What Drives the Growth of Aggregate Residential Mortgage Debt in the U.S.?

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Historically aggregate residential mortgage debt in the United States has shown significant long-term growth, driven by secular upward trend in the number of households, incidence of home ownership, housing price, and loan to value ratio or leverage in buying homes. However, most of these variables move too slowly to explain the substantial year to year variation of aggregate residential mortgage debt around its secular growth. The purpose of this paper is to examine empirically if the annual variations can be explained and predicted by well-known factors in financial asset pricing along with housing price information. On the basis of annual data for the 1955–2002 period, we find that the financial asset pricing factors are indeed important drivers of year to year variation in the growth of residential mortgage debt.

According to the 2005 Economic Report of the President, there was about $10.1 trillion of mortgage debt outstanding against farm and nonfarm properties in the U.S. at the end of the third quarter of 2004. Of this total, a staggering $7.8 trillion of mortgage debt was against single family (1 to 4 family) homes.[1] This is more than the $7.4 trillion of U.S. Treasury Securities outstanding at the time. The enormous growth in mortgage debt has in turn led to massive debt financing and securitization by Federal Housing Agencies. At the end of the first quarter of 2005, $5.6 trillion of mortgage-related securities topped the outstanding debt securities tracked by the Bond Market Association and there was about $2.7 trillion of (Federal Housing) Agency Securities primarily to finance their retained portfolios of mortgages.[2]

The staggering size and growth of mortgage debt and the associated securities have important risk implications. The borrowing households have clearly become vulnerable to unfavorable income, interest rate, and housing price shocks,[3] while the likelihood of such shocks seems to be on the rise as well. Although the U.S. economy continues to grow at a decent pace, surging energy prices and potential slowdown in global growth spots such as China and Asia in general raise the possibility of an economic slowdown in the U.S. Meantime, to fend off long-term inflationary pressures, if the Federal Reserve continues to tighten liquidity, the long-term interest rates may ultimately follow the short term rate increases. Some also argue that the fast and continued pace of housing price appreciation in the USA is starting to resemble a bubble like situation with an eventual correction down the road.

Besides the undesirable consequences for the households, policymakers including those at the White House and at the Federal Reserve are also quite concerned about the systemic risk posed by the fast pace of growth in the mortgage portfolios retained by the Government Sponsored Enterprises (GSEs) such as Fannie Mae and Freddie Mac, and the highly leveraged funding of these portfolios.[4] To manage the high

concentration of market, credit and leverage risks, these enterprises routinely engage in large derivative trades. In a turbulent financial market, such large trades may either become infeasible, leading to insolvency risk for these institutions, or destabilize other financial market participants acting as counterparties.

Given the overwhelming implications of the growth of aggregate household mortgage debt, it is naturally important to explore what drives this growth. Demographics, long-term income or economic growth, and household preferences for home ownership are important factors behind growth in mortgage debt over long spans of time.[5] Accordingly, companies such as Fannie Mae and Freddie Mac use a macro structural approach to project the longer term growth of the mortgage market.[6] However, the structural factors do not change appreciably over shorter periods of time such as a year while mortgage debt growth does show ample annual variations. From the perspective of businesses engaged in mortgage financing, investment, and securitization, the annual variations in the aggregate mortgage debt outstanding are equally important, if not more. For example, suppose a corporation such as Fannie Mae maintains its market share and margins. Then the changes in the size of its portfolio, liabilities, and risk management positions, and its dollar profitability in a given year are expected to be intimately linked to the growth in aggregate mortgage debt in that year. For policymakers engaged in active macroeconomic management, it is also the annual variations that are of interest. If cooling down the housing market (and the mortgage debt market) is one of the intended consequences of the current Fed tightening cycle, then the targeted variable is likely the shorter term growth in this market, rather than its longer term growth.

