). Importantly, these estimates were developed based on actual pool performance and projections about likely defaults and losses of loans that were *already* delinquent or performing. This contrasts with the simulator used for estimating loss distributions on *new* mortgage transactions without pool performance history. This data provides estimates of lifetime losses on mortgage pools that are still outstanding.

For clarity, Rocco (2009) reports two sets of forecasts: those that assume impact from government intervention and those that do not. Since it is difficult to model government intervention, the latter was more relevant in this exercise.

At this point it is useful to note that views on lifetime losses, both from an average-per-vintage perspective and from a transaction-specific perspective, vary widely among market participants, many of whom are examining the same or similar data. In reality, future losses cannot be observed, so estimates of these future losses are forecasts by their nature. That said, at the time these experiments were conducted (April 2009), the general consensus in terms of the order of magnitude of losses seems to cluster around levels that are not qualitatively dissimilar from the Moody's estimates. Of course even small differences in opinions about pool losses can translate into economically meaningful differences in losses at tranche level and in security valuation. However, since the goal in this exercise is to provide stylized observations about the drivers of these losses rather than precise economic quantities, even market participants with different views on lifetime losses due to differing assumptions or differing information sets may still find the results reported here to be of interest.

FIGURE 1 Cumulative mortgage pool losses by vintage.



Source: Moody's, March 2009 reporting period.

3 INCORPORATING AN ASSESSMENT OF UNDERWRITING QUALITY

It is generally agreed that the quality of underwriting can vary over time. In hindsight, some periods, such as 2006 and 2007, appear to have been characterized by particularly lenient lending for a variety of reasons. Not surprisingly, the rates of delinquency and the values of severity for pools originated during these vintages are particularly high. This can be seen clearly in Figure 1, which shows average cumulative losses by vintage for subprime mortgage pools. The high loss rates of the late-vintage pools stands in stark contrast to the more modest levels of earlier vintages.

However, while the figure shows marked differences in performance between vintages, it does not provide much insight into the *drivers* of these changes. For example, the property values underlying many late-vintage loans have also deteriorated substantially, and have done so rapidly. This could explain a good deal of the higher losses. On the other hand, the anecdotal evidence, supported by some of the research mentioned in the introduction, suggests that there could also have been time-varying underwriting quality effects driving portions of this performance. Endogenous measures like the fixed effects associated with the vintage cannot always provide sufficient information to parse these factors. Thus it was appealing to use an exogenous measure of underwriting quality in the current experiments. The simulator uses this factor to shift the default probabilities and the severity values to reflect the underwriting quality at the time the loan was originated. The factor is a variant on a data series provided by the Fed.

The series reports the results of a survey of bankers that the Fed conducts periodically in which it asks loan officers at various lending institutions whether their institutions are more or less likely to tighten their underwriting criteria in various asset classes, including mortgage loans, in the coming months. The Fed aggregates these responses and compiles a series that reflects *net tightness* of underwriting conditions based on this survey as the net percentage of the number of respondents who indicate tightening versus loosening.[3] For example, if the net tightness number is positive, it means that the underwriting quality is likely to tighten, whereas a negative number for net tightness means that the banks are likely to loosen the underwriting criteria. A variant of this measure was also used at the pool level in Hughes (2007). Prior to 2007 Q2, there was no subprime version of this series. In fact, the Fed initially reported a single series for all mortgages but switched in 2007 Q2 to separate series for prime and subprime markets. In order to create a contiguous series prior to this point, the newly released subprime series is adjusted to stitch it to the historical all-mortgage lending series.

Figure 2 on the next page shows the value of the raw series. From this figure, it is clear that the quarterly raw series is quite volatile. For example, note that in 2004 Q4, the series actually shows a *tightening* of standards, despite the loosening in the periods immediately before and after (boxed and inset in Figure 2 on the next page), and the bankers reported *tightening* in 2006 Q3. This volatility is characteristic of the behavior of the raw series. In early experiments, the raw series demonstrated little predictive power when used on its own. However, suitably smoothing this series (using, in this case, an eight-quarter moving average) appears to produce a factor that has greater explanatory power compared to the raw series. The experiments used a normalized version of the series, adjusted so that average underwriting tightness had a value of zero: positive values imply tighter underwriting reports and negative values imply looseness.

The results of the smoothing and the historical estimation used together produce a series that appears to be more predictive than the raw series. The smoothed series is shown in Figure 3 on page 31.

