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An Index of Commercial Real Estate Underwriting: Construction, Causes, and Effects

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Abstract

We constructed an index of the national level of underwriting standards for commercial mortgages. The index incorporates the shifting standards and the shifting market shares of banks, life insurers, and commercial mortgage-backed securities.

Vector autoregressions implied that underwriting importantly affected both commercial real estate mortgage flows and prices. VARs also implied that faster growth of CRE prices led to easier underwriting, and thus amplifying CRE movements.

While prior prices affected underwriting throughout the estimation period, only after the crisis did underwriting respond significantly to predictions about future commercial real estate prices, consistent with the crisis fundamentally changing CRE market analysis.

Introduction

Underwriting standards for commercial real estate mortgages are now widely regarded as having been unusually lax in the years leading up to the financial crisis and the Great Recession, both of which began in latter 2007. Standards are also widely regarded as having tightened sharply during and immediately after that crisis and recession, and then having eased nearly as rapidly and as much in the years that followed.

To measure how lax (or stringent) underwriting standards were, and when, we constructed a quarterly index of the level of underwriting standards for commercial mortgage approvals for 1990-2011. To reflect differing standards and shifting market shares, the index combined data for underwriting and data for mortgage volumes for the three largest groups of originators and holders of commercial mortgages: depositories, life insurers, and issuers of commercial-mortgage-backed securities. From each of the three largest groups, we used two indicators of commercial-mortgage underwriting, as well as each group's mortgage volume.

The index shows that underwriting standards in the aggregate did ease in the years leading up to the financial crisis, but then tightened rapidly and severely. The index shows that underwriting eased until the financial crisis and then tightened sharply, peaking in 2009, when national financial and economic markets had been weak for some time and still were weak. In the years following the crisis and the Great Recession, underwriting standards then eased nearly as rapidly and as much as they tightened a few

years earlier. Even by the end of 2011, however, commercial real estate underwriting had not become as lax as it had been just before the crisis and recession.

In addition to constructing an index that incorporated standards for nonbank as well as bank lenders, we analyzed whether commonly-cited data sufficiently well reflected aggregate commercial mortgage underwriting after the 1980s. One reason that no single indicator was likely to be a "sufficient statistic" is, for example, that underwriting standards may well have loosened before the crisis by more than reflected by commonly-cited indicators. Another reason is that, as we show below, the market shares of the three largest originators and holders of commercial mortgages shifted considerably since the 1980s.

Perhaps best known as an indicator of commercial-mortgage underwriting is the net percentage of banks that reported tightening their standards for approving commercial mortgages to the Federal Reserve (Fed). A similar, but much less well known, is the net percentage of banks that the U.S. Office of the Comptroller of the Currency's (OCC) bank examiners reported had tightened their underwriting standards for commercial real estate mortgages. Cumulating the net tightening percentages reported by OCC examiners through time, for example, implies that banks loosened twice as much during the 1990s (in 1994-1999) as they loosened during the 2000s (in 2004-2007). One reason for that disparity was likely that underwriting was especially tight in the wake of the commercial real estate debacle in the first few years of the 1990s. By comparison, the index implied that underwriting standards were a bit easier than average in the early 2000s, and then

eased from there, by the mid-2000s reducing the index of underwriting tightness to its lowest recorded levels.

Relying solely on surveys of banks may be problematic. Although banks remain the largest single source of commercial mortgage funds, nonbank investors became large and growing funders of commercial mortgages. As a result, over our sample period, depositories' share of all commercial-real-estate-mortgage balances outstanding fell by about 10 percentage points. To the extent that underwriting by the increasingly-important, nonbank investors was generally looser and also loosened more than that of banks during the 2000s, survey data for banks from the Fed and OCC were likely to mis-measure the overall level of tightness, and of tightening, of market-wide underwriting standards for commercial mortgages.

In contrast to the survey data, our constructed index implies that underwriting was far tighter during the early 1990s than during the early 2000s. The index also implies that underwriting was far looser during the middle of the 2000s and far tighter during and after the financial crisis than at any time from 1990 through 2011.

We used a vector autoregression to estimate how CRE prices and commercial mortgages responded to changes in underwriting, and, in turn, how prices and mortgages affected underwriting itself. We found that underwriting had important, independent effects on the CRE market. And, in turn, we found that underwriting tended to respond to the CRE market. In particular, before the crisis, underwriting loosened when CRE had risen more in the recent past. An implication of that finding is that underwriting amplified

movements in CRE markets: Faster growth of CRE prices led lenders to loosen underwriting, which raised CRE lending and prices further, which loosened underwriting even further.

We began this study with our hypothesis that, when they reasonably predicted that mortgage collateral would be worth more in the future, lenders would loosen their current underwriting standards. For the period before the crisis, we found little support for that hypothesis: Although past prices helped explain underwriting, predictions of future prices didn't. On the other hand, once we included the crisis years in our sample, the picture became more complex: While past prices continue to be directly correlated with underwriting, predictions of future prices of CRE also significantly explained underwriting. Taken together, these results fit with the perspective that the crisis changed how commercial mortgages were underwritten.

The remainder of this paper proceeds as follows. Section II reviews studies of the connections of underwriting to commercial real estate. Section III provides a theoretical model of the commercial mortgage market. Section IV explains how we combined information from the three largest segments of the commercial mortgage market (depositories, life insurers, and CMBS issuers) to construct our index of commercial mortgage underwriting. Using a vector autoregression, Section V analyzes the reverberation of CRE price growth, underwriting, and mortgage flows on one another. Section VI demonstrates how predictable the future growth of CRE prices is. It then shows that our measure of those predictions had no detectable effects on underwriting

before the crisis. Once the crisis years were included in our sample period, however, those predictions had significant effects on underwriting: For instance, predictions of lower future prices would be associated with tighter underwriting. Section VII summarizes our evidence and draws some implications.

Research on CRE Underwriting

The financial crisis that began in 2007 produced a torrent of real-estate-related problems and programs. The crisis has also spawned several studies about how much underwriting of commercial mortgages changed, and why, in the run-up to the crisis. The mixed signals during the 2000s of whether underwriting eased then produced mixed evaluations since then. Most, but not all, of the literature points toward underwriting's having eased until the financial crisis erupted, after which it tightened abruptly and severely.

Measuring Underwriting

Jacob and Manzi (2005) published one of the first articles that claimed that underwriting standards had eased substantially during the 2000s. They compared typical terms, conditions, and criteria for mortgages that were in CMBS pools that were originated in 2004 with those in 1998. The first sentence from their article suggests it was widely perceived that standards had declined: "Commercial mortgage-backed securities investors and rating agencies have been wrestling with whether the market has moved too far in relaxing many of the credit-enhancing features common in the early MBS deals." From their vantage point, the relevant question was not whether standards eased, but whether they had eased too much: The subtitle of the article was "Have they declined too far?"

Jacob and Manzi (2005) claimed that for a typical CMBS deal, while both the LTV and debt-service-coverage ratios (DSCRs) remained unchanged from 1998 to 2004, many other components of underwriting had apparently loosened. Thus, for the typical deal, by 2004, there were more interest-only mortgages, fewer loans (reducing diversification), more 5-year balloon mortgages, more secondary debt, and lower reserves. Particularly striking, in light of the apparently unchanged reported LTVs, was the increase in Moody's Stressed LTV from a range of 83-89% to 93-95%.[1] Thus, Jacob and Manzi (2005) implied that the two most commonly-relied-upon indicators of underwriting standards and default risk, LTVs and DSCRs, were likely to be flawed.

Not all observers, however, have concluded that underwriting standards for commercial mortgages eased during the 2000s. Among the most prominent of the naysayers are Stanton and Wallace (2018). They make a convincing empirical case that the underwriting criteria, and in particular the subordination levels, that were required by ratings agencies for CMBS tranches to be rated AAA declined considerably before the financial crisis struck. Such a decline might well have raised the (dollar-weighted-average) rating of a given CMBS pool. As a consequence, to the apparently-very-large extent that investors relied on ratings, the average spread of CMBS yields over Treasurys, for example, would be expected to fall. As suggested by Jacob and Manzi (2005), that decline in spreads would, in turn, be expected, at least eventually as supplies and

[1] Moody's Stressed LTV makes adjustments for how "sustainable" cash flows are. Perhaps more importantly, Stressed LTV uses a consistent set of cap rates, so that changes in assumptions about cap rates don't affect V and thus LTV. We address the connection of cap rates to LTVs in more detail below. We also discuss why LTVs are unlikely to be satisfactory indicators of underwriting standards.

demands equilibrated, to also lead conduit lenders (and then other originators) to reduce their underwriting criteria. Interestingly, Stanton and Wallace (2018) concluded that underwriting did not detectably ease before the crisis on the commercial mortgages that went into their CMBS pools.

One reason for the divergent views about whether and how underwriting eased during the 2000s is that some indicators signaled ease, while others did not. Those who are skeptical about easing sometimes point to the data on LTVs. One way that underwriting ease might occur is by lenders' raising their ceilings on maximum allowable LTVs (Cohen and Manuszak (2013)). Figure 1 shows that the average (first-lien) LTV on commercial mortgages originated by life insurers has generally trended down over the past two decades. The decline in the LTV series was particularly acute from 2005 through 2008. On the face of it, that suggests that, rather than having levered up, borrowers were financing less of their CRE purchases with debt and more with equity. The contrast of the LTV data with anecdotal information and data for other components of underwriting is so striking that it calls into question whether the LTV data should be taken as reliably signaling persistent tightening of underwriting over the past two decades in general and during the real estate bubble in the middle of the 2000s in particular.

In residential markets, the surge in piggyback and any other second mortgages that were originated at the time of home purchases during the middle of the 2000s also complicate the interpretation of the 2000s' decline of LTVs that were based solely on first

mortgages. Adding these seconds to firsts, for example, apparently turns the decline into an increase for residential LTVs (Wilcox (2009)).

Interpreting LTVs for commercial mortgages is typically even more difficult than it is for residential mortgages. The difficulties do not arise primarily from second mortgages, although mezzanine financing might have played a rising role during the 2000s that was analogous to residential second mortgages.

More importantly, difficulties in interpreting LTVs arise from the practices used to generate magnitudes of *V*, the "value" of CRE, that are used to calculate LTVs. Fabozzi (2007) observes that CMBS markets, for example, look to two key indicators of default risk: debt service coverage ratios and LTVs. Presumably banks, life insurance companies, and other originators and investors look to the same two indicators. In practice, according to Fabozzi (2007), *V* tends to be calculated as the ratio of net operating income to a cap rate, both of which are subject to considerable discretion on the part of originators. "Thus, analysts are skeptical about estimates of market value and the resulting LTVs reported for properties."

In addition, LTVs are likely to be set in conjunction with lenders' assessments of underlying risks of the CRE that serves as collateral and with the other terms and conditions of commercial mortgages. Grovenstein et al. (2005) make a compelling case for this endogeneity of LTVs. They point out that potential commercial mortgage borrowers and lenders often bargain over underwriting terms, conditions, and criteria, including LTV. For example, lenders may reasonably trade-off higher LTVs for other,

tighter terms and conditions. Grovenstein et al. (2005) argue that the resulting endogeneity of LTVs helps explain the otherwise-puzzling empirical findings of no or of negative effects of LTV on the (default) performance of commercial mortgages. As a result, Grovenstein et al. (2005) conclude that, before the financial crisis, LTVs are unreliable indicators of default risk. In contrast, they conclude that an empirically more reliable indicator of default risk is the (also, presumably endogenous) spread of yields on commercial mortgages over the yields on comparable Treasurys.

Reasons Underwriting Changed

Jacob and Manzi (2005) hypothesize that eased standards resulted from investors' being "complacent" about risk, "… no doubt …" due to "… a significant drop in defaults …" They also contend that the eased standards that stemmed from the environment and reduced defaults allowed conduit lenders to either reduce interest rate spreads or weaken some mortgage terms and conditions.

Several studies have focused on explanations for why the cap rate, an important component of underwriting, changed over time, typically tightening in the 1990s and easing in the 2000s. Chervachidze et al. (2009) address that particular aspect of reduced underwriting standards during the 2000s: "… *the great cap-rate compression* …" (italics added). They conclude that cap rates typically reflect interest rate and other macroeconomic conditions. In addition, they find a separate role for the flow of aggregate (not just CRE-related) debt, which surged during the 2000s and thus played a particularly important role then, if not before. These additional effects help add to the model's ability

to account for patterns in cap rates. Nonetheless, even their expanded specifications suggest that cap rates were inexplicably high following the CRE troubles of the early 1990s and inexplicably low during the 2000s, especially just before the crisis struck. Ultimately, they attribute these deviations from their estimates by unusually pessimistic and then unusually optimistic sentiments.

Clayton, Ling, and Naranjo (2009) concluded that, in addition to being primarily determined by fundamentals of the sort that other studies had suggested, cap rates also responded significantly during the 2000s to a "non-fundamental" factor, sentiment.

Mei and Saunders (1997) report that past increases of CRE prices raised individual banks' CRE lending. One explanation that they consider for their finding is that stronger demand boosts CRE prices and also boosts the demand for mortgages to fund the higher-priced CRE. They also offer another possibility: When they observe that other banks are making more commercial mortgages, banks might decide to join the herd, thereby generating the correlation that they report. And, yet another explanation might be that momentum in CRE prices leads lenders to supply more and/or investors to demand more CRE mortgages.

Reverberating Effects of Changes in Underwriting

Jacob and Manzi (2005) suggested that easier standards for CMBS and the ratings of their tranches reverberated into eased underwriting standards at conduit lenders. Banks and life insurance companies were likely to balance the risks of the large amounts of CMBS that

they held with the risks of the whole mortgages they had originated and held. If so, then eased underwriting for CMBS and their mortgages may well have led commercial banks and life insurance companies to ease their standards for the commercial mortgages that they expected to hold in their portfolios. Thus, competition and portfolio considerations would likely convey eased underwriting rather broadly across the commercial mortgage market.

Clayton (2009) explains how a positive feedback loop might develop in CRE markets. An initial increase in demand for CRE that makes the market more liquid can thereby fuel higher CRE prices. As price increases spread across CRE markets, their resulting lower cap rates may spill over into a more general decline in cap rates. When the lower cap rates are then used to justify granting larger mortgages, that increase in mortgage supply can reinforce the original increase in demand for CRE, in liquidity, and in prices. Clayton (2009) uses those mechanisms to account for developments in CRE markets in the years leading up to the financial crisis: He shows how "… rose-colored glasses in property pro forma projections …" can get translated into "… weak underwriting …" and "… easy access to low cost debt …" The resulting increase in the supply of commercial mortgages then can fuel mortgage and thus property demand.

Arsenault et al. (2012) provide econometric evidence to support the positive feedback from CRE prices to commercial mortgage supply. Based on data for 1991-2011, they show that, based on their particular specifications of the variables, faster growth and lower volatility of CRE prices increased the supply of commercial mortgages. In turn,

they also found that, based on their measure of its exogenous increases, mortgage supply further raised CRE prices. Thus, the CRE market apparently had financing feedbacks that were similar to those that allegedly then contributed to downward spirals in other parts of the economy during the financial crisis.

In part because of data limitations, there are fewer studies that directly connect underwriting to CRE lending volumes and prices, for either the crisis period or for the years just before the crisis. Long before the crisis, Hancock and Wilcox (1994, 1997) argued that banks' capital shortfalls reduced their lending generally and lending for commercial real estate in particular. Peek and Rosengren (2000) present empirical evidence that convincingly-exogenous, prior loan losses in Japan reduced Japanese banks' capital, which in turn reduced their lending in the U.S. Of course, one might regard blanket denials of credit to creditworthy borrowers as underwriting being infinitely tight. And, it may be that the banks in their studies reduced their lending by differentially tightening their underwriting. But, neither Hancock and Wilcox (1994, 1997) nor Peek and Rosengren (2000) provided evidence that underwriting was tightened especially at capital-constrained banks.

The Federal Reserve has long surveyed commercial banks about their underwriting standards. Unfortunately, the publicly-available survey data does not systematically indicate how much banks' underwriting tightened or loosened. But, Federal Reserve surveys seem consistent with anecdotal reports that banks' tightened their underwriting particularly in the early 1990s and during the financial crisis.

And, some studies have found that the replies to the survey are informative. Based on vector autoregressions, Lown and Morgan (2006) concluded that tighter bank lending standards for business loans were correlated with subsequently lower bank lending and real gross domestic product (GDP). By that yardstick, lending standards outperformed some alternative indicators of credit conditions, such as business loan interest rates. The particular channel that they emphasized was that the reduction in loan supply that was associated with tighter lending standards reduced business inventory investment. Lown and Morgan (2006) neither used the banks' replies about their CRE underwriting standards nor analyzed whether the CRE market in particular was affected by lending standards for commercial loans or for commercial mortgages. O'Keefe, Olin, and Richardson (2003) argued that surveys of bank examiners were informative about banks' underwriting standards in that the surveys helped explain subsequent loan losses.