Given the corporate and public policy management implications of annual variations in the mortgage debt market, surprisingly there is no published research on this topic that we are aware of.[7] In this paper, we initiate publicly available research in this area by an empirical examination of what drives the annual variations in the growth of Aggregate Single Family (SF) Mortgage Debt Outstanding (MDO) or Unpaid Principal Balance (UPB). Our expectation is that the year to year dynamics of the mortgage debt outstanding is primarily a financial rather than a structural phenomenon. If financial markets including the mortgage related claims are integrated, then there will be some overlap of factors driving the dynamics in these markets. Further, it is the financial factors that exhibit sufficient year to year variations and as such have the potential to explain similar variations in the aggregate mortgage debt outstanding. Accordingly, along with housing price change, we have chosen three key pricing factors from the fixed income market that are known to be important in asset pricing and asset allocation decisions.[8] These are the interest rate level or the level of the Treasury yield curve, the term premium or the slope of the Treasury yield curve, and the default risk premium of corporate bonds.[9] Since these variables are empirically persistent, and the trends in these variables are closely watched in the financial world, we include them as well along with the lagged value of mortgage debt growth.

Our regression results, with R^2 in excess of 75%, suggest that the interest rate level, the default risk premium (and its trend), and the housing price change are significant drivers of annual MDO growth, but the term premium is not. As expected, lower interest rate level and stronger housing price appreciation accelerate growth in mortgage debt through increased production of new mortgages and cash out refinancing. The effect of corporate default risk premium is not clear *a priori*; empirically we find that an increase in the default risk premium boosts growth in mortgage debt, but an upward trend in the premium seems to dampen the growth in mortgage debt. This supports the view that an increase in the price of default risk leads to a substitution away from corporate debt to household mortgage debt; however, a continued increase in the price of default risk may signal pervasive credit concerns and hence dampens the growth of mortgage debt. Overall, our results imply that the short term growth of aggregate residential mortgage debt is primarily a financial (fixed income) market rather than a structural or demographic phenomenon. Accordingly, mortgage financing businesses and policymakers should focus on fixed income pricing barometers and shorter term housing price prospects in assessing the immediate risks and returns associated with mortgage debt growth.

The rest of this paper is organized as follows. First, we describe the methodology of our investigation and the data. Second, the empirical results are presented, and a summary and conclusions are given in the subsequent sections.

METHODOLOGY AND DATA

Traditionally, mortgage institutions such as Freddie Mac and Fannie Mae have used a structural approach to forecasting aggregate mortgage debt. In the structural approach to MDO/UPB Growth, one would model demand and supply related variables (such as household

formation, incidence of home ownership, housing starts and completions, home financing leverage, mortgage rate, and housing price growth) in terms of macroeconomic (for example, GDP growth, Quarterly Average Employed Civilians over 25), demographic (for example, immigration, population entering work force), and mortgage and financial market barometers (for example, Freddie Mac's PMMS 30-year Fixed Rate, Weighted Average Coupon on Freddie Mac's 30-Year Fixed Rate Portfolio, Real S&P Return). These in turn determine the growth of MDO/UPB at the aggregate market level. It seems likely that fixed income market and house prices would have good correlation with many of the demand and supply variables, and as such would pick up similar influences albeit in a reduced form.

Using fixed income prices to explain or forecast MDO has the additional advantage that exchange-traded and OTC derivatives on fixed income instruments are more readily available. Regression equations linking the MDO/UPB Growth and fixed income prices can thus be helpful in evaluating related contingencies and corresponding risk management strategies using the fixed income derivatives. Further, liquid market for fixed income derivatives allow implying market predictions of future fixed income prices or parameters, which in turn can be incorporated in MDO/UPB Growth prediction/simulation.