To provide some context, three lagged economic series are also shown and each is compared with the lagged survey series. Visually, none of the three macro-series appear to have a strong pattern of co-movement with the underwriting series, although there is some commonality in the behavior during some periods.

Examining the relationship of this series to losses on late-vintage pools provides some sense of the impact of underwriting on losses in general and this can be used to incorporate the impact of underwriting into the simulations. As shown in the next section, analysis using this underwriting quality factor enhanced the fits of

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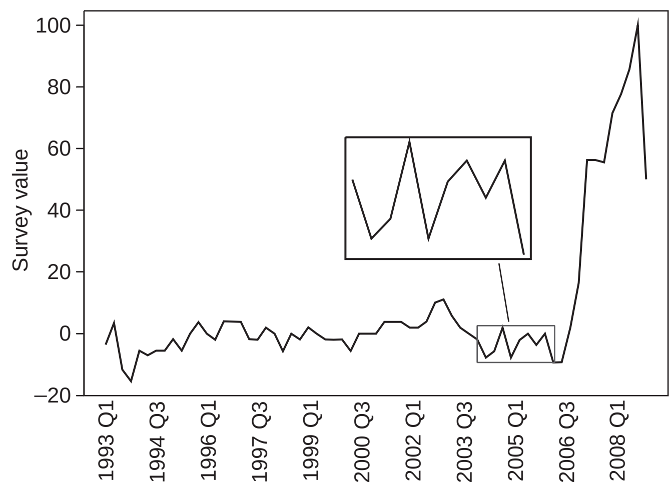
[3] See www.federalreserve.gov/boarddocs/snloansurvey/200902/chartdata.htm.

FIGURE 2 Raw series for Fed subprime underwriting survey.



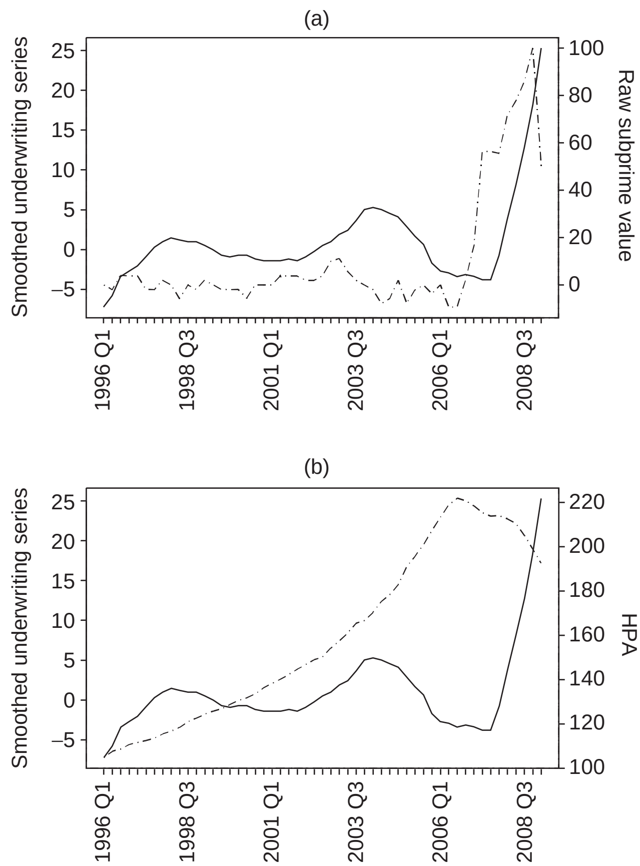
estimated pool performance to projected lifetime pool performance. In other words, the underwriting quality factor appears to provide information beyond the economic factors used in the simulations. Importantly, it does so without requiring *a priori* assumptions about issues such as the length or shape of the credit cycle, etc.

For default and severity this factor is only relevant *at the point of mortgage origination*. The tightness of underwriting reflects an estimate of the leniency that the banking community overall reported exercising in underwriting loans at that time. Once the terms of the loan are set and the borrower is granted a loan, changes in underwriting will not affect the quality of underwriting for that specific loan. For this reason, while the behavior of this factor is observed quarterly and is used to adjust the default rate and severity for each loan in a given vintage, there is no need to simulate the vintage factor into the future, since all loans in a portfolio will already have closed and future changes in underwriting practices will not affect them.