Thus, prior studies have made strong cases that some aspects of underwriting of commercial mortgages have tightened and loosened importantly over the 1990s and 2000s. Below we take into account several aspects of underwriting and the relative importance over time of different sources of mortgage funds. We endeavor to construct an index of the overall stance of commercial mortgage underwriting. We then use vector autoregressions to estimate the causes and effects of underwriting and of commercial real estate prices and mortgages, both for a sample period that ends before the financial crisis and for one that includes the financial crisis.

A Model of the Market for Commercial Mortgages

Here we present a model of the market, or aggregate, demand for and supply of commercial mortgages. The model incorporates a role for underwriting in the demand for commercial mortgages by borrowers (e.g., builders and investors), as well as in lenders' supply of commercial mortgages. The model's implied equilibrium relations between commercial mortgages, prices, underwriting, and exogenous variables helps motivate the econometric specifications that we estimate in sections V and VI below. Those relations also inform our interpretations of the estimates.

We presume that there is enough heterogeneity across lenders, borrowers, and commercial real estate projects that the model's elasticities are finite. Heterogeneity is one reason, for example, that everyone in the model is not always at the margin, which otherwise might lead to some supplies and demands being infinitely elastic at the market equilibrium. If all projects were identical, then higher borrowing rates might have no effect on mortgage volume or property prices until, suddenly, when a tiny increase in rates tipped all projects into having negative NPVs, volume went to zero. Instead, here, when Treasury bond yields and contract mortgage interest rates rise by equal amounts, borrowing declines, but is not completely extinguished. Fewer (construction or purchasing of) projects would be undertaken and some might be scaled down, but some, albeit reduced, amount of lending and borrowing continues in that case.

To avoid unnecessary distractions and complications, the model abstracts from long-run economic growth and taxes. There is little doubt that such factors can be very important

in practice, but they are not central to the task at hand. We also assume that each of the variables corresponds to the economically-relevant horizon. As a result, we could consider, for example, the interest rates, expectations about future net operating income ("rents") and about future commercial real estate prices that pertain to a 10-year horizon.

Mortgage Supply

The aggregate supply of commercial mortgages *(M^s)* depends on the risks to lenders in CRE markets *(risk)*, on a composite measure of all of the underwriting terms, conditions, and criteria that are used by lenders *(u)*, and on other, exogenous shifts in mortgage supply *(M^s_x):*

$$M^s = s(risk, u, M^s_x) \quad (1)$$

Risk

To begin, we consider the risks that arise from factors that are external to lenders but that importantly affect them. Because they can suffer such large losses when risks turn out adversely, lenders do, of course, deliberately alter their underwriting so as to determine the resulting ("net" or "internal" to the lender) risks that they bear. We discuss the determinants of underwriting in more detail in the next subsection.

Risk can vary considerably over time. We consider risks to CRE lenders (and borrowers) to be driven by three factors.[2] These three factors tend to be determined predominantly by overall conditions in the macroeconomy and in the CRE sector. On the other hand, we assume that lenders' current supply of commercial mortgages has negligible effects on risk and on the macroeconomy.

The first factor that affects risk is the expected future price of commercial real estate. We posit that higher (expected) prices for commercial real estate reduce current estimates of risk: The more valuable that lenders expect the real estate that collateralizes their commercial mortgages to be in the future, the lower the risks of default and loss that lenders associate with commercial mortgages.

This effect is connected to the mean, or first moment, of expectations about future prices of commercial real estate. A separate, additional risk arises from the uncertainty, or forecast error variance, that accompanies a forecast of future CRE values. That variance, or volatility, reflects the second moment of the distribution of CRE values. We do not separately incorporate or measure this latter source of risk. Our empirical implementation includes a variable that might well capture both expectations and uncertainties, i.e., the forces that are related to first and second moments, of rents. As such, that same variable may well provide information about expectations and uncertainties of future CRE values.

[2] For simplicity, we take the function that relates the three components to risk to be the same for borrowers and lenders. The effects of risk on supply and demand, however, may differ. That is, Ms is not the same as Md.

The second factor that affects the risk of commercial mortgages is related to the uncertainty about future net operating income. Borrowers' currently failing to make promised mortgage payments may raise lenders' concerns about future payments and about CRE market conditions more generally. Thus, we posit that uncertainty about future rents and occupancy rates is higher when lenders experience higher commercial mortgage delinquency rates *(del)*.

We also include a third factor, r_x, to capture any sources of risk other than those that are attributable to the first two factors. Thus, we can express the effects of these three factors on risk as:

$$risk = r(p, del, r_x) \quad (2)$$

Underwriting

We next discuss the composition of underwriting. Later, we discuss how our underwriting index is endogenously determined.

Underwriting is typically comprised of several terms, conditions, and criteria, as we discuss in Section IV. We do not observe the overall, or composite, measure of underwriting directly. We can delineate three distinct, but typically complementary, components of lenders' underwriting. The data from surveys of lenders about underwriting of business loans show that when lenders tighten or loosen their underwriting overall, they tend to do so by adjusting many of their underwriting terms, conditions, and criteria in the same direction.

The first component of underwriting is the spread *(s)* of the mortgage interest rate over a relevant benchmark rate. Lenders typically raise the spread to control their expected returns in light of their risks and to take advantage of any market power that they might have. Note that the benchmark interest rate itself does not directly enter equation 1. (The benchmark interest rate will quite directly affect the demand for commercial mortgages below.)

One candidate for the benchmark rate is the yield on 10-year Treasurys. To the extent that the rates on alternative investments or on funding costs are connected more to shorter-maturity yields, the yield spread *(s)* might be set relative to those shorter-maturity yields. Commercial banks, for example, might rely heavily on yields that move closely with the federal funds interest rate. Life insurers, on the other hand, may regard 10-year Treasury yields as their relevant benchmark rate. Either way, it is a spread, rather than a benchmark rate, that is more directly relevant to lenders.

In addition to this "price" component of underwriting, we include two "non-price" components that are suggested by the discussion of lending practices that we present in Section IV. The second component is based on the mortgage balance *(M)* relative to the value *(V)* of the property being financed. (For ease of exposition, rather than *M/V*, the loan-to-value (LTV) ratio, we use its reciprocal, the value-to-loan ratio.) Since higher *V/M* connotes more collateral per dollar of commercial mortgage balances, lenders are willing to supply more funds when the *V/M* ratio is higher. The higher the *V/M* on their

newly-originated commercial mortgages, the lower the risks to lenders.[3] The third component, u_{nec}, reflects all the remaining aspects of underwriting, such as personal and cross-property guarantees, debt coverage ratios, documentation requirements, and so on.

For simplicity, we specify the composite indicator of underwriting, u, as a linear function of its three components:

$$u = b_0 + b_1*s + b_2*(V/M) + b_3*u_{nec}. \quad (3)$$

In section IV below, to construct a composite measure of underwriting, we use indicators of these components of CRE underwriting that pertain to the sources of CRE mortgage funds.

Mortgage Supply and Underwriting

Lenders supply more mortgage funds when u is higher. A larger spread, a higher property value relative to its mortgage balance, and more stringent standards for guarantees or the debt service coverage ratio, for example, each raise u. Higher u raises the risk-adjusted, expected return on commercial mortgages, thereby giving stronger incentives to supply mortgages.

As Grovenstein et al. (2005) pointed out, however, higher (external or gross) risk leads lenders to raise u. That response of u to risk makes it more difficult to estimate the effects of more stringent underwriting on measures of risk, such as loan default rates. For

[3] Geltner et al. (2007) identify LTV as the "classical … underwriting criterion … arguably the most fundamental and important single underwriting criterion." They also state "during periods of rapid price inflation and during real estate booms there is often strong pressure on lenders to relax this (LTV) traditional limit."

example, if lenders raised *u* just enough to compensate for external risk, then we might observe no simple, negative correlation between *u* and resulting, net risk as measured by mortgage default rates. Thus, we allow explicitly (1) for the direct, negative effects of (external) risk on mortgage supply and (2) for the separate, somewhat-offsetting, positive effects on mortgage supply that operate through higher risk's raising *u* and, thus, raising mortgage supply. If *u* rises enough to only partially offset such increases in risk, then the net effect of increased risk would be to reduce mortgage supply, despite higher *u*.

An Additional Channel for Underwriting: Value

An additional channel through which risk can affect mortgage supply is through its effects on the estimated "value" of the real estate being financed. In practice, most commercial mortgages are made for income-producing properties. Very many of the permanent mortgages that are first made on newly-constructed real estate do not involve an explicit sale or sales price. Therefore, rather than using a market-transaction price or than even having one available, lenders estimate "value."

Even when they have a transaction price, lenders may combine that price with information about the expected income and risks of a property to arrive at an estimate of value. Outside appraisers may also often use similar methods.[4] One reason to use information beyond a transaction price stems arises from the possibility that the price does not fully reflect all information. To the extent that future commercial real estate prices are somewhat predictable, they are not fully informationally-efficient. (Below we

[4] See Geltner et al. (2007).

offer evidence that CRE prices are predictable.) In that case, using income-based estimates of value, perhaps in conjunction with or in place of transactions prices, is justifiable.

Consider the case of having no current transaction price. To obtain estimates of the value of commercial real estate, it is common practice to estimate the value of real estate with the appropriately-discounted present value of expected net rents. Here is a simplified version (where expected future growth rates of net operating income, or rent, has been accommodated by using R^e, expected, future, average rent):

$$V = R^e/cap = R^e/(i + c(risk, u)) \quad (4)$$

In equation 4, *cap* is the "cap rate" at which rent is capitalized, i is the nominal, risk-free bond yield that serves as a base for cap rates and the function $c(.)$ reflects the effects of risk and underwriting on the cap rate that is applied to rents.

We assume that R^e depends on all sorts of forces, both macroeconomic and those that are specific to commercial real estate. A stronger economy, for example, is likely to raise both the expected rent per square foot of space that is rented and the amount of space that is expected to be rented. Alternatively, a stronger economy may raise the expected (or assumed), future growth rate of rents. That higher rent growth rate can be translated into a higher level of R^e. (Below we also note that the faster rate can be translated into a lower cap rate.) Because both of these increases may be (inversely) related to the delinquency

rate on commercial mortgages, we assume that the effects of these forces can be summarized in the aggregate delinquency rate on commercial mortgages *(del)*:

$$R^e = r(del) \tag{5}$$

Suppose that lenders' underwriting policies place fixed ceilings on the loan-to-value ratios (LTVs) that they will accept on newly-originated mortgages. With a fixed ceiling on LTV, a rise in risk or a fall in expected, average rents would each reduce estimated property values and, thus, the volume of mortgages that would be supplied. A rise in interest rates would have effects in the same direction.

It may also be that risk, in addition to raising *s*, may also reduce the LTV ceiling (or the LTV ceiling for any given settings of the other components of *u*). If so, then increased risk may impose two reductions on mortgage supply: Not only would it reduce the estimated *V* in LTV, but it would also reduce the ceiling LTV, thereby further reducing mortgage supply. On the other hand, during a time when risk is perceived to have fallen, lenders might both reduce the cap rate that they apply in estimating value and reduce the *V/M* ratio that they require. Each of these two reductions leads lenders to supply more commercial mortgages.

When current rent (R) rather than expected rent *(R^e)* is used to calculate cap rates, then assumptions of higher levels of future rent or assumptions of faster growth of future rents are impounded into the denominator of equation 4 by lowering the cap rate.

Exogenous Shifts in Mortgage Supply

Over time, lenders may in the aggregate shift their supply of mortgages for reasons other than those captured by measures of risk and of underwriting. If lenders, for example, sometimes effectively use non-price rationing, say by imposing quantity limits on their mortgage volumes, then mortgage supply falls by more than can be accounted for by rising spreads and other components of u.

We suggest two episodes when non-price rationing of credit may have been especially important. Anecdotal reports during the early 1990s, for example, suggested that bank credit was tighter than could be attributed to weakened demand or increases in conventional measures of underwriting, such as yield spreads. Nonetheless, several studies concluded that the "capital crunch" of the early 1990s reduced banks' supply of credit.[5] And, second, during the financial crisis that began in 2007, the nearly-complete cessation of CMBS issuance and the reduction in commercial mortgages that were originated also seems more severe than can be attributed to changes in conventional measures of risk, underwriting, or borrower demand for commercial mortgages. Any extra reduction in the supply of credit of this sort then can be regarded as being captured by $M^{s}{}_{x}$.

[5] See, for example, Bernanke and Lown (1991), Peek and Rosengren (1995), Hancock and Wilcox (1994, 1997).

Mortgage Demand

Mortgage demand (M^d) in the aggregate, say nationwide, is a function of the costs and benefits of borrowing to build or purchase commercial real estate:

$$M^d = d(i\text{-}p, u, R^e, risk, M^d_x) \quad (6)$$

As noted by Jorgenson (1967), higher expected rates of price appreciation of the capital good that is funded, here commercial real estate and denoted by *p*, reduce real borrowing costs. In equation 6, demand falls as the "real" cost of borrowing, *i-p*, rises, where the real cost is the nominal interest rate minus the growth rate of the price of CRE.

Demand also falls the higher are underwriting standards, *u*. Equation 6 also includes a term to stand in for the (gross) benefit of owning commercial real estate, the expected average net rent, R^e. And, since building and borrowing may be deterred by risk, we also include *risk*. Finally, demand rises with any exogenous, not-otherwise-specified source of demand, M^d_x.

The contract mortgage interest rate, which does not directly appear in *d(.)*, is the sum of *i*, the yield on (risk-free) the 10-year U.S. Treasury bond, and *s*, a spread above that yield. Since the spread is one of several components of underwriting, we capture that effect by including *u* in equation 6. Tightening of any of the other components of underwriting that deter borrowing are captured by *u* in equation 6. One example of such a component might be increased personal guarantees by the borrower, which impose higher expected costs on borrowers.

Figure 2 shows the relations of mortgage supply and demand to underwriting, *u*. More stringent underwriting, as indicated by higher *u*, raises the supply of and reduces the demand for CRE mortgages. While tighter underwriting deters borrowing, it also raised the risk-adjusted expected returns to lenders. The reduced forms for the endogenous variables of particular interest to us, the amounts of commercial mortgages *(M)* and underwriting *(u),* of course, depend on all of the model's exogenous variables (*i, p,* R^e, r_x, *del*, M^s_x, and M^d_x). Because they also depend to some extent on the endogenous variables, the variables *risk*, *cap*, and the components of *u* are also each determined endogenously by the model.

Figure 2 shows that when, for example, the nominal interest rate rises, *ceteris paribus,* the demand for mortgages shifts left, as fewer projects are deemed profitable by builders and investors. Absent any supply side reaction, both *M* and *u* decline, as shown by the movement from *A* to *B* in Figure 2. At unchanged spreads between their lending and borrowing yields, lenders would not change their supply of mortgages.

To the extent that a higher interest rate also raises the cap rate (and we would expect that it would), then the maximum loan per given project would also decline, even if the lender's maximum-allowable LTV were unchanged, because the higher cap rate, *ceteris paribus*, would reduce the value of CRE. In that case, the supply curve would also shift leftward, as shown by the shift from M^S_A to M^S_C in Figure 2. The combination of the two leftward shifts surely reduces the volume of mortgages *(M)*, but leaves uncertain whether

u would rise or fall. As depicted in Figure 2, the net effect is to raise *u* from u_A to u_C at point *C* due to the reduction in mortgage supply that stemmed from the higher cap rate that lenders use when the interest rate is higher.

On the other hand, suppose that both borrowers and lenders perceive that commercial mortgages have become less risky, perhaps because of an increase in the expected price appreciation of CRE. Then, both supply and demand shift rightward, surely increasing *M*, but again leaving uncertain the net effect of the supply and demand shifts on *u*.

These examples reflect an age-old difficulty in analyzing markets for lending--almost everything that affects loan supply also affects loan demand, and vice versa. Thus, it is often the case that models of lending can pin down the direction of net effects, whether on the quantities or on the prices (in this case, underwriting) of interest. In our model, supply and demand shift in the same direction when there is a change in *risk, p,* R^e*, or del*, for example. As a consequence, although it predicts which direction mortgage volumes move, unless sufficient restrictions are imposed on the magnitudes of the responses in the model, the model does not predict whether *u* would rise or fall when any of those variables change.

Implications for Empirical Implementation

We use our evaluation of the (lack of sizable) feedback from the commercial mortgage market to the macroeconomy and the model above to guide our selection of endogenous and exogenous variables to include when we estimate a vector autoregression (VAR) for

the market for commercial mortgages. Because the commercial real estate market is too small to importantly affect macroeconomic magnitudes, we take *i* and *del* to be exogenous. We also included two other exogenous variables: (1) a linear time trend and (2) the economy-wide inflation rate.