While there could be econometrically sophisticated techniques and elaborate structural models that may yield better estimation results, we wish to analyze the annual growth of Single Family Mortgage Debt Outstanding (MDO), sometimes referred to as Unpaid Principal Balance (UPB), in the simplest and most parsimonious fashion using fixed income and housing price related variables alone. This is meant to target the broadest possible audience, including senior management, regulators, and policy makers of mortgage business, and also to keep potential forward simulation applications at a manageable and cost-effective level. Accordingly our primary tool of analysis is multiple linear regression of the annual growth rate (MDOG) of MDO on a few fixed income and housing price related variables. To understand the relationship of these variables to the MDOG, contemporaneous values of the fixed income and housing price related variables are used as explanatory variables or regressors. For projection or forward simulation purpose, on the other hand, one period (year) lagged values of the fixed income and housing price related variables are used as predictors. Additionally, the lagged value of mortgage debt growth is included in the choice of both explanatory variables and predictors. As we shall see in the descriptive statistics later, the growth rate exhibits a high level of serial correlation even at the annual frequency.

The contemporaneous linear regression model (explanatory behavioral equation) and the lagged linear regression model (predictive behavioral equation) are as follows:

$$\mathrm{MDOG}(t) = \alpha + \beta_1\,\mathrm{MDOG}(t-1) + \beta_2\,\mathrm{T10Y}(t) + \beta_3\,\mathrm{TSLOPE}(t) + \beta_4\,\mathrm{DRP}(t) + \beta_5\,\mathrm{HPAG}(t) + \beta_6\,\mathrm{T10Y_TR}(t) + \beta_7\,\mathrm{TSLOPE_TR}(t) + \beta_8\,\mathrm{DRP_TR}(t) + \beta_9\,\mathrm{HPAG_TR}(t) + \varepsilon(t) \quad (1)$$

$$\mathrm{MDOG}(t) = \phi + \gamma_1\,\mathrm{MDOG}(t-1) + \gamma_2\,\mathrm{T10Y}(t-1) + \gamma_3\,\mathrm{TSLOPE}(t-1) + \gamma_4\,\mathrm{DRP}(t-1) + \gamma_5\,\mathrm{HPAG}(t-1) + \gamma_6\,\mathrm{T10Y_TR}(t-1) + \gamma_7\,\mathrm{TSLOPE_TR}(t-1) + \gamma_8\,\mathrm{DRP_TR}(t-1) + \gamma_9\,\mathrm{HPAG_TR}(t-1) + e(t) \quad (2)$$

Where

MDOG(t)	: Growth rate of SF Mortgage Debt Outstanding, from $t-1$ to t
MDOG(t - 1)	: One period (year) lagged value of MDOG
T10Y(t)	:Yield to Maturity of Constant Maturity 10-year Treasury
TSLOPE(t)	: Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-month Treasury Yield
DRP(t)	: Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated corporate bonds
HPAG(t)	: Growth rate of U.S. National Housing Price
T10Y_TR(t)	:T10Y(t) – [0.5 T10Y($t-1$) + 0.5 T10Y($t-2$)]
TSLOPE_TR(t)	:TSLOPE(t) – [0.5 TSLOPE($t-1$) + 0.5 TSLOPE(t - 2)]
DRP_TR(t)	: DRP(t) – [0.5 DRP($t-1$) + 0.5 DRP($t-2$)]
HPAG_TR(t)	: HPAG(t) – [0.5 HPAG($t-1$) + 0.5 HPAG($t-2$)]
ε(t), $e(t)$	: Regression error

A more detailed description of the variables and their source are provided in Exhibit 1. The National Housing Price growth data covers the period 1950–2002 and was compiled by some Freddie Mac researchers using

EXHIBIT 1
Variable Description and Source

MDOG: The Annual Growth Rate of Total Single Family Mortgage Debt Outstanding. The variable is percentage change in the End of year Total Mortgage Debt Outstanding on 1- to 4-family houses, Government Underwritten (FHA Insured, VA Guarantee) plus Conventional. Source: Council of Economic Advisers: Economic Report of the President, 2005, EXHIBIT B–75: Mortgage debt outstanding by type of property and of financing, 1949–2004. Source website for this variable is http://www.gpoaccess.gov/eop/Exhibits05.html.