3.1 Average loss estimates with and without underwriting quality adjustments

The remainder of this paper describes experiments that rely on the simulation tool discussed in Section 2. These experiments are augmented with the underwriting quality factor (described in this section) to decompose loss drivers into those associated with generic mortgage pool quality, those associated with changes in the macroeconomic environment and those attributable to changes in underwriting quality during the period of study. In order to provide some sense of the effect of the

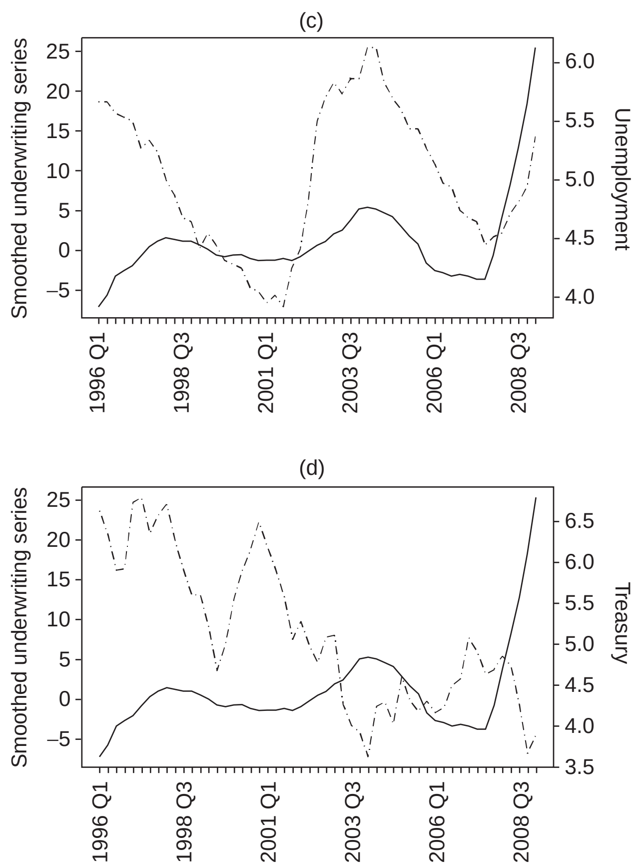
FIGURE 3 Lagged and smoothed underwriting quality series from Fed survey: (a) smoothed series (solid line) versus raw series (dot-dashed line); (b) smoothed series (solid line) versus HPA (dot-dashed line).



underwriting quality factor, it is first necessary to demonstrate the general role of this factor in establishing a better fit to the estimated lifetime losses than appears possible using loan quality and economic factors alone.

To give some notion of this, the simulator estimates the lifetime mean loss rate for a pool using a 10-year horizon from the date of closing. More specifically, the simulator divides the 10-year loss horizon for a seasoned pool into two periods. The first period comprises the time span from the given transaction's closing to the start of the simulation (typically the current date). The losses for this period are estimated using original pool composition and the actual realized economic factors until the current date. Thus, some portion of the portfolio will default or prepay in the simulation based on the realized economy (though the affected loans in the

FIGURE 3 Continued. (c) Smoothed series (solid line) versus unemployment (dot-dashed line); (d) smoothed series (solid line) versus 10-year Treasury Bonds (dot-dashed line).



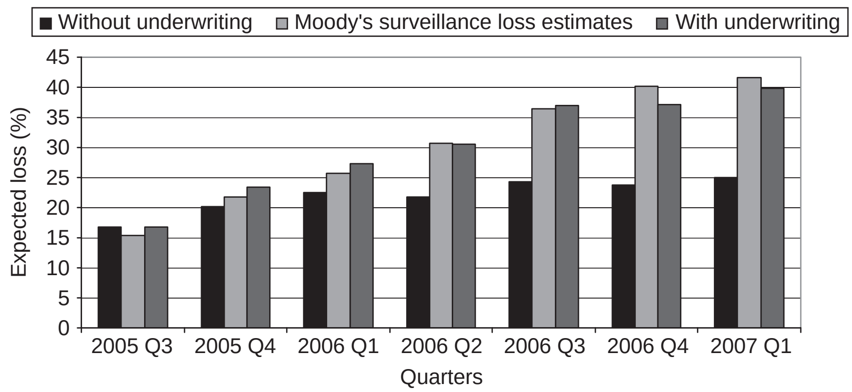
simulation may not be the same as the loans that have actually defaulted and prepaid in the subsequent performance data). The second period is populated by simulating many paths for the economy from today to the end of the time remaining in the 10-year period. Estimated mean loss for the pool in any given economic path is simply the sum of the mean losses from the first period and the second period.