In our VAR, we included three endogenous variables: *M*, *u*, and *p*. We took *p*, the growth rates of prices of CRE, however, to be pre-determined with respect to *M* and *u*. We regard *p* as responding over time, though not contemporaneously, to the supply and demand for mortgages, as well as to the exogenous variables.

Underwriting can be quite quickly adjusted at low cost by lenders in response to changes in any market conditions. If lenders raise their expectations of the future growth rate of the prices of real estate, *p*, then *u* could well respond soon. We do assume, however, that *u* does not respond instantly, here in the current quarter, to shocks to the exogenous variables, including contemporaneous shocks to the demand for mortgages. In contrast, we assume that CRE mortgage originations, however, can respond, either because of the decisions and actions of lenders or borrowers in the current quarter to shocks to either *p* or *U*. This suggests the appropriate ordering of the variables in a VAR: *p*, *u*, *M*.

Measuring Commercial Mortgage Underwriting

In this section, we describe what we regard as underwriting, some available data that reflect underwriting, and how we calculated our index of commercial mortgage underwriting (UW).

Some, but not all, data sources include multifamily mortgages in commercial mortgages. When data did not include multifamily mortgages, we made adjustments to so that our data reflects multifamily mortgages being in our measures of commercial mortgages.

What is Underwriting?

We regard underwriting to include the many standards or lending policies that lenders use to determine whether to originate loans, of what amounts, and with what terms, conditions, and criteria. We regard as underwriting those standards and policies that lenders may tighten or loosen, relative to their (risk-adjusted, actual or opportunity) cost of funds. As a benchmark, lenders might generally use some combination of economy-wide interest rates, such as the federal funds interest rate and the yield on 10-year U.S. Treasurys.

Indicators of Underwriting

Underwriting for residential mortgages includes standards for minimum monthly payment to income ratios, down payments, minimum credit scores, employment history, documentation, and so on. Commercial mortgage underwriting includes standards for similar concepts, plus others. Unlike in the residential market, the terms on commercial mortgages are often negotiated and customized to individual transactions (Geltner et al. (2007), Grovenstein, et al. (2005)).

The Senior Loan Officer Opinion Survey (SLOOS) conducted by the Board of Governors of the Federal Reserve System (2011) asks about five dozen banks quarterly about

(changes in) their underwriting standards for commercial mortgages. Less frequently the SLOOS asks banks about particular components of underwriting for commercial mortgages. Annually, the SLOOS asks banks whether they have changed the following components of their underwriting for commercial mortgages: maximum loan size, maximum loan maturity, spreads of loan rates over banks' cost of funds, loan-to-value ratios (LTVs), requirements for take-out financing, and debt-service coverage ratios (parts a through f of question 13).[6]

Figure 3 presents data for banks' loosening or tightening of those components during 1997-2012. Figure 3 shows that the components generally moved in unison, loosening in 1997-1998Q3and tightening in 1999-2002Q1, then loosening in 2004-2007Q1 and tightening in 2007-2011. Banks reported substantially more tightening during the late 2000s than during the early 2000s. Some components were reported as changing most often and/or most considerably (spreads, LTVs, and maximum loan sizes) and others less so (take-out financing and maximum maturities). The simple correlations of these six components were very high, ranging from 0.90 to 0.97. Correlations between the annual values of those components and the responses to the question about underwriting overall (in the appropriate quarter) were also quite high, ranging from 0.75 to 0.84.[7]

[6] Geltner et al. (2007) lists several other CRE terms including: amortization rates, up-front fees and points, prepay options, back-end penalties, recourse, (cross-) collateralization, and equity participation for the lender. Clauretie and Sirmans (2010) list other terms for construction loans including: disbursement conditions, collateral, takeout commitments, rental agreements from major tenants, personal guarantees, and commitment fees.

[7] Since these correlations are generally so large and similar to one another, we do not provide a table presenting these individual correlations.

Constructing an Index of Underwriting

Lenders may alter their underwriting standards over time for commercial mortgages in light of their assessments and proclivities for risks and returns and of their liquidity and capital positions. Different conditions may lead different originators (i.e., bank A vs. bank B) or even entire segments (i.e., depositories, life insurers, issuers of commercial mortgage-backed securities (CMBS), etc.) to have somewhat different underwriting standards at any given time. At any given time, lenders also alter the components of underwriting (spreads, LTVs, etc.) by individual borrowers and by types of loans (e.g., short-term construction loans vs. long-term "take-out financings," and fixed-rate vs. variable-rate loans).

Creating an index of overall commercial mortgage underwriting standards, then, inevitably involves combining data for different components of underwriting and types of loans from the major segments that originate commercial mortgages. [8] For simplicity, we refer to issuers of CMBS as having, in effect, originated commercial mortgages. To the extent that CMBS issuers set underwriting standards for the commercial mortgages that they would buy from mortgage bankers and other conduit lenders, the CMBS issuers were for all practical purposes setting the underwriting standards that those originators adhered to. In that case, CMBS issuers were originators in all but name.

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CRE lending often can be separated into two stages. Borrowers first obtain short-term, variable-rate land development and construction loans, typically from depositories (Clauretie and Sirmans, 2010). Once construction is finished, owners of the projects borrow via newly- and separately-originated and underwritten longer-term fixed-rate financing (often 7-10 years).[9] The decisions about whether to originate these longer-term mortgages, often referred to as take-out financing, are often based, to a large extent, on the relationship between their income-producing ability (i.e., projected rental income) and their mortgage payments, as typified by the debt-service-coverage ratio (Clauretie and Sirmans, 2006).[10] Thus, questions 13a-d in the SLOOS likely apply to most types of commercial mortgages, question 13e applies only to long-term take-out financings, and question 14f applies to income-producing take-out financings (i.e., not to owner-occupied properties that do not generate rental incomes).

We calculated our index of commercial mortgage underwriting (UW) as a share-weighted average of indicators of underwriting that pertained to the major segments of the market for commercial mortgage originations as follows:

$$UW_t = \sum_{i,t} \left(s_{i,t} * uw_{i,t} * c_i \right) \quad (7)$$

where *t* indicates the quarter of observation during 1990:2 and 2011:3; i indicates the segment of commercial mortgage originators: depositories (commercial banks plus

[9] Depositories commonly require recipients of construction loans to have arranged in advance long-term financing for the property, with which a large part of the construction loan will be paid off (i.e., takeout commitment) (Clauretie and Sirmans 2006).

[10] For perspective, on December 2010, commercial banks' commercial real estate mortgages included $240 billion of construction loans, $463 billion of mortgages to owner-occupied properties, and $679 billion of mortgages to income (i.e., rent) producing properties. Nearly all mortgages held then by life insurers ($299 billion) and CMBS issuers ($622 billion) were for income-producing properties.

thrifts), life insurers, or CMBS issuers. Our index incorporates separate information about underwriting by each of the three segments because each segment can and does use their own underwriters and underwriting standards to originate commercial mortgages. Because market competition and common factors affect them all, changes in the underwriting by one segment may spill over to other segments, contributing to correlation of underwriting across segments. But, in addition, segment-specific factors and sluggish adjustments may cause differences in underwriting standards across segments. One reason for the differences may be that different segments cater to customer bases that only partially overlap.[11] Another reason is that different segments may face different capital and liquidity constraints at different times, say due to regulations or to technological advances. That underwriting standards differ across segments is, in part, reflected by their shifting market shares of originations and of commercial mortgages outstanding. (Figure 10 shows that changes over time in relative market shares have been quite substantial.)

We designed UW to incorporate the sizable shifts in the relative shares of commercial mortgages that were provided by the three segments of loan originators. Thus, in equation 7, $s_{i,t}$ is the relative share of commercial mortgages held by a segment. (We used the relative share, which is the share for each segment of the sum of the three segments.)

[11] Life insurers tend to specialize in properties in the most prime locations. Borrowers in less prime locations tend to be included in CMBS pools.

We used shares of commercial mortgages outstanding (i.e., balances) instead of shares of net flows or of originations. Shares of mortgages outstanding provide an indicator of the medium-term importance of each segment of the market, or of its near-term capacity to originate mortgages. We eschewed using shares of net flows or originations, because a segment with substantially tightened underwriting might exhibit short-term declines in its share of net flows (even negative) or originations (as low as zero for CMBS during the financial crisis) that belied that segment's importance to the CRE market.

Figure 4 plots the ratios of commercial mortgages outstanding that were held by each of the three segments, as well as of the sum of all other smaller segments, each as a percentage of potential GDP. Depositories and life insurers both reduced their holdings greatly in the early 1990s. The very small but growing participation by CMBS issuers then offset only a small fraction of those reductions. In the late 1990s, by contrast, holdings by CMBS issuers and then by banks rose quite dramatically. Life insurers' holdings continued to slowly dwindle from the late 1990s onward. Then, in the middle 2000s, depositories and nontraditional investors both accelerated their holdings. By 2007, CMBS issuers, having been a miniscule part of the commercial mortgage market through the middle of the 1990s, had grown to be about half as large as depositories.

CMBS issuers began to scale back their holdings (as always, relative to potential GDP) starting in 2007, while banks continued to add to their holdings, which peaked in 2008. From 2008 through the end of our data in the third quarter of 2011 (2011:3), holdings by depositories and CMBS issuers both dropped dramatically. Although bank holdings

dropped by a larger percentage of potential GDP, the percentage decline in CMBS issuers (30%) was considerably greater than that for banks (20%).

In equation 7, $uw_{i,t}$ indicates measures, not of the changes in underwriting (i.e., tightening), but of the level of underwriting (i.e., tightness) in each of the three segments. That is, we designed UW_t so that it allowed comparisons over time, not only of tightening but, of the overall level of underwriting tightness. Thus, it permits direct comparisons of how tight commercial mortgage underwriting was, for instance, (1) when CRE was severely troubled in the early 1990s, (2) during the 2001 recession, and (3) during the financial crisis and recession and their aftermath.

Below, we discuss how we constructed each of the three measures of a segment's underwriting, $uw_{i,t}$. Since the units of measurement for each of the indicators differed, we transformed each measure into comparable units. First, we standardized the measure for each of the three segments by subtracting its own mean and dividing by its own standard deviation, each computed for 1990-2011. ($uw_{i,t}$ refers to the standardized indicators). That produced three variables that had means of zero and standard deviations of one.

Next, we weighted those standardized measures by the relative importance of each segment. However, this approach alone would imply that the total variation in underwriting across sectors was identical. A casual glance at the dynamics in each segment reveals that this is unlikely to be the case. For instance, while CMBS originations ceased completely during the crisis, those for depositories and life insurers did not. Further, while interest spreads for mortgages granted by life insurers climbed

markedly, even the spreads on AAA CMBS securities climbed far more, implying that even if CMBS had originated loans, the spreads would have been even larger. Since changes in underwriting may surface both in more price-like terms (e.g., interest spreads) and in more quantity-like effects (e.g., the amount of originations), we transform the standardized indicators by multiplying them by time-invariant conversion factors (c_i) based on the one element (or effect) of underwriting for which we had comparable data across all three segments: the amount of originations.

We computed c_i as follows. First we adjusted the times series of originations from each segment for inflation and economic growth, by dividing it by potential GDP. Next we computed c_i as the ratio of the standard deviation divided by the mean for each adjusted time series. Each c_i provides an indicator of how volatile originations were for each segment. In particular the values were 0.42 for depositories, 0.33 for life insurers, and 0.95 for CMBS issuers. Thus, first we standardized raw indicators of underwriting for each segment, that each used non-comparable units, by subtracting their means and dividing by their standard deviations. Next, we transformed the standardized indicators into ones with more comparable units by multiplying each by a conversion factor that is based on the standard deviation of series (i.e., originations) that are affected by changes in underwriting standards. Note that we are not using the time path of originations to calculate the time path of underwriting. We use data for gross originations to calculate time-invariant conversion factors, c_i,, which we use to construct indicators of underwriting by segments that have more comparable units ($uw_{i,t} * c_i$).

Surveys of Banks and Bank Examiners as Indicators of Underwriting

Federal banking regulators regularly conduct surveys on banks' underwriting. The Fed asks loan officers of banks to report whether they have tightened underwriting; the OCC asks its own employees whether the banks that they have directly examined have tightened underwriting. Importantly for our purposes, the questions ask about changes in, but not levels of, underwriting. [12]

Figure 5 plots the net percentage of banks that the Fed survey and the OCC survey reported as having tightened their underwriting.[13] (Appendix A lists the questions and possible answers in the Fed's and in the OCC's surveys about commercial mortgage underwriting.) For instance, the net percentages in the Fed survey range from about -20 (indicating that more banks reported loosening than tightening) in 2005 to more than +80 during the financial crisis.

The two series in Figure 5 were highly correlated over the 1990-2011 sample period, at 0.67. The OCC's bank examiners reported net tightening to be generally negative (i.e., banks were loosening) from 1994 through 1999. In the Fed survey, banks themselves reported much more modest loosening then. Both surveys reported considerable net

[12] The question is prefaced by the following statement: "If your bank's lending standards or terms have not changed over the relevant period, please report them as unchanged even if they are either restrictive or accommodative relative to longer-term norms. If your bank's standards or terms have tightened or eased over the relevant period, please so report them regardless of how they stand relative to longer-term norms. Also, please report changes in enforcement of existing standards as changes in standards."

[13] The OCC reports data for the first quarter of each year. To obtain the data for the other quarters, we linearly interpolated between the values reported for the first quarters. This approach almost guarantees that the OCC data here will be smoother and have more measurement error than the Fed data. The OCC reported this data in 1995-2011. In Appendix B we explain how we extrapolate values of our OCC variable for 1990:2-1994:4 and 2011:2-2011:3.

tightening during 2001-2003, which included and followed the 2001 recession. During 2004-2006, loosening was reported, especially in the OCC survey. During the financial crisis, both surveys then reported record high percentages of banks tightening.

To construct an indicator of (the level of) commercial mortgage underwriting by depositories, we cumulated the survey answers on net tightening at banks. However, figure 5 also plots horizontal lines depicting each survey's 1990-2011 mean. The higher horizontal line shows that, on average, the net percentage of banks that reported tightening to the Fed was over 15 percent. The OCC survey average was close to 10 percent. The surveys' answers do not provide much detail about how much tightening or loosening took place. But, if tightenings and loosenings were of equal magnitudes across banks and time, then the very substantial average net percentage tightening means that underwriting at banks tended to become tighter and tighter over 1990-2011, and even over 1990-2006.

Cumulating the net changes in tightening over these two decades would imply that underwriting would have been substantially tighter during mostly of the 2000s than it was in 1990. Given the widespread perceptions that underwriting had loosened appreciably by 2003-2007, that implication seems unwarranted. Its large, positive mean net tightening also implies a similar, but less dramatic, trend in OCC examiner assessments of banks' commercial mortgage underwriting. Because that relentless tightening of underwriting seemed quite implausible, we linearly de-trended each cumulated series. To do so, we

regressed each cumulated series on a constant and a linear trend. We then used the residuals of each regression as the de-trended series.

We cannot, of course, know which survey more accurately measures actual underwriting at banks—presumably each survey carries some valuable information. But, we can see that different indicators, even those that presumably seek to measure quite similar phenomena in similar samples, can carry quite different information.[14] To bring the information in each to bear, we simply averaged the (cumulated, de-trended) answers to both surveys to generate our overall indicator of commercial mortgage underwriting by depositories (which we extended to include both commercial banks and thrifts).[15]

Figure 6 contrasts the indicator of tightening (i.e., change in tightness) from the Fed's survey and our indicator of tightness (i.e., cumulative amount of tightening) that we derived by cumulating, de-trending, and averaging the Fed and OCC surveys. (To ease presenting both series in the same set of axis and since tightening was reported four times per year, we annualize the cumulative indicator dividing it by four.) The figure highlights, of course, that tightness does not peak when most banks are reporting tightening the most (e.g. 2008 for the most crisis). Rather, tightness peaks at the end of each period of tightening, or when more banks begin to loosen than to tighten (i.e., 2010 for the most crisis).

[14] We used the quarterly answers on overall credit standards from the Fed survey instead of the annual answers for specific terms (from question 13 in the January 2012 SLOOS) assuming that the quarterly overall data properly aggregates the annual information available for the several specific terms.
[15] i.e., our index assumes that commercial mortgage underwriting by thrifts largely mimics that by commercial banks.

According to our indicator of bank underwriting tightness, conditions were far tighter during the crisis (peaking at an index level of 83 in 2011:1) than following the earlier thrift crisis (38 in 1992:1) and the relatively milder recession of the early 2000s (8 in 2003:3). In contrast, the level of looseness from bank was roughly comparable following the loosening of the 1990s (reaching -60 in 2000:1) and the loosening of the mid 2000s (reaching -50 in 2007:1).