3MTBY: 3 Month US TREASURY Bill Rate: The variable is Yield Percent per Annum (bank-discount basis) on new issues of 3M Treasury Bills. Source: Council of Economic Advisers: Economic Report of the President, 2005, EXHIBIT B–73: Bond yields and interest rates, 1929–2004. Source website for this variable is http://www.gpoaccess.gov/eop/Exhibits05.html.

T10Y: 10 year Constant Maturity Treasury Rate: The variable is based on Yields on the more actively traded issues adjusted to constant maturities by the Department of the Treasury. Source: Council of Economic Advisers: Economic Report of the President, 2005, EXHIBIT B–73: Bond yields and interest rates, 1929–2004. Source website for this variable is http://www.gpoaccess.gov/eop/Exhibits05.html.

TSLOPE: Term Structure Slope: It is the spread of T10Y over 3MTBY.

DRP: Default Risk Premium: This variable is the spread between the yields of corporate bonds rated Baa and Aaa by Moody's. Source: Council of Economic Advisers: Economic Report of the President, 2005, EXHIBIT B–73: Bond yields and interest rates, 1929–2004. Source website for this variable is http://www.gpoaccess.gov/eop/Exhibits05.html.

HPAG: The Annual Growth Rate of US House Prices. Source: Freddie Mac, based on information from E. H. Boeckh and Associates, BLS, Census Bureau, and Freddie Mac. This variable is the percentage change in the US National Housing Price Index. It is different from the index CMHPI regularly published by Freddie Mac, but is highly correlated with the CMHPI National Series over the common period when both indices are available.

T10Y_TR: Recent time trend of T10Y, measured as the current level of T10Y less the average level for the last two years. A positive value is symptomatic of an upward trend in interest rates. An increase in T10Y_TR means that T10Y is increasing faster than its lagged average (acceleration in the pace of interest rate increase).

TSLOPE_TR: Recent time trend of TSLOPE, measured as the current level of TSLOPE less the average level for the last two years. A positive value is symptomatic of a steepening yield curve. An increase in TSLOPE_TR means that TSLOPE is increasing faster than its lagged average (acceleration in the steepening of yield curve).

DRP_TR: Recent time trend of DRP, measured as the current level of DRP less the average level for the last two years. A positive value is symptomatic of a widening default spread. An increase in DRP_TR means that DRP is increasing faster than its lagged average (acceleration in the widening of default spread).

HPAG_TR: Recent time trend of HPAGR, measured as the current level of HPAGR less the average level for the last two years. A positive value is symptomatic of accelerating housing price growth. An increase in HPAG_TR means that HPAG is increasing faster than its lagged average.

various sources. This housing price (HPA) series is not the same as the widely published CMHPI (Conventional Mortgage Home Price Index) National Index series of Freddie Mac, which is a weighted average of the nine Census division indices.[10] Unfortunately the CMHPI data extends back to 1970 only and as such does not provide enough data points for an examination of the annual growth in MDO. Fortunately, over the 1971–2002 period when both CMHPI data and the HPA series are available to us, their correlation is 0.94 and the average difference in annual national housing price growth rate is quite small at 13 basis points.[11]

All data for the fixed income market was obtained from the 2005 Economic Report of the President available at the website of the Federal Reserve Board. The annual data for the constant maturity 10-year Treasury yield is available from 1953 to 2004. The 3-month new issue Treasury yield, used in calculating term premium, starts in 1949 and ends at 2004; Moody's Aaa and Baa corporate bond yields, used for calculating the default risk premium, are also available for the same period. Although the data for aggregate mortgage debt also starts in 1949, it ends in 2003.

The earliest year for which the raw data is available for all the variables is 1953 and the latest year is 2002. Further, the calculation of the trend variables involves two lags. Accordingly, the regression equations (with lagged dependent variable) are estimated using the 1956–2002

period, and the summary statistics for the key variables are based on the 1955–2002 period.