Note that the historical macroeconomic data used in these experiments was data on home prices, unemployment and interest-rate levels through 2008 Q4, which is the last reported period at the time of the experiments.

Figure 4 on the facing page shows the estimated mean percentage losses[4] of the model for the 2005 Q3 through 2007 Q1 vintages with and without the underwriting

[4] All losses in this paper are expressed as a percentage of the original pool balance.

FIGURE 4 Expected losses with and without underwriting factors.



factor. The middle bar in each group represents Moody's forecasted lifetime losses based on observed pool performance,[5] while the solid black bar represents simulation results based only on the realized economy without using the Fed underwriting factor. Finally, the dark gray bar shows the current model including the Fed underwriting factor.

Note that in the case of the simulations that do not include the factor, simulated losses may agree reasonably well with a specific vintage (eg, 2005 Q3), but losses simulated on the other vintages are much lower (higher) than the realized losses. However, when including the transformed value of the Fed factor, realized losses on *many* vintages can be matched reasonably well. Note also that the difference between the simulated lifetime losses (without the underwriting factor) and empirical lifetime-loss estimates varies substantially. For example, in 2006 Q4, the relative gap is about 40%, while in 2005 Q4 it is only about 10%. This suggests that a simple multiplicative or additive adjustment will not capture the time-varying components of the loss process.

In hindsight, the behavior of the model with this factor makes sense if, as most market participants and a number of researchers believe, there were changes in the information in various measures of loan quality and the rigor with which these were collected, verified and calculated. Thus, examining the performance of loan pools based solely on these criteria may miss the change in meaning of these factors.

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[5] Note that because only a sample of pools is used for each vintage and the pool-specific lifetime-loss estimate is used for each, the average loss numbers shown in this informal study may not agree in all cases with the overall mean vintage loss estimates published in Rocco (2009).

4 THE EXPERIMENTS AND DATA

The method used for estimating the mean loss rate for a pool from an earlier vintage using a 10-year horizon simulation was described in the previous section. To recap, the simulator divides the 10-year loss horizon for an old vintage into two periods. The first period estimates the losses arising from the realized economy through the current date, and the second part projects losses based on simulated economies.

For the next set of experiments, it is necessary to run simulations in another way. For some of these experiments it is useful to net out the effect of the realized (abnormal) economy so it is convenient to estimate future losses of a pool based strictly on the information available *at the origination of the transaction*. In other words, the economic factors are simulated *from the start of the transaction's closing* for the subsequent 10 years, based only on the economic data available at that time rather than by using the realized economy up until the present and only simulating thereafter. Losses on the pool are then estimated using the 10 years of simulated economic factors. This method of estimating losses based on 10 years of simulated economic factors can be termed the "as of" method, while the other method of estimating losses based partly on the realized economy and the rest on the simulated economy may be termed the "combined" method. The key distinction is that the "as of" method represents an unconditional estimate of losses, while the "combined" method represents a conditional estimate of losses, where conditioning is done based on the realization of the economy through the current period.

These two approaches can be used to try to understand the relative impact of the economic environment and the quality of underwriting on future lifetime losses by first considering what the expected losses would be in an economy-neutral and underwriting-neutral setting then comparing these with the losses obtained when these factors are introduced. For example, if the unconditional expected losses (ELs) are estimated to be 5% without economy and underwriting factors, but when these effects are included, the figure becomes 11%. The remaining 6% ($= 11 - 5$) of losses can be explained either in terms of abnormal economic conditions or abnormal underwriting.

In order to try to disentangle the components of the average loss for a given pool losses were simulated on 136 pools, originated between 2002 Q3 and 2007 Q1, in four different ways:

(1) **As of without underwriting (unconditional EL):**[6] As of simulations are run without including the underwriting factor. Conceptually, this assumes that nothing

[6] Note here that even the unconditional estimates are based on a new simulation methodology implemented after the onset of the crisis, and therefore do not represent estimates of what the loss forecasts might have been at the actual time the RMBS was issued. For clarity, the simulator used for the experiments reported here was released in November 2008 and used components that were calibrated based on the recent subprime experience and macroeconomic dynamics.

about the realized economy is known and the underwriting condition is taken to be approximately "average" at origination. This estimate represents the unconditional EL for the pool where the losses are not conditioned on either underwriting quality or severe economic conditions. Thus, it is a baseline against which realized losses will be compared.