Table 1 presents the correlations between (1) the raw answers (i.e., before cumulating and de-trending) to the Fed and OCC survey questions on net tightening by banks, (2) our indicators of the level of bank tightness (i.e., cumulative, de-trended tightening), and (3) the overall underwriting index (i.e., including information about life insurers and CMBS issuers). The correlation between the two indicators of bank tightening is high (0.67), as is that between the two indicator of bank tightness (0.87). Many of the correlations across indicators of tightening and tightness are, unsurprisingly, low (e.g., 0.16 between the Fed's indicator of net tightening and its resulting indicator of tightness).

Indicators of Underwriting from Life Insurers and CMBS Issuers

Absent survey data or other indicators of overall underwriting for the other two large segments of the commercial mortgage market, we sought to construct indicators for those segments that included as much information as possible for the many components of underwriting.

For our indicator of commercial mortgage underwriting by life insurers, we used the product of (1) an adjusted capitalization rate and (2) the spread of the interest rates on their commercial mortgages over the yield on 10-year U.S. Treasurys. In the commercial mortgage market, the capitalization rate is the rate at which the future projected rental incomes associated with a property are discounted to estimate the underlying estimated value of the property that lenders will use deciding whether to originate a loan and setting its amount and terms. Life insurers and CMBS issuers lend to income-producing properties and may use as the value of the property not its potential (and uncertain) resale value, but the discounted value of projected rental income.[16] Using a lower capitalization rate will lead to higher estimated values of the properties and, assuming that the amount of money to be lent is capped by an LTV standard, then lower capitalization rates could lead to larger loan amounts. Since the impact of lower interest rate spreads (paid by borrowers) and lower capitalization rates (leading to potentially higher loan amounts) likely compound one another nonlinearly, we did not compute their joint impact on underwriting as a weighted average, but rather as their product.

Since we regard underwriting as including those factors set by individual loan originators beyond economy-wide interest rates, we used an adjusted capitalization rate instead of its unadjusted version. Our adjusted capitalization rate is computed as the unadjusted version minus the yield on 10-year U.S. Treasurys plus half of an inflation rate.[17] In our

[16] According to Geltner et al. (2007), when both are available, value may be set as the lower of the sale price and the appraisal price.

[17] For this calculation, we used an inflation rate based on the core private consumption expenditures price index, computed as a 5-year moving average, centered on the current observation, using the FOMC's median projections for the values for 2012 and 2013.

adjustment, we included half the inflation rate because total rental income likely rises when economy-wide prices rise, but not as fast. Clayton, Ling, and Naranjo (2009) show that cap rates tend to move in the range of ½ as much as nominal interest rates. Over our two-decade sample period, lower inflation was the main reason for the downward trend in nominal interest rates. That suggests that, apart from other forces, cap rates tended to rise when inflation fell. Thus, to calculate the adjusted cap rate, we added ½ of the economy-wide inflation rate to the reported cap rate.

Figure 7 plots the adjusted capitalization rate, the mortgage interest spread, and their product. Our indicator of commercial mortgage underwriting by life insurers (i.e., the product) shows substantial tightening following the recessions of 1990-1991 and 2001, and far sharper tightening during the financial crisis. It also shows significant loosening in the late 1990s and only slightly more loosening during the mid-2000s. Since the crisis, much of the extreme tightening has subsided, but conditions remain at levels that would have been considered very tight even during earlier tightening episodes.

For our indicator of commercial mortgage underwriting by CMBS issuers, we combined (1) the values from a "loan" spread when loans were originated, (2) those from a "security" spread during several quarters surrounding the financial crisis (2008:3-2010:2), when CMBS were not originating new loans, and (3) estimates of the loan spread for some early quarters. The loan spread refers to the spread between the average interest rate paid by individual mortgages within a CMBS pool (i.e., the weighted average coupon, WAC) over the yield on 10-year U.S. Treasurys. The security spread refers to the

spread between the current yields on pre-existing AAA securities issued by CMBS pools over the yield on 10-year U.S. Treasurys.[18]

Figure 8 plots the components of our indicator of commercial mortgage underwriting by CMBS issuers. The figure highlights several key features about the two key series and their relationship. Since interest payments on CMBS securities are ultimately paid by interest payments from the underlying mortgages, the loan spreads (on average loans) have typically been higher than that for the spreads for the most senior securities. However, the spread between those two spreads has varied over time. During the early years of infancy in the CMBS market (e.g., 1993-1995), loan interest rates tracked oscillations in the yields of 10-year U.S. Treasurys far less closely than did interest rates on market-traded AAA securities. Moreover, the spread between the two spreads narrowed markedly for several years during the boom leading to the financial crisis. While we cannot be certain what interest rates would have prevailed had CMBS originated loans during the quarters when they did not, using the spreads for AAA securities as a proxy for underwriting by CMBS issuers clearly highlights how much tighter conditions were in this segment of the market during the financial crisis.

[18] Data providers (e.g., Commercial Mortgage Alert) report that data on mortgage rates within CMBS during the early 1990s was not as reliable as since the mid-1990s. Thus, for 1992:1, we used the average of values in 1991:4 and 1992:2 instead of the reported value. For 1992:3, we also used the average of values in 1992:2 and 1992:4 since data was missing. For 1990:2 through 1991:2, since data was also missing, we used extrapolated fitted values from a regression of the spread of WAC over Treasurys and the spread of life insurers contract interest rates over Treasuries (and one lag) computed for 1991:3 -2008:2. We also used the AAA spread instead of the WAC spread for 2009:4 and 2010:2 since the values of the WAC spread for those two quarters were clear outliers from the general relationship between WAC spreads and AAA spreads during 1991:4-2011:3. Current yield equals the interest rate at origination divided by current price.

Excluding Originations as an Indicator of Underwriting

Many other data series that are related to CRE markets are likely to be correlated with underwriting. Many of them would be correlated because of a causal link from underwriting to the other variables. For example, originations, net flows, and total balances of commercial mortgage, expenditures on commercial construction, CRE prices, and many other variables likely reflect underwriting. We deliberately chose to exclude these variables when we constructed UW. Because our goal is to construct an underwriting index that we can then use to help account for movements in those and other variables in a VAR, we avoided including them in the construction of UW.

The Index of Commercial Mortgage Underwriting

Figure 9 presents again the indicators of underwriting for the three largest segments in commercial mortgage lending: depositories (from Figure 6), life insurers (from Figure 7), and CMBS issuers (from Figure 8), but each re-scaled into comparable units (each series was, first, standardized subtracting its mean and dividing by its standard deviation and, second, converted into comparable units multiplying by the ratio of the standard deviation and mean of the ratio of originations to nominal potential GDP for each segment, $uw_{i,t} * c_i$).

Figure 9 highlights that the level of tightness and looseness across segments has varied across segments in recent decades. For instance, according to these indicators, depositories loosened underwriting more than CMBS issuers during the late 1990s, but CMBS loosened far more than depositories during the mid-2000s. Further, CMBS (and

life insurers) tightened far earlier and far more than depositories during the crisis.[19] While spreads may not be a complete indicator of underwriting, our indicators imply that tightness peaked for life insurers and CMBS issuers far earlier (both in 2009:1) than for depositories (2011:1). Thus, while the current level of tightness is close to its pre-crisis highs for all three segments, tightness for life insurers and CMBS have decreased substantially from the their crisis peaks, but tightness for depositories has only diminished slightly.

Figure 4 above presented commercial mortgages outstanding (i.e., not originations) held by the three largest segments of originators relative to nominal potential GDP, highlighting for instance that depositories' holdings of commercial mortgages experienced rather large swings from, for instance, 10% in 1990 to 6% in 1996, 11% in 2008, and 9% in 2011. In contrast, Figure 10 presents the time-varying shares, $s_{i,t}$, (of the sum of the three segments' holdings) of commercial mortgages held by each of the three segments. In contrast to its swings relative to GDP, depositories' share oscillates far less relative to the other two segments, falling slowly from close to 70% in 1990 to around 60% in 2007. The decline in life insurers' share has been more pronounced from 30% in 1990 to about 10% in 2007. CMBS's share has concomitantly grown from negligible levels in 1990 to about 30% in 2007. The shares for all three segments have been largely frozen in place since 2008.

[19] Recall that during the crisis, CMBS issuers did not actually originate any mortgages. While this might not be operationally different from underwriting standards of infinity, we simply used the AAA CMB spread as a proxy for CMBS underwriting tightness. These spreads were temporarily very high, and were higher than those for mortgages originated by life insurers, which were also temporarily very high.

Table 2 presents the correlations among the indicators of underwriting for the three segments ($uw_{i,t}$) and the overall weighted index (UW). The correlations highlight how despite the likely influences across segments (e.g., from depositories to life insurers and CMBS issuers, and in the opposite direction), using a single indicator (e.g., depositories') to describe the overall market likely involves large shortcomings. Thus, the correlations between underwriting by depositories and the other segments' are relative low (at 0.33 and 0.36). In contrast, the correlations between the overall index *UW* and those for each of the three segments are rather high (ranging from 0.78 to 0.82). The high correlations among many (but not all) of the individual components, indicators, and segments of underwriting, coupled with our relatively small sample size (86 quarters) and a statistical method that estimated many parameters, rendered impractical including all potential candidates separately. Thus, an important goal of our project was to construct a single underwriting index that would reflect as many of the components of the commercial mortgage market as was practical.

Figure 11 displays our index of commercial mortgage underwriting, UW_t ($UW_t = \sum_{i,t} \left(s_{i,t} * uw_{i,t} * c_i\right)$).

Underwriting tightened noticeably in the early 1990s (with the index peaking at 0.35 in 1993:3), on the heels of the turmoil in CRE markets that began around 1990. During the long macroeconomic recovery of the 1990s, we calculated that underwriting loosened substantially (down to -0.50 in 2000:1). Underwriting again tightened, but crested in 2002 barely above its longer-term average level (of zero) and still well below its peak

during the early 1990s (at 0.07 in 2002:4). Our index then indicates continual and speedy loosening of underwriting until the spring of 2007, reaching the loosest levels ever in 2005-2007 (at -0.59 in 2007:2). Once turmoil struck financial markets in 2007, underwriting tightened more and more sharply than at any time during 1990-2011. After being at historic highs in 2008-2009 (at 1.58 in 2009:1), our index suggests that much of the extreme tightening during the crisis has been removed (down to 0.51 in 2011:1). However, the level of tightness still exceeds by far any experienced before the crisis. These readings for underwriting generally conform to public perceptions over time. This pattern of underwriting also offers reasonable prospects for helping to account for the observed patterns in CRE prices and commercial mortgage flows.

An Estimated Model of CRE Prices, Underwriting, and Mortgages

In this section, we explain how we estimated the effects of underwriting, CRE price growth, and commercial mortgage flows on one another. We are particularly interested in (1) whether predicted increases in prices loosened underwriting, and (2) whether looser underwriting increased commercial mortgage flows.

Estimating a VAR

To address these questions, we estimated a vector autoregression (VAR) with three endogenous variables and three exogenous variables. The three endogenous variables were: our indicator of the level of tightness in commercial mortgage underwriting (henceforth: underwriting or UW), the year-on-year percentage growth rate of nominal

CRE prices (henceforth: CRE price growth), and the net flow of commercial mortgages as a percent of potential GDP (henceforth: mortgage flows). The three exogenous variables in our VAR were: a commercial mortgage delinquency rate, the yield on 10-year U.S. Treasurys, and an inflation rate (derived from the GDP deflator).[20]

We selected our endogenous and exogenous variables based on our literature review and on the judgment that they were important, aggregate variables that were likely to affect or be affected by underwriting, or both. To estimate a VAR, we regressed each of the three endogenous variables in the VAR on: their own (first two quarterly) lags, the (first two quarterly) lags of each of the other two variables, a constant, a linear trend (or time) variable, and on the one-period lags of the three exogenous variables. As the sample period, we used 1990:2-2011:3, the period for which UW was available.[21] (Coincidentally, we used indicators from three segments in the CRE mortgage market to construct UW, and the VAR contains three endogenous variables and three exogenous variables.)

Figures 12 and 13 contrast the "level" and "flow" versions of two of the endogenous variables in our VAR. Figure 12 presents the inflation-adjusted level (i.e., not the nominal growth rate) of CRE prices and the total amount (i.e., not the net flow of

[20] Appendix B describes more precisely all data series we used in this paper and provides their sources. All data series are national aggregates and seasonally adjusted as appropriate. For example, GDP was seasonally adjusted; interest rates were not.

[21] The results were not very sensitive to a number of alternative specifications. For example, the results were not much affected by substituting real for nominal house price growth, or by including as exogenous variables GDP gap, the federal funds rate, or a commercial mortgage vacancy rate. They also were not much affected by using more or fewer lags of our endogenous and exogenous variables. We also experimented with sample periods excluding the financial crisis, and much longer periods using information from life insurers' underwriting as proxies for the overall commercial mortgage market.

originations minus repayments and defaults) of commercial mortgages as a percent of potential GDP. In the figure, we re-based the data so that each series equaled 100 in the first quarter of 1990 (1990:1). The figure highlights that CRE markets have been on a roller coaster for the past two decades. During the early 1990s, both prices and mortgages (relative to the size of the economy) declined a lot and for a long time. The index of CRE prices fell by more than 20 percent from 1990 through 1992. Commercial mortgage balances fell by about one-third through 1996. By the late 1990s, both series had rebounded somewhat. Starting in 2002, CRE prices then rose sharply for several years, climbing more than 50 percent by the end of 2007. CRE prices then plummeted, falling by about 40 percent in 2007-2009. Despite some subsequent recovery in CRE prices, at their trough in 2009, real CRE prices were below where they had been in 1990. Mortgage balances rose more steadily before the crisis, rising faster in the late 1990s and in the middle 2000s. After 2008, mortgage balances also declined, dropping by about 15 percent from the end of 2007 through the middle of 2011.

Figure 13 is based on the same data as Figure 12, but plots "flows" rather than "levels." Perhaps more than Figure 12, this figure highlights the dramatic declines in CRE prices during the financial crisis and the substantial decline in the early 1990s. Figure 13 also alerts us that CRE prices not only rose considerably by the middle of the 2000s, but that price growth accelerated in the middle of the 2000s. (Faster price growth in the middle of the 2000s will later play an important role in our explanation of why underwriting loosened so very much during the middle of the 2000s.) Figure 13 also shows that net

flows of commercial mortgages rose quite steadily through the end of 2007. After 2008, of course, net flows were negative.

One question is whether broad, macroeconomic conditions either caused or were at least highly correlated with CRE price growth and mortgage flows over the past two decades. Figure 14 suggests that macroeconomic conditions alone were not likely sufficient to account for some of the most important developments in commercial real estate. Figure 14 plots data for the percentage gap between actual real GDP and potential real GDP. Figure 14 shows that the GDP gap rose considerably during the late 1990s, but from 2001 onward, hovered near zero until the financial crisis struck. Although CRE price growth and mortgage flows were somewhat correlated with GDP gap before 2000, they seem unconnected since then, at least until the financial crisis when so very many economic measures turned down. Figure 14 also shows that the nominal yields on 10-year U.S. Treasury bonds and the federal funds interest rate both generally declined over the 1990-2011 period as the underlying inflation rate trended down.

Table 3 presents the correlations among the variables in our VAR. The correlations among the variables specific to CRE are rather high and are consistent with intuition. For instance, price growth and mortgage flows are somewhat highly correlated (0.49), with both strongly inversely correlated with underwriting (-0.62 and -0.74). Of course, simple correlations do not establish whether higher price growth led lenders to loosen underwriting, whether looser underwriting leads to higher price growth, or both. VARs can help sort that out.

Correlations were also high, and unsurprising, between commercial mortgage delinquency rates and the other measures of the CRE market. Tighter underwriting coincided with high mortgage delinquency rates. Faster growth of CRE prices coincided with larger mortgage flows and with lower mortgage delinquency rates. The correlations between our macroeconomic variables and CRE-specific variables were lower, ranging from -0.34 and 0.39. An exception was the correlation of -0.61 between underwriting and the 10-year U.S. Treasury yield, which perhaps reflected interest rates deterring CRE activity.

Estimated VAR coefficients imply impulse response functions (IRFs), which trace out the responses over ensuing quarters to an unpredictable increase, or "shock," (of one standard deviation of the residual) in any of the endogenous variables. These responses capture the reverberations through time of an initial shock throughout the model.[22]

An IRF illustrates the responses over time, for example, of CRE price growth to an upward shock (tightening) to underwriting. Then, for subsequent quarters, it shows the total effect on CRE price growth when the repercussions of resulting changes in mortgage flows, as well as any lagged responses, are considered. To the extent that the responses of underwriting to other variables, and vice versa, fit our other information about underwriting, our confidence in the caliber of *UW* is bolstered.

Responses to Underwriting and Other Variables

[22] We include results based on the ordering: prices, underwriting, mortgage flows, but we did not find results to be affected by the choice of ordering.

Figures 15-17 display six IRFs, one for the responses of each of three endogenous variables to an upward shock to each of the other two endogenous variables.[23] We display responses over eight quarters since they typically were statistically insignificant at longer horizons. Our results typically were damped, rather than explosive, over longer horizons.