In our regression models, the variables T10Y, TSLOPE, and DRP are intended to capture the contemporaneous fixed income market environment while HPAG proxies for the countrywide housing price situation. The variables with TR extension are intended to describe the trends in the corresponding fixed income and housing price variables.

The variable T10Y is chosen to represent the effect of general level of interest rates on mortgage debt growth. We expect $\beta_2 < 0$, as potential shoppers are less enthused about home buying, moving upscale or refinancing at higher interest rate levels, other things remaining the same. Higher interest rate levels may also induce a household portfolio substitution effect away from borrowing to investing (in bonds). Although other points on the Treasury Yield Curve can be chosen to represent the interest rate level, we prefer the 10-year rate since it is a widely quoted and referenced midpoint with a corresponding liquid swap market as well. Longer term fixed mortgage rates are typically benchmarked against T10Y, and it is also the key rate in the model for the Risk Based Regulatory Capital for housing finance enterprises, Freddie Mac and Fannie Mae.

A one-factor interest rate model is often cited as inadequate to describe the dynamic behavior of fixed income prices. Among other things, it has the unrealistic property that all interest rates are perfectly correlated. The slope of the term structure, TSLOPE, is selected here to model the additional effect of interest rates on mortgage debt growth. We expect $\beta_3 > 0$, as borrowers may find it attractive to buy or refinance (favoring perhaps mid range maturity) and leverage their home investments at a time when the yield curve is relatively steep, other things held the same. This could be based on expectation of rates (and inflation) going up. Practitioners often interpret a steeper yield curve as a sign of better economic times ahead and as such lenders may feel confident in providing more mortgage debt in anticipation of sustained income growth of the borrowers while locking in a wider profit spread.[12] Further, with a steeper yield curve, depository institutions find it more enticing to increase their mortgage investment to lock-in attractive interest spread.[13]

Although the Treasury term structure undoubtedly embodies important aspects of fixed income pricing environment, it does not capture the default or credit risk structure of interest rates. Previous studies have found default risk premium of corporate bonds as an important economic factor driving asset prices. The inclusion of the variable DRP is an attempt to see if default risk pricing also impacts the growth of the mortgage debt market. High DRP tends to deflate corporate security prices and the growth of such claims as relatively higher level of concern about corporate financial health and/or the value and liquidity of corporate assets keeps lenders at bay from corporate lending. It is possible, although not clear, that income-oriented but credit-concerned lenders such as depositories and pensioners/pension funds/insurance companies may be more aggressive in seeking secured (and easier-to-possess collateral) lending such as mortgage lending.[14] This potential supply effect leads us to expect $\beta_4 > 0$, i.e., a beneficial effect of high corporate DRP on home mortgage debt growth, of course other things held constant. A positive demand effect is also possible as credit-concerned household investors may substitute away from corporate investing to home ownership. On the other hand, if high DRP represents pervasive pessimism about the economy and broader asset markets, then the influence may be negative on mortgage debt growth.

The expected effect of relatively high (low) rate of housing price appreciation (depreciation) on mortgage debt growth is clearly positive ($\beta_5 > 0$) and is empirically well established.

Let us now discuss the expected marginal effects of the trend variables. The inclusion of trend variables is motivated by the fact that economic fundamentals often exhibit slow moving trends. As borrowers/lenders mull over the mortgage loan decision, they might find it useful in their decision making to place the current economic environment in the context of recent evolution of this environment.[15] A low interest rate now does not necessarily mean that now is the best time to buy or refinance a home if the rate trend shows that the rates could fall further, of course other factors remaining the same. Thus, we would not be surprised if we find $\beta_6 < 0$. If the upward (downward) momentum of rates get stronger (weaker), that is the positive (negative) gap between the current rates and their recent levels widen (shrink), borrowers may be reluctant to commit to higher household debt and instead wait for mean reversion. Of course, the opposite effect cannot be ruled out either if home borrowers rush to borrow in fear of fast escalation in the already rising borrowing cost.