(2) Combined path without underwriting (abnormal economy only): Combined-path simulations are run without including the underwriting factor. Conceptually, this assumes that the realized economy is factored into the losses but that the underwriting condition at the origination of the transaction is not factored into the losses.

(3) As of with underwriting (abnormal underwriting only): The full "as of" simulations including the underwriting factor are run. Conceptually, this assumes that no knowledge of the realized economy was available but that the underwriting standard, as it was reported at the time, is factored into the losses.

(4) Combined path with underwriting (conditional EL): Full combined-path simulations including the underwriting factor are run. Conceptually, this is the most informed case in which the realized economy and the underwriting standard, as it was reported at the time, are factored into the losses.

Turning different sources of information on and off in each case attempts to control the effects of each component of losses in different ways and thus to isolate the effects of each component of losses.

The contribution of *abnormal economic conditions* towards EL is defined as the difference in the ELs for the *combined* case (ie, with realized economy) without underwriting (2) and the *as of* case (ie, without realized economy) without underwriting (1). This attempts to isolate the degree to which knowledge of the more-adverse-than-expected realized economy to date adds to the overall forecast of EL:

$$\text{Abnormal economy effect} = (\textit{combined} \text{ without underwriting}) - (\textit{as of} \text{ without underwriting})$$

The direct contribution of *abnormal underwriting* toward EL is defined as the difference between the EL for the as of case *with underwriting effect*, (3), and the as of case *without underwriting effect* (unconditional losses), (1):

$$\text{Abnormal underwriting effect} = (\text{as of } \textit{with underwriting}) - (\text{as of } \textit{without underwriting})$$

Losses that incorporate both realized economy and underwriting effect (4) can now be decomposed into four components: losses that do not incorporate realized economy or underwriting effect, plus the contribution of economy, plus the direct contribution of underwriting, plus some (typically small) residual part that captures the non-linearities arising from the interaction of underwriting and economy (that is, $\{(4)-[(1)+((3)-(1))+((2)-(1))]\}$). This simplifies to $[((4)-(2))-((3)-(1))]$:

$$\text{Total losses} = (\text{unconditional EL}) + (\text{abnormal economy}) + (\text{abnormal underwriting}) + \text{residual}$$

The abnormal losses are defined as the conditional EL minus the unconditional EL:

$$\text{Abnormal losses} = (\text{conditional EL}) - (\text{unconditional EL})$$

Finally, the percentage impact of the underwriting effect on the EL is measured by dividing the sum of direct and indirect underwriting effects by the total abnormal losses (ie, the total losses above the unconditional EL). This is equivalent to isolating the total contribution of underwriting, (4) − (2), and dividing this by the total contribution of underwriting and economy, (4) − (1):

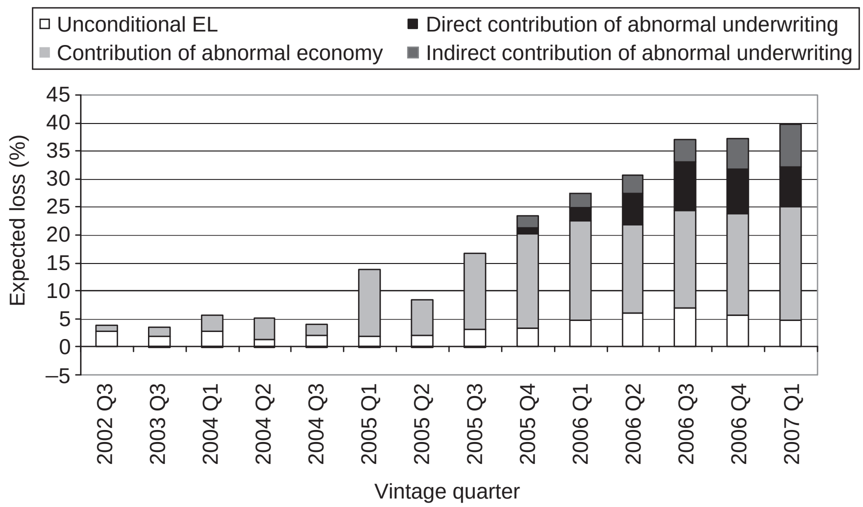
$$\text{Percentage contribution of underwriting} = \frac{(\text{underwriting} + \text{interaction of underwriting and economy})}{(\text{abnormal losses})}$$

The next section presents the results of these calculations in the simulation experiments.