Overall, there were relatively few surprises or puzzling results. The IRFs were generally consistent with *UW*'s serving as an effective index of aggregate underwriting. CRE markets slowed when *UW* tightened. And, *UW*, in turn, tightened when CRE markets slowed. Figure 15 plots the responses of CRE price growth to (upward) shocks in underwriting and mortgage flows. Upward shocks to underwriting lowered CRE price growth (significantly during quarters two through four). Somewhat surprisingly, shocks to mortgage flows did not have statistically significant effects on price growth. We cannot identify whether shocks to, or responses of, mortgage flows were due to attributable to mortgage supply or demand, or both.

Loosening Underwriting When Collateral Values Are Rising

Figure 16 plots the responses of underwriting to (upward) shocks in price growth and mortgage flows. Upward shocks to CRE price growth loosened underwriting (significantly during quarters two through five). Mortgage flows had a statistically insignificant, negative effect on underwriting. Because shocks to mortgage flows here

[23] Although we calculated them, we do not display or discuss the responses of a variable to shocks to itself, since these results were, unsurprisingly, positive and significant, and thus largely uninteresting.

came both from mortgage supply or demand, which our theoretical model suggests had opposite effects on underwriting, it is not surprising that we did not find a strong net response.

Figure 17 plots the responses of mortgage flows to (upward) shocks in price growth and underwriting. Price growth had a statistically insignificant, positive effect on mortgage flows. Upward shocks to underwriting lowered mortgage flows (significantly during quarters two through five).

Intriguingly, underwriting loosened in response to an upward shock to price growth. Given the strong momentum in CRE price growth, an upward shock to price growth reasonably presaged even further increases in prices. Sensibly predicting that the prices of CRE, which collateralize commercial mortgages, were likely to continue to rise, lenders may have rationally loosened their underwriting when CRE prices rose.

Did Predicted CRE Prices Affect Underwriting?

In this section, we show that future CRE price growth can be readily predicted with past information. We then show that, in the sample period before the financial crisis, underwriting apparently responded, not to predicted, future prices, but rather to recent, past prices. When the crisis is added to the sample period, the results are more complex. In the sample that included the crisis years, both recent, past prices and predicted, future CRE prices significantly affected underwriting.

The IRFs showed that *UW* tended to fall following an upward shock to CRE price growth. We hypothesize one reason, but perhaps not the only reason, for underwriting to loosen when CRE price growth rises. Table 4 below shows that future price growth rates are readily predicted from past information. In general, rising CRE prices have reliably predicted additional increases over ensuing quarters. Thus, rising prices signal that CRE collateral will become even higher priced, suppliers of commercial mortgages can loosen underwriting (e.g., lower mortgage spreads) without raising expected losses. (The same argument, applied however to residential real estate, was advanced in Wilcox (2009).)

Table 4 shows the results of regressing the actual, eight-quarter-ahead (annualized) CRE price growth rate, on recent, past values of the variables that we used in the VARs above.[24] Because the past values of the regressions' variables would have been available beforehand, these specifications are feasible prediction equations. (Rather than calculate regressions with sample periods that rolled forward quarter-by-quarter as a method that prevents future information from entering the calculations, we used a single sample period for each row in Table 4.) To explore whether our results are sensitive to including data from the crisis, in Tables 4 and 5, columns 1-3 present results for sample periods excluding the crisis, and columns 4-6 present results for sample periods including the crisis.[25] It turns out that the results are indeed very sensitive to including the crisis.

[24] We used a two-year horizon, since lenders are likely interested in predicting the value of their collateral for several years into the future. The specifications in Table 4, as well as the estimated VAR that used above, could be used to forecast over longer horizons than we did here.

[25] Using 2007:4 as a cutoff date for the pre-crisis period and using a two-year ahead CRE price growth measure, the sample periods excluding the crisis end on 2005:4 and those including the crisis end on 2009:4.

Columns 1 and 4 explore whether the first (one-quarter) lag of CRE price growth predicted CRE price growth over the ensuing eight quarters. Column 1 confirms the conventional empirical wisdom that momentum in CRE price growth made prices predictable, before the crisis. However, column 4 shows that lagged CRE price growth alone did not significantly predict CRE price growth over the ensuing eight quarters. Columns 2 and 4 show that the second (highly auto-correlated, one-quarter) lag was insignificant.

Columns 3 and 6 use as independent variables the same variables that were in each VAR equation. These additional variables improved explanation of CRE price growth, with adjusted R^2 rising from 0.13 to 0.65 for the sample that excluded the crisis and from 0.001 to 0.42 for the sample that included the crisis. They also substantially lowered the standard errors of the estimates, by 38% and 24%. F-statistics for tests of the joint significance of the VAR variables (i.e., rows 4-10) in the presence of lags of CRE price growth are labeled $F_{2,}$ in Table 4. These additional variables were significant at better than the 1% level. Tests of the joint significance of the lags of CRE price growth (i.e., rows 2-3) in the presence of the VAR variables are labeled F_3. Perhaps surprisingly, lags of CRE price growth added little, with significance levels of 21% and 57%. But, whether using only lagged prices or using the other VAR variables, CRE price growth is predictable from past information.

Predictable CRE price growth is necessary for the "higher prices-looser underwriting" hypothesis. Predictably higher prices, and thus collateral values, would allow lenders to

loosen underwriting without incurring raising risk above its prior levels. Absent predictable prices, neither high current prices nor recent, past price growth would justify eased underwriting.

Table 5 tests whether underwriting responds to recent, past CRE price growth or to current predictions of future CRE price growth. The dependent variable is our index of underwriting (*UW*). Each column includes the first lag of *UW* as an independent variable, whose coefficients were always economically large, ranging between 0.85 and 1.09, and statistically significant. Thus, like CRE price growth, underwriting exhibited considerable momentum.

Columns 1 and 4 present the results when two-year-ahead predicted CRE price growth is added as an explanatory variable. For predicted price growth, we used the fitted values from the regressions shown in columns 4 and 6 of Table 4. Columns 2 and 5 present the results from regressions that included instead one-quarter lags of (actual) CRE price growth. Predicted, future and recent, past price growth are weakly correlated (0.12). However, table 5 shows that underwriting significantly loosened when either predicted (columns 1 and 4) or actual (columns 2 and 5) CRE price growth rose, regardless of whether we included the crisis in the sample period.

Columns 3 and 6 constitute a statistical "horserace" between predicted and past price growth. The estimated effects of predicted and of actual price growth changed markedly when we included the crisis years. Before the crisis, predicted price growth was insignificant, once we included past, actual price growth (and the VAR variables). In

contrast, when we included the crisis years, both predicted price growth and past, actual price growth were clearly significant.[26] As with Table 4, the F-statistics test whether the VAR variables as a group (apart from lagged *UW*) were significant in the presence of predicted price growth (F_2) and whether predicted price growth was significant in the presence of the VAR variables (F_3).

Summary and Implications

Virtually all important aspects of commercial real estate markets endured large fluctuations during 1990-2011. Prices and volumes ebbed and flowed, and then ebbed and flowed again. The shares of commercial mortgages provided by different groups of ultimate funders also ebbed and flowed. So, too, did underwriting standards.

We constructed a quarterly index of the overall level of underwriting tightness. To do so, we used a wide range of indicators of the tightness of commercial mortgage underwriting. We used variables related to commercial mortgage underwriting standards at depositories, life insurance companies, and CMBS issuers, and incorporated the effects of their shifting market shares. In contrast to government surveys that report whether banks changed their underwriting standards since the previous period, our index provides a

[26] We also performed regressions of UW including as independent variables only lagged underwriting, predicted price growth, and actual lagged price growth, both excluding and including the crisis. The results for these independent variables matched those in columns 3 and 6, where other variables from the VARs were also included. In regressions of UW including as independent variables the first lags of all variables in the VARs, but excluding predicted prices, only the lags of UW and actual price growth were significant, both for samples excluding and including the crisis.

quarterly measure of the level of market-wide underwriting standards was during each quarter, which enables us to compare the overall tightness over time.

We used a vector autoregressions to estimate how CRE price growth and commercial mortgage flows were affected by underwriting, and, in turn, how price growth and mortgage flows affected underwriting. We found that underwriting had important, independent effects on the CRE market. And, in turn, we found that underwriting itself responded to the CRE market. In particular, we found that underwriting loosened when (the growth rate of) CRE prices rose. Our results suggested that, before the crisis, underwriting eased in response to faster growth of CRE prices. That implies that, before the crisis, underwriting amplified movements in CRE markets: Faster price growth led to easier underwriting, which in turn boosted CRE lending and prices, which, in turn, led to further easing of underwriting standards.

Our measure of predicted price growth is based not only on past, actual price growth, but also on the other VAR variables. We interpret the insignificance of predicted price growth as implying that, before the crisis, underwriting may have been based on simple extrapolations of prices, perhaps ignoring the information about future CRE prices that could have been extracted other variables in CRE market. An inappropriately narrow focus on recent, past prices may be a hallmark of a bubble. In contrast, we interpret the surge in the significance of predicted price growth that we found when we added the crisis years to the estimation period implying that underwriters then took a broader view of the information that was relevant to setting underwriting standards. Using more

information than just past prices to guide underwriting ought to reduce the amplification that can arise from the reverberations between prices, volumes, and underwriting standards.

It is easy to accept that informative variables should be used. It is much more difficult to judge whether they are being used appropriately. Just as some underwriting factors may have been under-weighted before the crisis, in the years following the crisis and the Great Recession, it might have been that some factors were over-weighted. We leave analyzing those issues to further research.

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Appendix A:
The Fed and the OCC Surveys of Banks' Underwriting of Commercial Mortgages

In their separate surveys, the Fed and the OCC ask about banks' commercial mortgage underwriting. The Fed conducts a "Senior Loan Officer Opinion Survey on Bank Lending Practices" (SLOOS) of among the largest banks in each Federal Reserve District. For example, as of March 31, 2011, the sample included 33 large banks (with over $20 billion in assets) totaling $6.7 trillion in assets and 22 other banks totaling $0.3 trillion in assets, out of the $10.5 trillion for all domestically chartered, federally insured commercial banks. In the July 2011 survey, the Fed asked the following question:

"Over the past three months, how have your bank's credit standards for approving applications for CRE loans (including construction and land development loans and loans secured by nonfarm nonresidential real estate) changed?"

The survey gave banks the following five choices for their responses: Tightened considerably, tightened somewhat, remained basically unchanged, eased somewhat, or eased considerably.

The Fed reported the net percentage tightening, which was calculated as the sum of the percentages of banks tightening considerably and tightening somewhat minus the sum of the percentages of banks easing somewhat and easing considerably.

The OCC conducts an annual "Survey of Credit Underwriting Practices." The 2011 survey included examiner assessments of credit underwriting standards at 54 of largest national banks with assets of $3 billion or more. The survey covers loans totaling $4.2 trillion as of December 31, 2010, approximately 94 percent of total loans in the national banking system at that time." In 2011, the survey included assessments of the changes in underwriting of commercial mortgages for the 52 banks engaged in this type of lending among the 54 in the survey.

The OCC survey gives examiners the following three choices for their responses: tightened, unchanged, and eased. We computed net percentage tightening as the share of banks tightening minus the share of banks easing.

Appendix B:
Data Descriptions and Sources

Life insurer's loan-to-value (LTV) ratio:

Ratio of (commercial mortgage) loan amount to property value, both as reported in the loan approval process. Data were available quarterly for 1965-2011:3 from ACLI, and were not seasonally adjusted.

Commercial mortgage underwriting index (UW):

Share-weighted average of the underwriting indicators for each segment of commercial mortgage originators: depositories, life insurers, and CMBS issuers.

Fed:

Net percentage of bank loan officers that reported tightening of commercial mortgage underwriting in the Fed's Senior Loan Officer Opinion Survey (SLOOS) on Bank Lending Practices. Data were available quarterly for 1990:3-2011:3 and were not seasonally adjusted. We cumulated and linearly de-trended the survey net percentages for 1990:2-2011:3.

OCC:

Net percentage of bank examiners that reported tightening of commercial mortgage underwriting in the OCC's survey of credit underwriting practices. Data were available annually for 1995-2011, and were not seasonally adjusted. Answers referred to the change between the first quarter of the current year (e.g., 1995) and the first quarter of the previous year (i.e., 1994). We interpolated values for the second through fourth quarters of each year. We estimated values for 1990:3-1993:4 and 2011:2-2011:3 based on the relationship between the OCC answers and Fed answers, and our composite indices of underwriting for life insurers and CMBS during 1994:1-2011:1. We cumulated and de-trended the resulting quarterly series for 1990:2-2011:3.

Life insurers' capitalization rate:

Net stabilized earnings divided by the value of CRE held by life insurers, each as reported during mortgage approvals. Net stabilized earnings are reported after operating

expenses and property taxes, but before incomes taxes, depreciation, and debt service. Data were available quarterly for 1965-2011:3 from the American Council of Life Insurers (ACLI), and were not seasonally adjusted.

Life insurer's interest spreads:

Difference between interest rates on fixed-rate commercial mortgages originated by life insurers and yields on U.S. Treasurys with a comparable average life. Data were available quarterly for 1996:1-2011:3 from ACLI. For 1990-1995, we used the difference between the average interest rate on fixed-rate commercial mortgages originated by life insurers and the yield on 10-year U.S. Treasurys.

Weighted Average Coupon (WAC):

Average interest rate at origination for mortgages within CMBS pools. Data were available quarterly for 1991:1, 1991:3-1992:2, 1992:4-2008:2, 2009:4, and 2010:2-2011:3 from Commercial Mortgage Alert, and were not seasonally adjusted.

AAA CMBS spreads:

Average spreads over comparable U.S. Treasurys for legacy (i.e., existing) AAA-rated securities issued by CMBS issuers. Data were available quarterly for 1992-2011:3 from CRE Finance Council and other sources, and were not seasonally adjusted.

Commercial mortgages (balances and flows):

Total and those held by depository institutions (commercial banks and thrifts), life insurers, and issuers of commercial mortgage-backed securities (CMBS). Balances are not seasonally adjusted. Flows are expressed as seasonally adjusted annual rates. We scaled total commercial mortgage balances and net flows by potential GDP. Data were available quarterly for 1952-2011:3 from the Federal Reserve's Flow of Funds and the Congressional Budget Office (CBO).

CRE prices:

Nominal level of the Transaction-Based Index (TBI). Data were available quarterly for 1984-2011:4 from the Massachusetts Institute for Technology (MIT) Center for Real Estate. We used the BEA's implicit GDP price deflator to adjust the level of CRE prices for economy-wide inflation.

Commercial mortgage delinquency rate:

End-of-quarter ratio of commercial bank's commercial mortgages (i.e., construction and land development loans, loans secured by multifamily residences, and loans secured by nonfarm, nonresidential real estate) that are delinquent (both accrual and nonaccrual). Data were available quarterly for 1991-2011:3 from the Federal Reserve, and are expressed as seasonally adjusted annual rates.

Interest rates:

Yields on federal funds and on 10-year U.S. Treasurys, not seasonally adjusted, were available quarterly for 1954:3-2001:3 from the Federal Reserve.

GDP Gap:

The percentage difference between actual GDP and potential GDP. Data were available quarterly for 1949-2011:3 from the Bureau of Economic Analysis (BEA) and CBO, and were seasonally adjusted. Positive values imply an economy operating above potential.

Table 1: Correlations of survey indicators of commercial mortgage underwriting by depositories

	FED: net tightening	OCC: net tightening	FED: cumulated, de-trended	OCC: cumulated, de-trended	Underwriting Index (UW)
FED: net tightening	1.00				
OCC: net tightening	0.67	1.00			
FED: cumulated, de-trended	0.16	0.64	1.00		
OCC: cumulated, de-trended	-0.24	0.29	0.87	1.00	
Underwriting index (UW)	0.30	0.73	0.89	0.71	1.00

Table 2: Correlations of composite indicators of commercial mortgage underwriting by segments of the market

	Depositories	Life insurers	CMBS	Underwriting Index (UW)
Depositories (from Fed and OCC surveys)	1.00			
Life insurers	0.36	1.00		
CMBS	0.33	0.90	1.00	
Underwriting index (UW)	0.82	0.78	0.80	1.00

Table 3: Correlations of variables in the commercial real estate vector autoregression (VAR)

	Underwriting index (UW)	CRE price growth	Commercial mortgage net flows	Delinquency rate	10-year U.S. Treasury yield	Inflation rate
Underwriting index (UW)	1.00					
CRE price growth	-0.62	1.00				
Commercial mortgage net flows	-0.74	0.49	1.00			
Delinquency rate	0.67	-0.52	-0.83	1.00		
10-year U.S. Treasury yield	-0.61	0.19	0.20	-0.08	1.00	
Inflation rate	-0.34	0.28	0.27	0.11	0.39	1.00

Table 4: Predictability of CRE price growth

Dependent variable: Eight-quarter-ahead CRE price growth

Sample period	1990:2-2005:4 (1)	1990:2-2005:4 (2)	1990:4-2005:4 (3)	1990:2-2009:4 (4)	1990:2-2009:4 (5)	1990:4-2009:4 (6)
Crisis included	No	No	No	Yes	Yes	Yes
1. Constant	4.69 (4.64)	4.64 (4.57)	15.63 (2.59)	3.75 (3.35)	4.01 (3.56)	5.51 (0.67)
2. Price growth (t-1)	0.41 (3.23)	0.24 (1.01)	-0.29 (-1.73)	0.02 (0.23)	0.30 (1.44)	0.19 (1.02)
3. Price growth (t-2)		0.22 (0.86)	0.28 (1.51)		-0.33 (-1.51)	-0.17 (-0.90)
4. Underwriting (t-1)			-4.94 (-0.40)			-5.16 (-0.69)
5. Underwriting (t-2)			29.14 (2.76)			28.07 (4.18)
6. Mortgage flows (t-1)			-1.06 (-0.52)			-0.74 (-0.28)
7. Mortgage flows (t-1)			1.60 (0.85)			-1.59 (0.66)
8. Delinquency rate (t-1)			-2.23 (-4.70)			-3.18 (-4.94)
9. 10-year Treasurys (t-1)			-1.52 (-1.44)			1.31 (0.96)
10. Inflation rate (t-1)			4.62 (3.41)			3.45 (1.95)
Summary statistics						
11. Adjusted R^2	0.13	0.13	0.65	0.001	0.004	0.42
12. S.E.E.	7.36	7.37	4.54	9.60	9.53	7.25
13. F_1	10.49 (0.00)	5.59 (0.00)	13.39 (0.00)	0.05 (0.82)	1.16 (0.31)	7.10 (0.00)
14. F_2			14.05 (0.00)			8.51 (0.00)
15. F_3			1.61 (0.21)			0.57 (0.57)

t-values are in parentheses under coefficients and p-values are in parentheses under F-statistics.

Table 5: The effects of predicted CRE price growth on underwriting

Dependent Variable: Underwriting Index (UW)

Sample period	1990:4-2005:4 (1)	1990:3-2005:4 (2)	1990:4-2005:4 (3)	1990:4-2009:4 (4)	1990:3-2009:4 (5)	1990:4-2009:4 (6)
Crisis included	No	No	No	Yes	Yes	Yes
1. Constant	0.009 (0.82)	0.003 (0.40)	0.002 (0.22)	0.06 (3.25)	0.03 (1.70)	0.26 (2.10)
2. Underwriting (t-1)	0.98 (28.06)	0.89 (24.16)	0.85 (8.69)	1.04 (27.30)	0.84 (14.19)	1.09 (10.29)
3. Predicted price growth (t, t+8)	-0.0031 (-2.41)		-0.0015 (-0.45)	-0.0103 (-4.46)		-0.0175 (-4.82)
4. Price growth (t-1)		-0.0056 (-4.82)	-0.0053 (-3.89)		-0.0072 (-3.29)	-0.0055 (-2.49)
5. Mortgage flows (t-1)			-0.03 (-1.17)			-0.08 (-2.18)
6. Delinquency rate (t-1)			-0.005 (-0.49)			-0.05 (-3.28)
7. 10-year Treasurys (t-1)			-0.01 (-0.43)			-0.01 (-0.52)
8. Inflation rate (t-1)			0.03 (1.26)			0.08 (2.88)
Summary statistics						
9. Adjusted R^2	0.93	0.95	0.94	0.91	0.90	0.93
10. S.E.E.	0.06	0.06	0.06	0.13	0.13	0.12
11. F_1	412.87 (0.00)	527.78 (0.00)	147.12 (0.00)	380.23 (0.00)	343.09 (0.00)	136.51 (0.00)
12. F_2			3.61 (0.00)			4.73 (0.00)
13. F_3			0.20 (0.66)			23.24 (0.00)

t-values are in parentheses under coefficients and p-values are in parentheses under F-statistics

Figure 1: Loan-to-value ratio of commercial mortgages originated by life insurers, 1990-2011:2.

Percent, quarterly, not seasonally adjusted, ACLI.

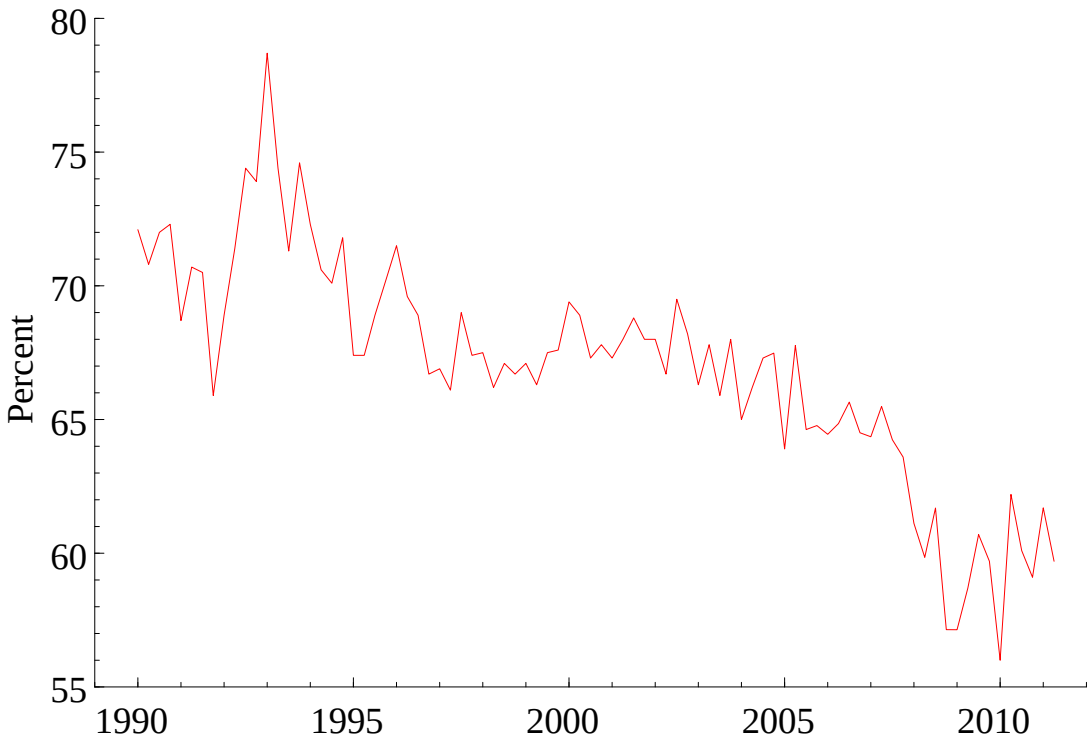

Figure 2: The supply of and demand for commercial mortgages.

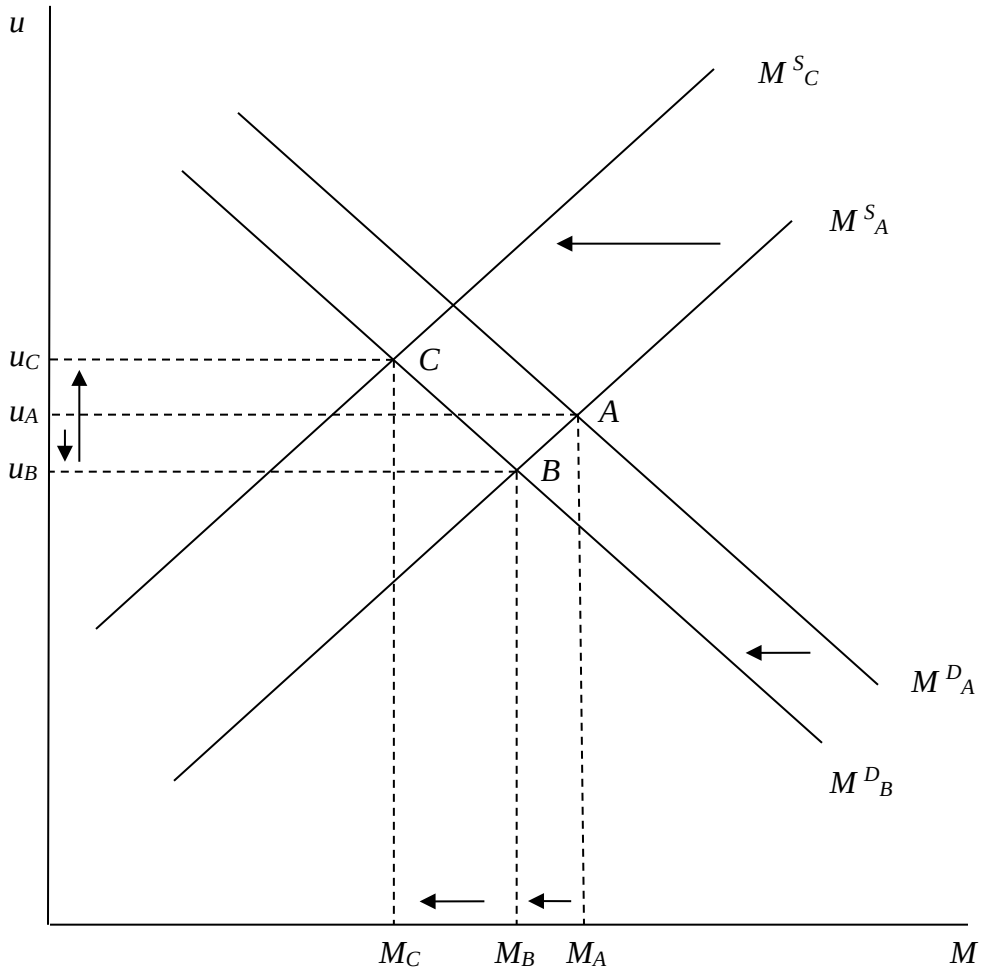

Figure 3: Changes in components of commercial mortgage underwriting, 1997-2012.

Changes from one year earlier, averaged across banks (1 = considerable tightening, 3 = basically unchanged, 5 = considerable loosening) from a year earlier, to Q2 in 1997, to Q3 in 1998, and to Q1 in 1999-2012, values for 2000 and 2003 are interpolated, annual, Federal Reserve SLOOS. The vertical axis is inverted.

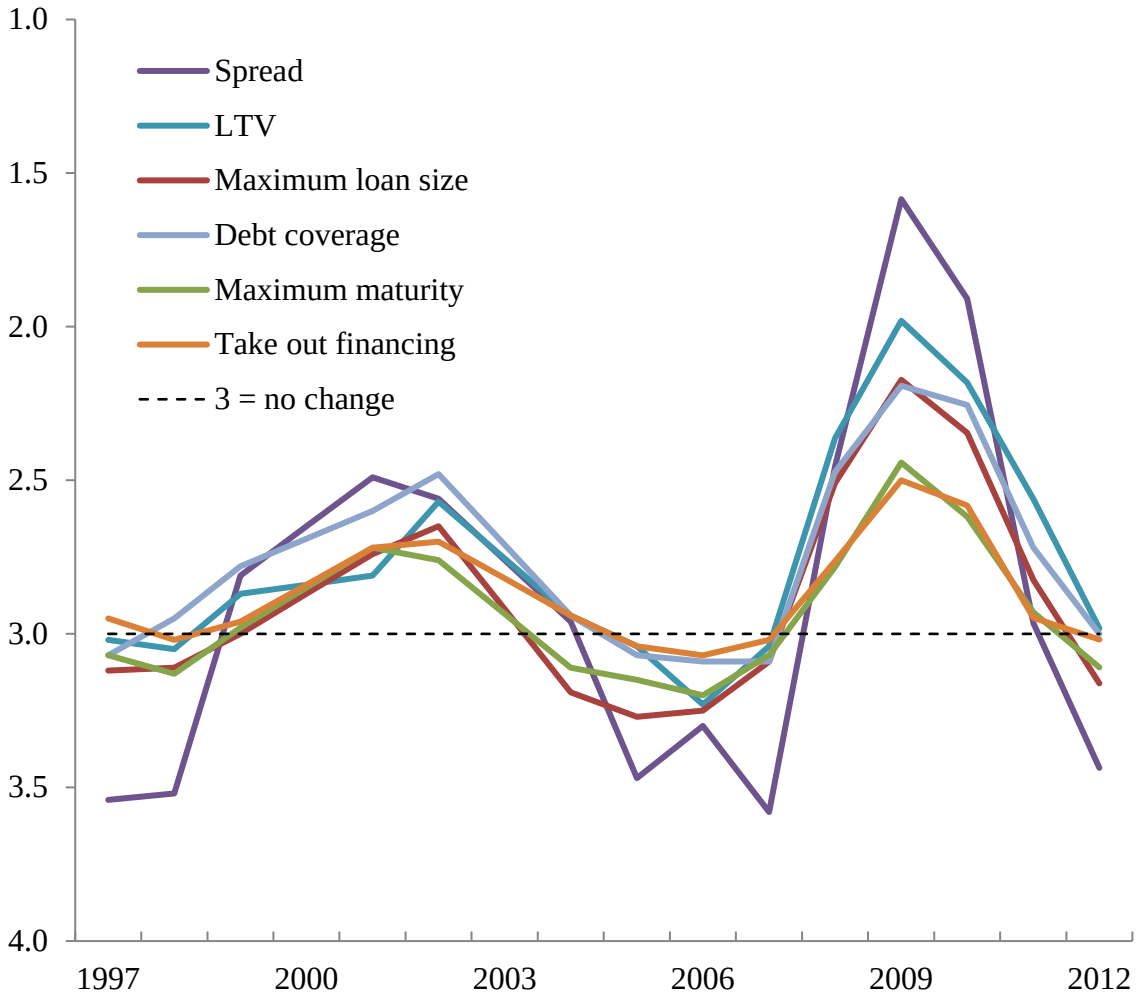

Figure 4: Holdings of commercial mortgages by depositories, life insurers, and CMBS issuers, 1990-2011:3.

Percent of annual potential GDP, quarterly, not seasonally adjusted, Federal Reserve and CBO.

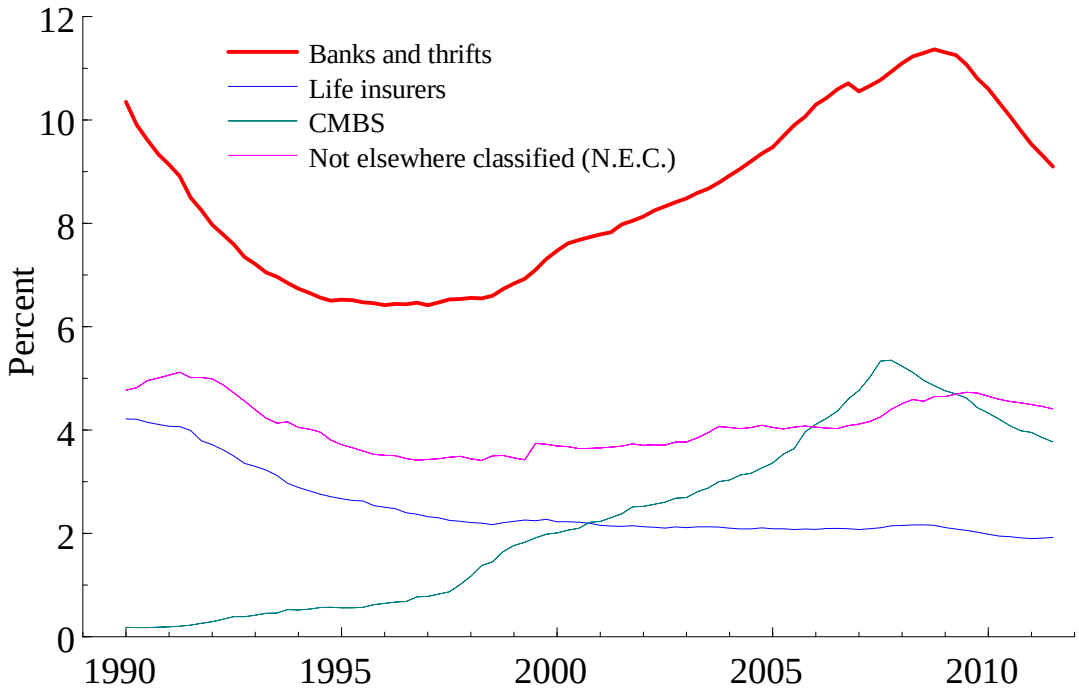

Figure 5: Survey indicators of commercial mortgage underwriting by depositories, Federal Reserve and OCC, 1990:3-2011:3.