5 RESULTS: THE IMPACT OF UNDERWRITING ON SUBPRIME LOSSES

While these results are informal and therefore only intended to be directional, they are fairly straightforward and can be seen graphically in Figure 5 on the facing page. In the figure, the bars represent the mean projected lifetime losses of the pools of a specific vintage, with the height of each bar showing the average loss of the loans in the sample for each vintage. The bars are made up of four components. The first component, "unconditional EL", shows the amount of losses that can be attributed (approximately) to the baseline quality of the pools in that vintage in typical underwriting environments, given the economy at the time of origination. The second component, "abnormal economy", shows the amount of losses that can be attributed to changes in the economy between origination and the current period, then from the current point through the rest of the simulation. (These losses are overwhelmingly due to declines in home prices.) The third component, "abnormal underwriting", shows the contribution of the underwriting environment at the time of origination. Finally, the last component is a residual, which is labeled as the indirect contribution of underwriting. This last component can reasonably be characterized as the combined effect of declining home prices and more lax underwriting in which lax underwriting compounds the effect of a declining economic environment.

FIGURE 5 Decomposition of the factors driving projected lifetime losses: mean contribution of each factor.



A number of things are apparent from the figure. Looking first at the baseline quality of the pools originated in each vintage, evidence of some drift in pool quality can be seen given the economic environment prior to origination, as denoted by the relatively higher loss levels associated with this component of losses in later vintages. However, in examining this component it also becomes clear that these shifts in quality were neither the dominant cause of losses nor a consistent proportion of losses. Note in particular that the mean value of the "unconditional EL" component is almost identical in 2004 Q1 and in 2005 Q4, though the projected lifetime losses for each are quite different. Importantly, this component is measured slightly differently in each period due to the starting point of the simulation in each case (the state of the economy at the time the RMBS transaction closed) so care should be taken when interpreting it.

Turning to the second contributor, the impact of the abnormal economy, a sudden and dramatic increase in the size of the losses in this component can be seen for transactions that contain loans originated closer and closer to the peak of real-estate prices in 2006 (recall that mortgages in a particular transaction are typically originated one to two quarters before the closing of the transaction itself).

The third component of losses, the impact of abnormal underwriting quality, which is the major area of focus in this study, shows a marked pattern as well. A dramatic increase in the size of this factor's impact for later vintage pools can be observed. For example, the mean contribution of underwriting quality to losses from 2003 to 2005 was very small (negative). In contrast, the mean contribution from 2005 Q4 through 2007 Q1 was about 33%. The details of these calculations are given for each vintage in Table 1 on the facing page.

In addition, the contribution to the abnormal losses of abnormal underwriting is summarized as:

$$\text{Percentage contribution of underwriting} = \frac{(\text{underwriting} + \text{interaction of underwriting and economy})}{(\text{abnormal losses})}$$

and presented in column 8.

To give some basic sense of the economic impact, shifts in underwriting quality accounted for an average of about 33% (relative) of abnormal projected late-vintage subprime losses under this analysis. In these simulations, if underwriting quality had been closer to the historical mean levels then lifetime losses on these pools might have been in the 20%–25% (absolute) range, rather than the 24%–40% range that the simulations currently suggest based on 2008 Q4 data.

6 CONCLUSION

This paper has attempted to delve a bit deeper into the effects of the underwriting environment and subsequent pool performance. In doing so, a new application of a readily available (transformed) Fed series has been introduced, which exogenizes underwriting and thereby facilitates the decomposition of the components of losses. This is particularly useful in settings where underwriting standards and the state of the economy are evolving in tandem. An attractive feature of this measure is that it can be observed in real time, and thus may be useful in forming forecasts of subsequent mortgage performance for newly originated mortgages before any performance history is available on the mortgages.

Though the experiments discussed in this paper are preliminary and informal, a number of stylized observations can be made.