Net tightening (percent of banks tightening minus percent loosening) from surveys of bank loan officers, Federal Reserve, quarterly data, 1990:3-2011:3, and from bank examiners of the Office of the Comptroller of the Currency, annual data for the net tightening from the first quarter of the prior year to the current year, 1995-2011. Quarterly values for the OCC were linearly interpolated. Details on the estimated values for the OCC for 1990-1994 and for 2011:2-3 are in the text, not seasonally adjusted.

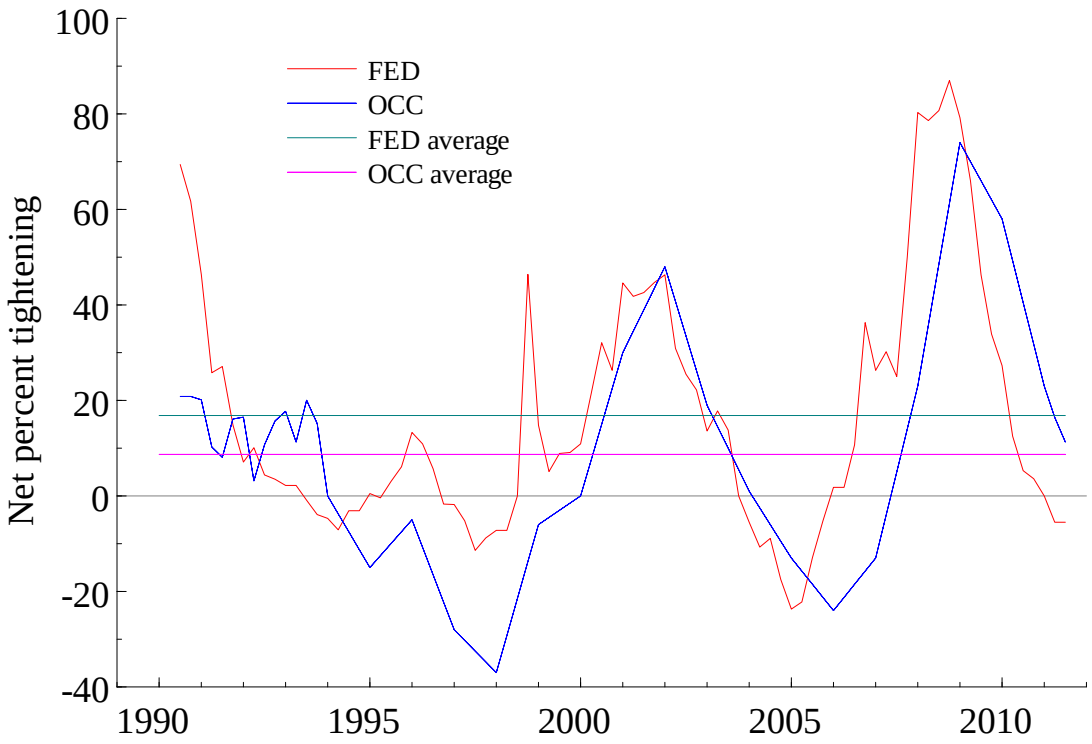

Figure 6: Survey indicators of commercial mortgage underwriting by depositories: tightening (changes in tightness) and tightness (cumulative level of tightening), 1990:2-2011:3.

(Net) tightening is the percent of banks tightening minus percent loosening from the Fed survey. Tightness is the average of the cumulated, de-trended tightening series from the Fed and OCC annualized dividing by four, quarterly, not seasonally adjusted, Federal Reserve and OCC.

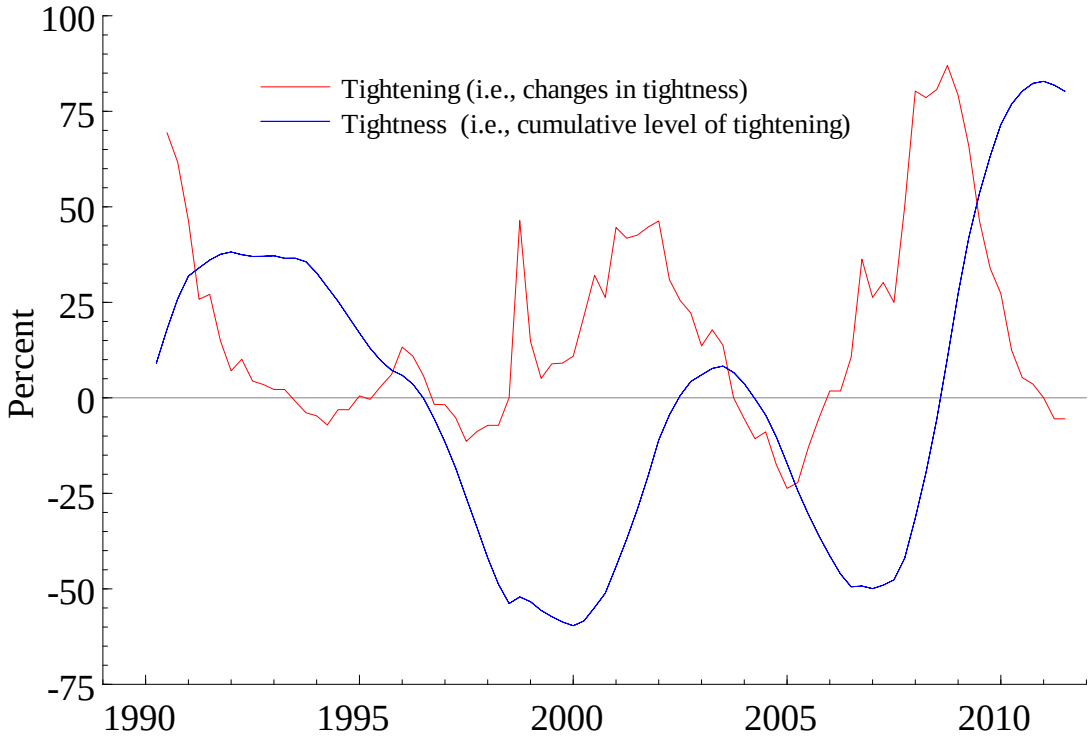

Figure 7: Indicators of commercial mortgage underwriting by life insurers: adjusted capitalization rate and spread of mortgage rates over Treasurys, 1990-2011:3.

Percent, quarterly, not seasonally adjusted, ACLI.

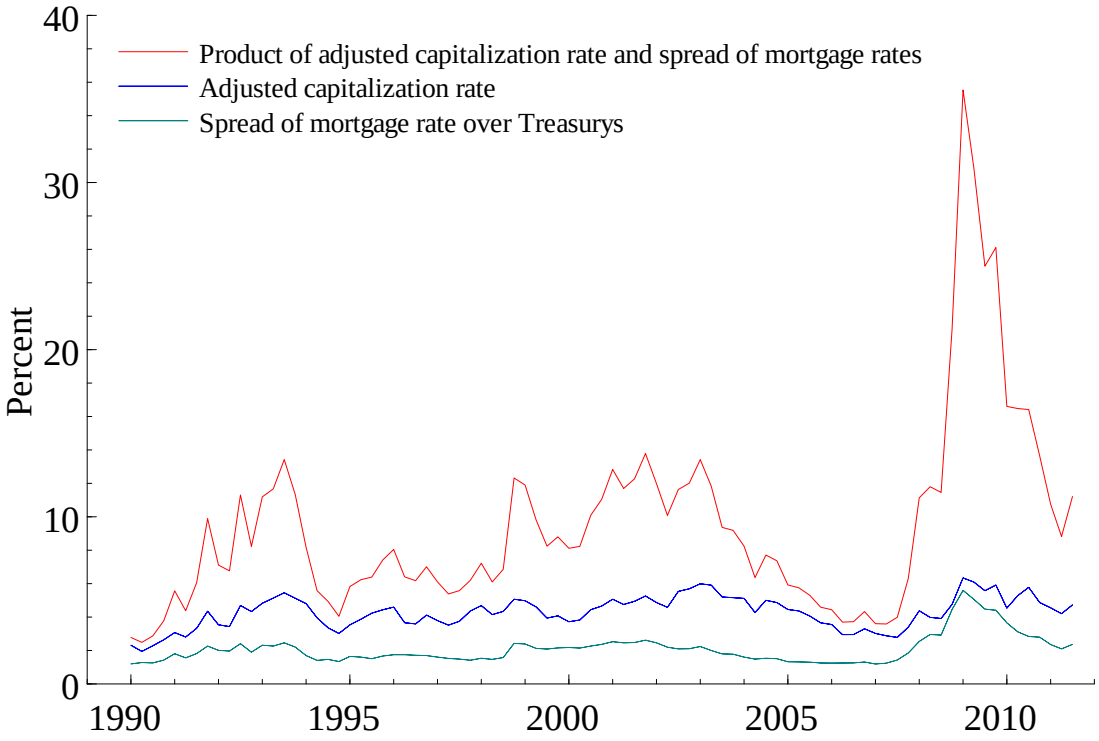

Figure 8: Indicators of commercial mortgage underwriting by CMBS issuers: spread of mortgage interest rates over Treasurys and spread of yields on AAA CMBS over Treasurys, 1990:2-2011:3.

Percent, quarterly, not seasonally adjusted, Commercial Mortgage Alert and CRE Finance Council.

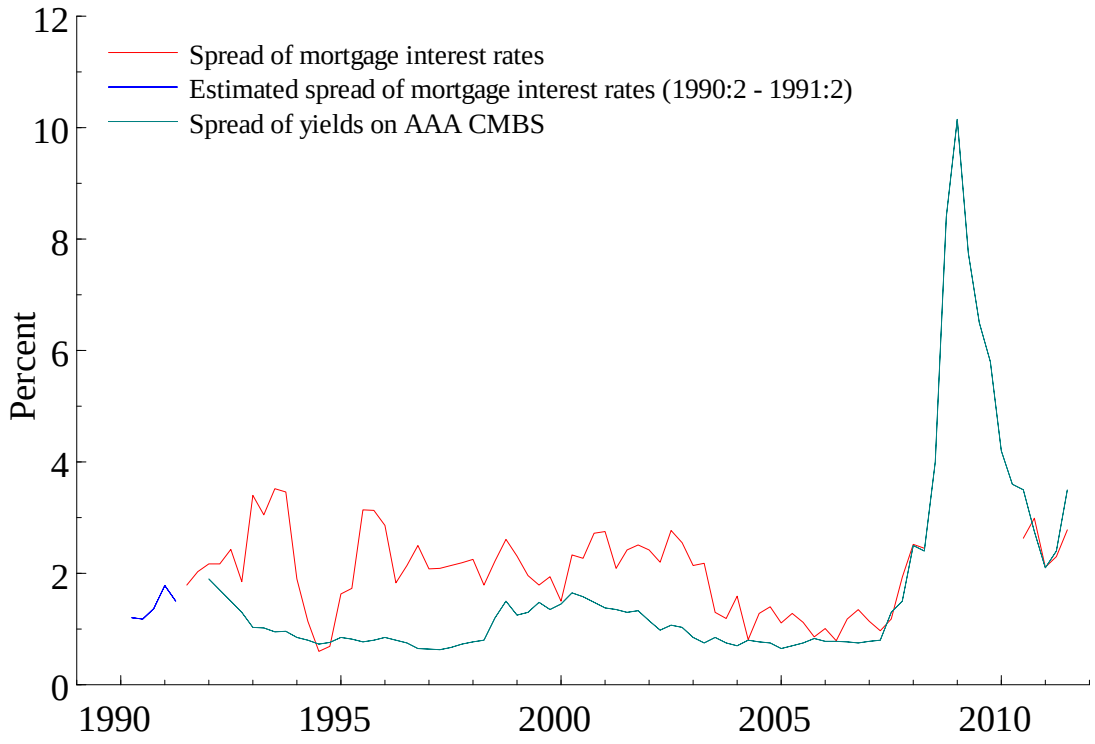

Figure 9: Indicators of commercial mortgage underwriting (uw_i) by depositories, life insurers, and CMBS issuers, 1990:2 -- 2011:3.

Indexed with mean = 0, quarterly, not seasonally adjusted.

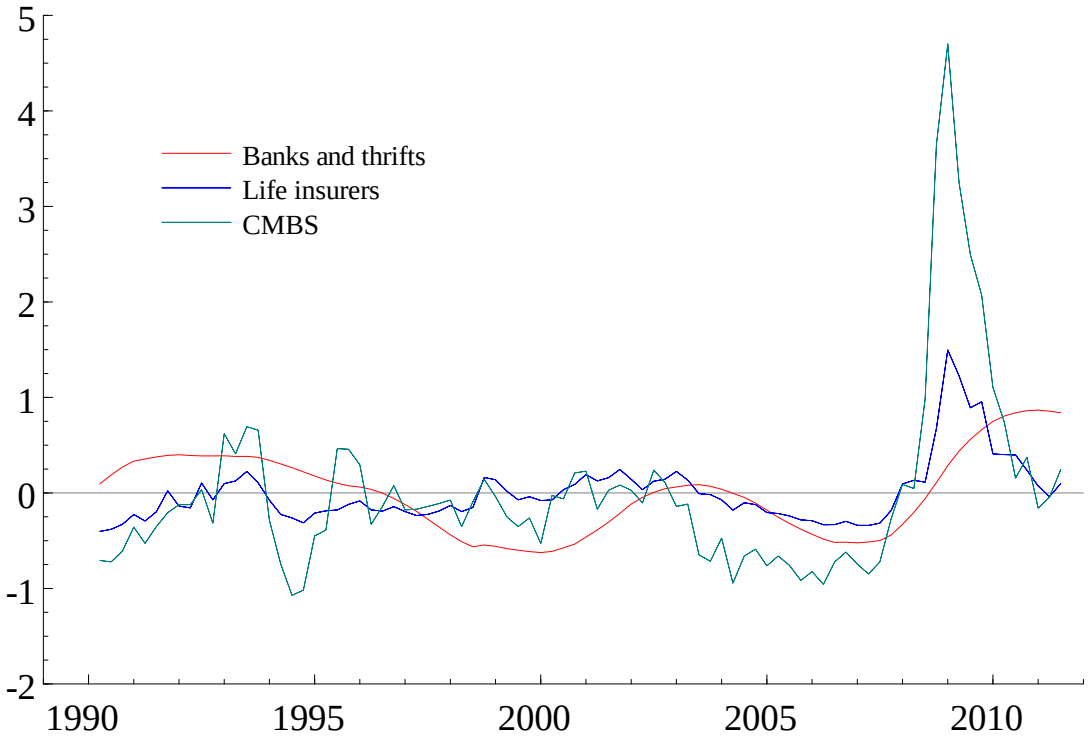

Figure 10: Shares of commercial mortgages outstanding held by depositories (banks and thrifts), life insurers, and CMBS issuers, 1990:2-2011:3.

Percent of the total of the three segments, quarterly, not seasonally adjusted, Federal Reserve Flow of Funds.

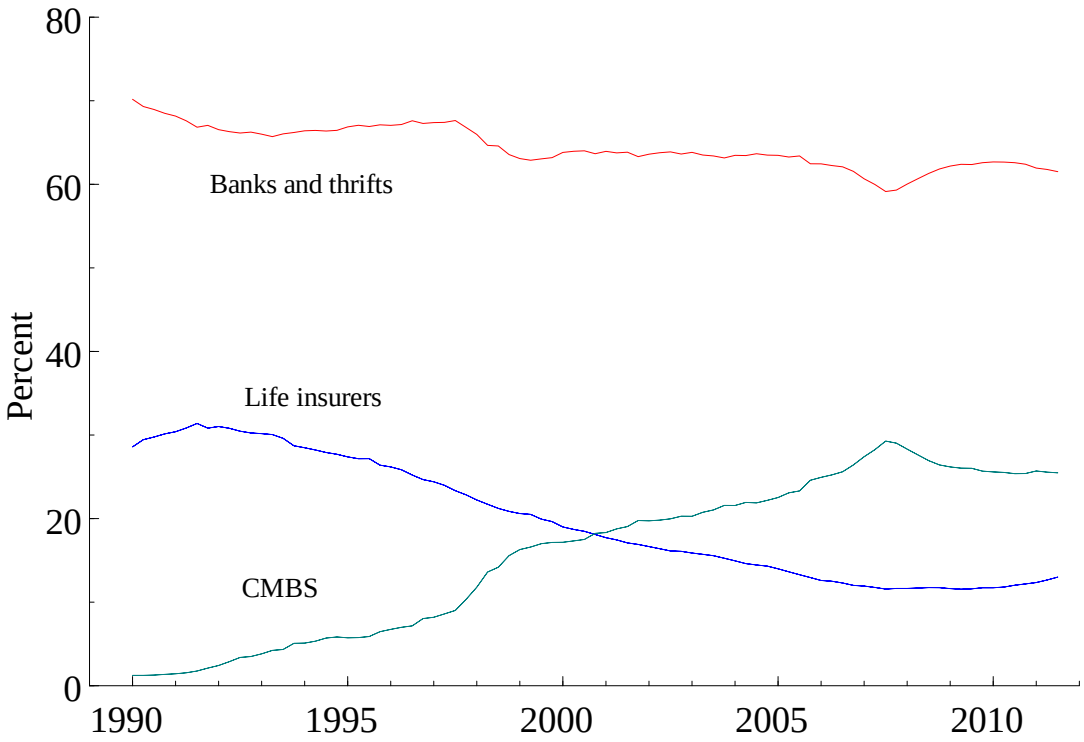

Figure 11: Index of commercial mortgage underwriting (UW) constructed as a share-weighted average of indicators for depositories, life insurers, and CMBS issuers, 1990:2-2011:3.

Indexed with mean = 0, quarterly, not seasonally adjusted.

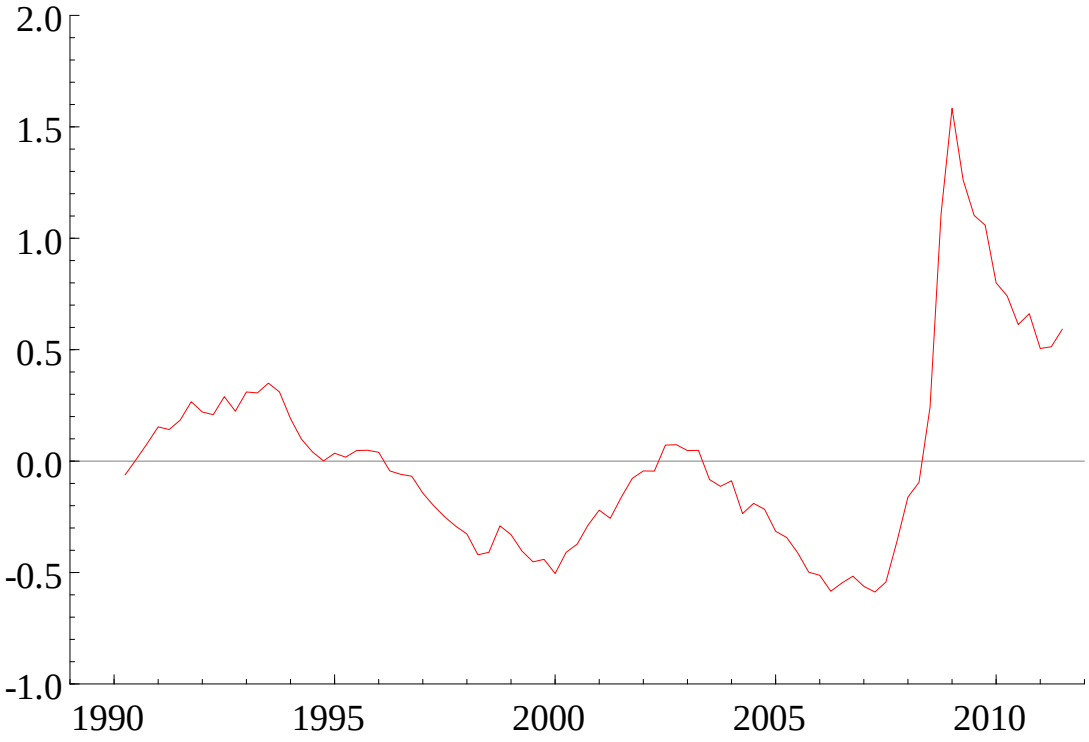

Figure 12: Real CRE prices and commercial mortgage balances per potential gross domestic product, 1990-2011:3.

Indexed: 1990:1 = 100, quarterly, not seasonally adjusted, MIT, BEA, Federal Reserve, and CBO.

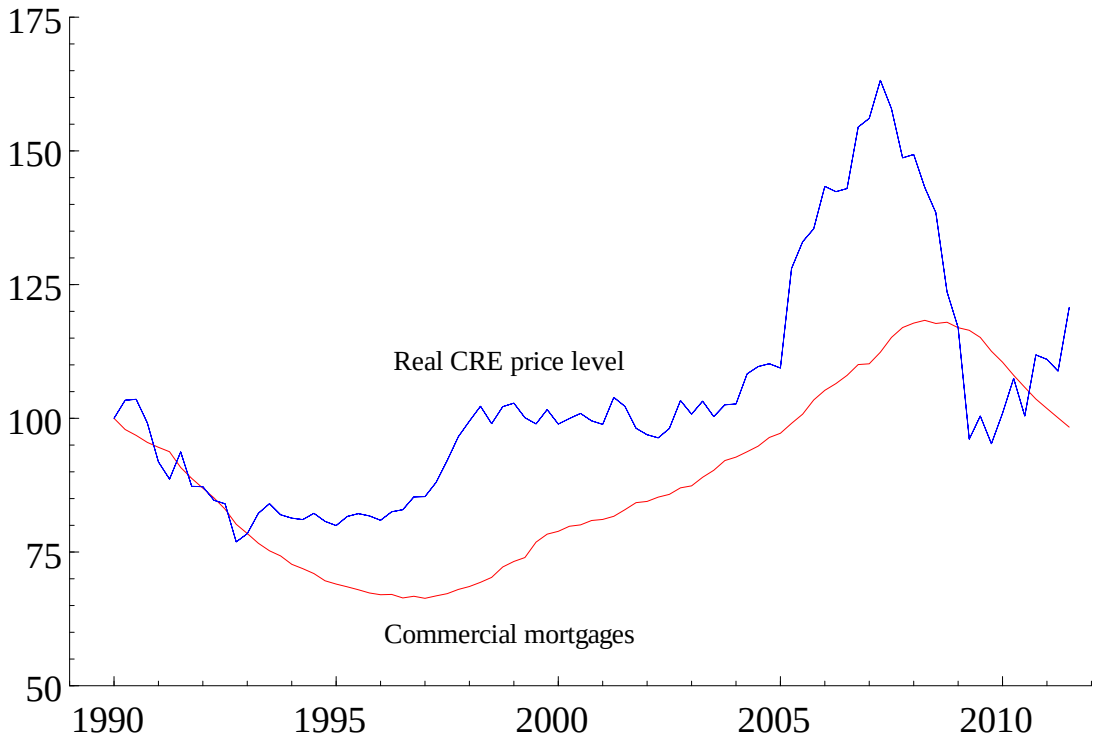

Figure 13: Nominal CRE price growth and net flows of commercial mortgages per potential gross domestic product, 1990-2011:3.

Percent, quarterly, (the price growth rate is calculated year-on-year, then divided by four), MIT, BEA, Federal Reserve, and CBO.

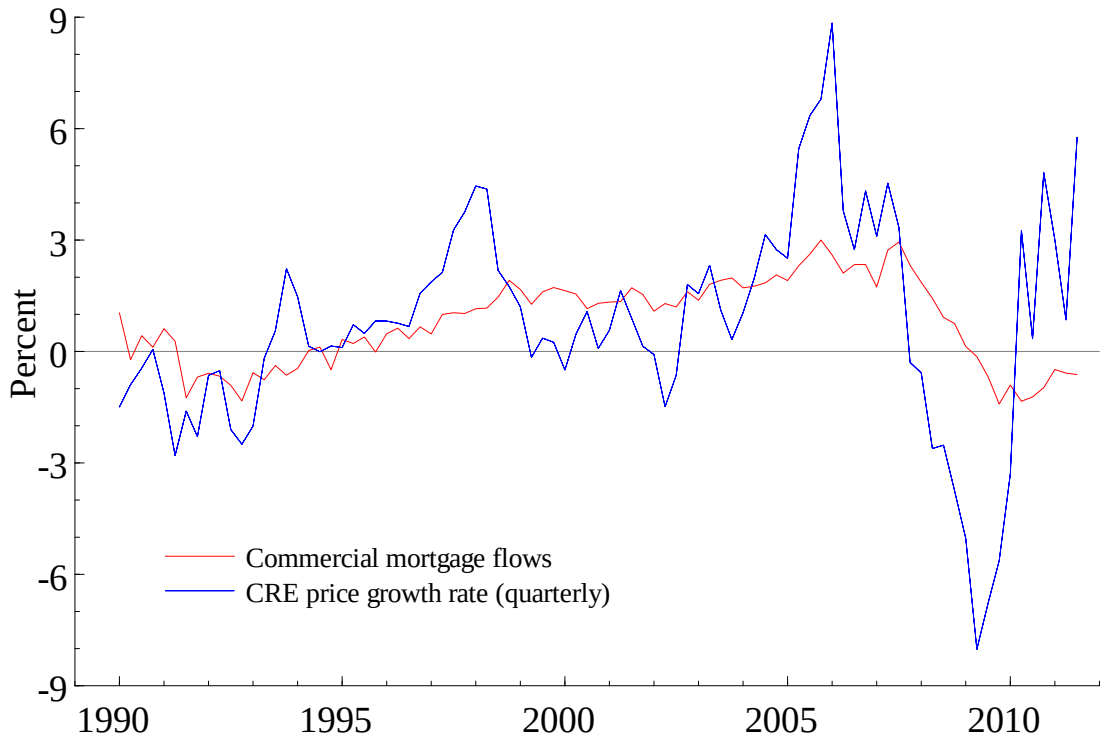

Figure 14: GDP gap, yield on 10-year U.S. Treasurys, and federal funds interest rate, 1990-2011:3.

Percent, quarterly, not seasonally adjusted (except GDP), BEA, CBO, and Federal Reserve.

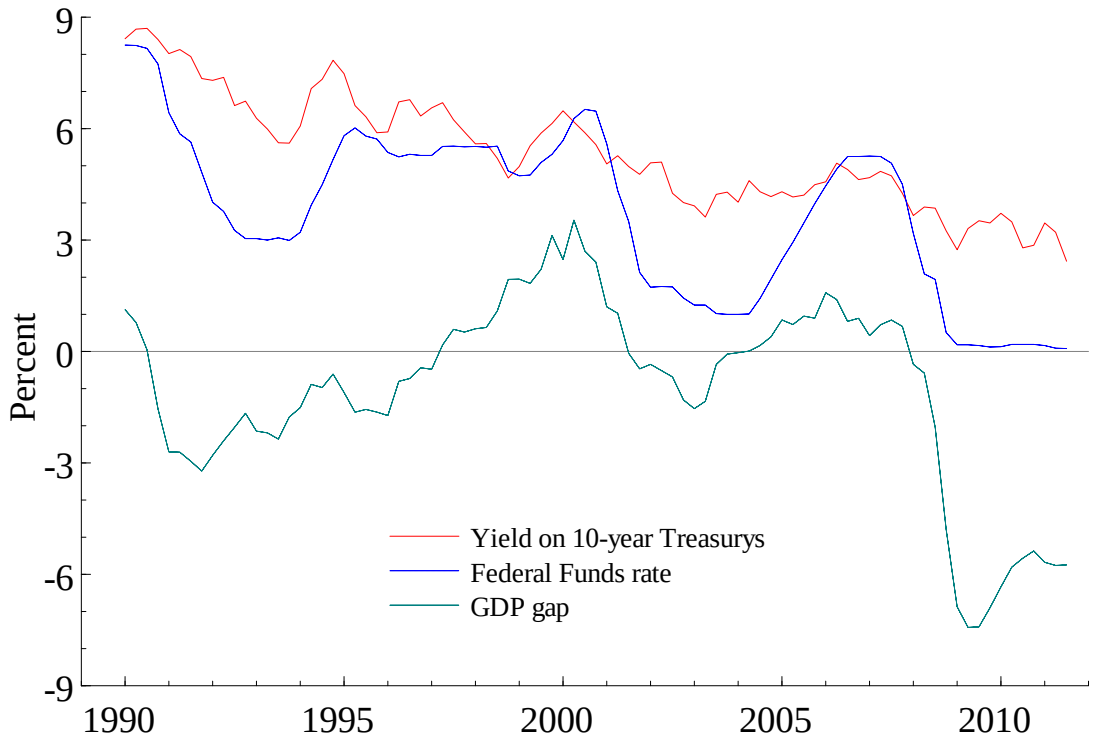

Figure 15: Responses of CRE price growth to an upward shock to underwriting and to commercial mortgage flows.

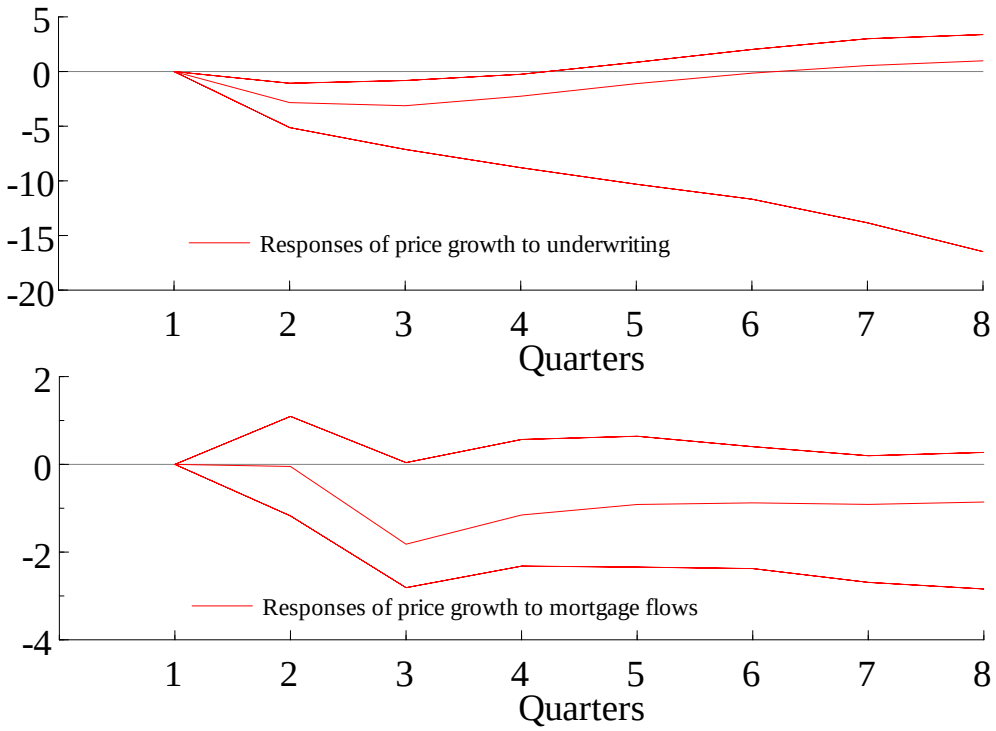

Figure 16: Responses of underwriting to an upward shock to CRE price growth and to commercial mortgage flows.

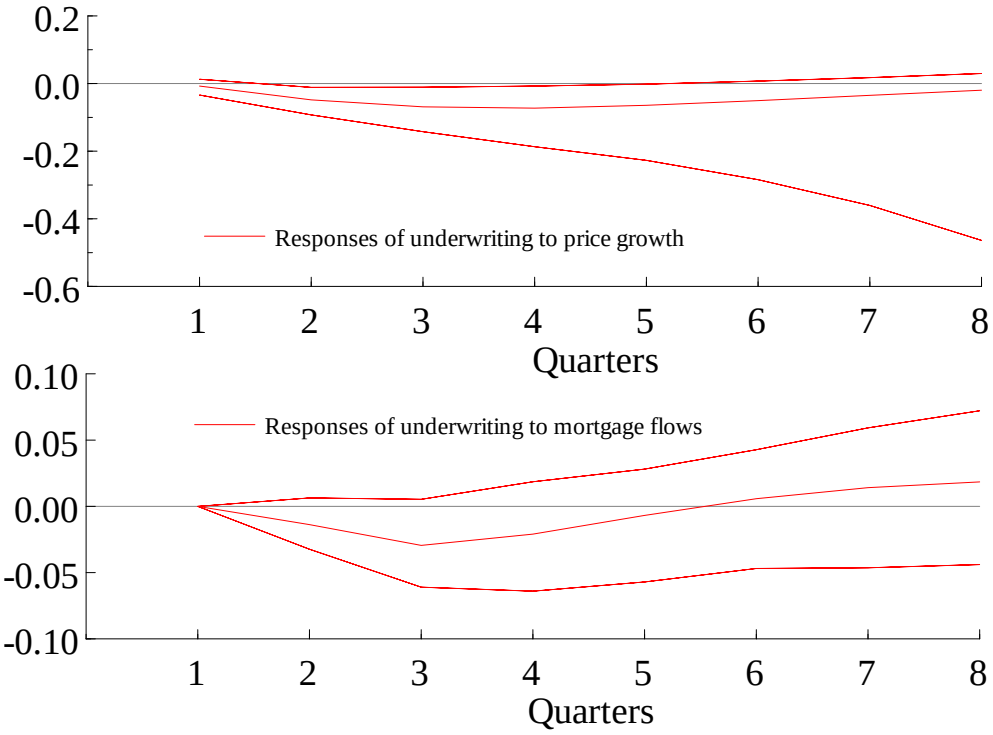

Figure 17: Responses of commercial mortgage flows to an upward shock to CRE price growth and to underwriting.