Firstly, it would appear that, as many commentators believe heuristically, underwriting quality has substantially altered the risk profile of subprime mortgage pools in recent years. While many market participants appeared aware of the general trend towards loosening (as evidenced by the survey levels), it would appear that even those in the retail banking community (ie, lending officers who reply to the Fed survey) did not fully appreciate the degree to which the standards had changed. For example, the quarterly underwriting quality survey actually reported credit standard *tightening* in 2006 Q4, one of the worst-performing vintages of recent history. There is some evidence that standards were in fact loosening during this period and, indeed, the smoothed series shows this more clearly. This can also be seen in the experiments which show that in 2006 Q4, the increase in the loss estimate due only to abnormal underwriting relative to the unconditional EL (Table 1, (6)/(1)) was about 140%, compared with about 122% in the prior quarter.

TABLE 1 ELs and contributions under various combinations of realized economy effect and underwriting effect (mean).

	1	2	3	4	5 = (2 − 1)	6 = (3 − 1)	7 = (4 − 2) − (3 − 1)	8 = (6 + 7) / (4 − 1)
Vintage quarter	**Uncond. EL**	**Abnormal economy only**	**Abnormal underwriting only**	**Cond. EL**	**contribution of abnormal economy**	**Direct Contribution of abnormal underwriting**	**Indirect contribution of abnormal underwriting**	**Percentage contribution of abnormal underwriting**
2002 Q3	2.79	3.81	2.83	3.86	1.02	0.04	0.01	4.67
2003 Q3	1.82	3.46	1.80	3.44	1.64	−0.02	0.00	−1.23
2004 Q1	2.70	5.76	2.66	5.69	3.06	−0.04	−0.03	−2.34
2004 Q2	1.39	5.12	1.36	5.06	3.73	−0.03	−0.03	−1.63
2004 Q3	1.98	4.05	1.95	4.00	2.07	−0.03	−0.02	−2.48
2005 Q1	1.86	13.81	1.84	13.69	11.95	−0.02	−0.10	−1.01
2005 Q2	2.12	8.44	2.09	8.35	6.32	−0.03	−0.06	−1.44
2005 Q3	3.11	16.76	3.10	16.71	13.65	−0.02	−0.03	−0.36
2005 Q4	3.31	20.16	4.47	23.41	16.85	1.15	2.10	16.18
2006 Q1	4.75	22.51	7.16	27.37	17.76	2.41	2.45	21.48
2006 Q2	6.01	21.80	11.56	30.61	15.80	5.55	3.26	35.81
2006 Q3	7.00	24.36	15.60	36.97	17.36	8.60	4.01	42.08
2006 Q4	5.65	23.76	13.60	37.22	18.11	7.95	5.51	42.63
2007 Q1	4.70	25.07	11.81	39.78	20.36	7.11	7.61	41.95

Secondly, based on these experiments, there is some evidence of the detrimental role of the looser underwriting standards in subsequent projected losses. Based on this analysis it would appear that about 33% (relative) of abnormal late-vintage subprime losses can be attributed either directly or indirectly to the reported quality of underwriting at the time of loan origination. For reference, this implies that if reported underwriting quality was closer to the historical mean levels, simulated lifetime losses on these pools could have been in the 20%–25% (absolute) range, rather than the 24%–40% range that the model estimates based on 2008 Q4 economic data.

Finally, there appears to be some evidence that a portion of the high loss levels that are currently forecast is due to the interaction of reduced underwriting standards and concomitant declines in the economic environment. This would be the case, for example, if CLTV were understated because of less rigorous appraisals and this additional (unseen) leverage became magnified due to home price declines. Thus, the lax underwriting would exacerbate the increase in losses due to declines in the economy.

In all, while these findings are suggestive, the goal here was to provide directional evidence rather than precise quantitative guidance on the impact of underwriting on subsequent pool losses. There are many limitations to the approach (for example, data on the relationships described here is available for a limited number of years: the underwriting series itself required a fair amount of transformation and also required the realization of high loss levels on existing mortgage pools before the relationships became clear; and the distribution of mortgage pools that is shown here is less well populated in the earliest vintages).[7] The authors hope that other researchers who find this topic to be of interest will extend this research stream in the future and propose additional measures of underwriting quality. Hopefully, the instrument used (the transformed Fed survey series) will also aid researchers both in academia and in industry to better understand and characterize the complicated relationship between mortgage risks on the one hand and loan characteristics, underwriting quality and the state of the economy on the other.

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[7] Note also that the experiments do not control for the possibility of outright mortgage fraud, though this would certainly influence the results if it could be confirmed and measured.

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