When it comes to the yield curve steepening faster (flattening slower), i.e., higher value for TSLOPE_TR, home buying/refinancing may pick up hoping to lock-in longer-term rates. If the yield curve is steepening slower (flattening faster), mortgagors may just wait for better longer-term rates. This suggests $\beta_7 > 0$. However, this

effect presupposes a preference bias on the part of home buyers/borrowers for longer-term rates and it is not clear why such term preference should continue to hold.

Although we have argued that a higher level of corporate default premium may spur MDO/UPB growth because of aggressive supply of mortgage loans from the lenders, the opposite may be expected when the default premium is rising faster (higher DRP_TR) or falling slower. Such a situation may indicate the possibility of corporate woes spreading to consumers, financials, and other sectors of the economy. In other words, the corporate default risk premium widening faster (narrowing slower) may create a widespread lack of confidence in the economy going forward. Naturally both home borrowers and mortgage lenders/investors would be cautious under such circumstances, leading to a negative effect ($\beta_8 < 0$) on MDO/UPB growth. This argument relies on the trend in corporate default premium as a barometer of confidence in the future of the broader economy. This linkage may or may not hold in a strong fashion.

Lastly, acceleration in housing price appreciation, that is higher HPAG_TR, may or may not bode well for the growth of mortgage debt. Momentum buyers/borrowers/investors may continue to push up the mortgage debt while the contrarians could be fearful of a bursting bubble and may be looking for an exit from mortgage debt. The net effect (sign of β_9) remains primarily an empirical question.

The early 1950s saw some historically high double digit growth in mortgage debt, which however tapered off during the late 1950s. During the sixties, mortgage debt growth was below average hitting a bottom in 1970. The growth rate had a general upward trend during much of the seventies reaching the highest ever pace in 1977. The sharp deceleration during the 1978–1982 led to a new bottom in 1982. While the growth pace picked up somewhat during the mid-eighties, mortgage debt growth remained below average till 1998. A phase of acceleration starting in 1998 pushed the growth rate above the historical average in 1999, and to double digit growth in the years 2002 and 2003.

During our sample period, the bell-weather 10-year Treasury rate has averaged to 6.818%, the yield curve has sloped upward by 131 basis points on average, the average corporate default risk premium (Baa-Aaa) was about 96 basis points and nationally house prices have appreciated at an average annual rate of 4.956%. Once again the standard deviations and the lows and highs indicate substantial variation around the historical average for all the variables.

Looking at the simple pairwise correlations, housing price growth (HPAG) has the highest simple contemporaneous correlation (0.49) with mortgage debt growth, as one would normally expect. However, somewhat surprisingly, the correlation between mortgage growth and the fixed income prices (T10Y, TSLOPE, and DRP) appears weak. Moreover, the positive sign of the correlation between rate level (T10Y) and mortgage growth is also counterintuitive.

One, however, needs to be careful in interpreting the simple correlation coefficients. There are some strong pairwise correlations among the fixed income and housing price variables. This could play a nontrivial role in disguising the marginal (abstracting from joint influences) relationship between mortgage debt growth and any of

EMPIRICAL RESULTS

In this section, we first present descriptive statisti on the variables. This is followed by the discussion of co temporaneous (explanatory) and lagged (predictive) regre sion results.

Summary Statistics on Data

EXHIBIT 3

Summary Statistics and the Correlation among the Annual Growth of US Aggregate Single Family Mortgage Debt Outstanding, and Fixed Income and Housing Price Variables, 1955–2002

Summary Statistics for 1955–2002									
	MDOG	T10Y	TSLOPE	DRP	HPAG				
N	48	48	48	48	48				
Mean	9.700	6.818	1.313	0.960	4.956				
Std. Dev.	3.235	2.638	1.056	0.405	3.273				
Min	4.348	2.820	−0.601	0.380	0.700				
Max	17.584	13.910	3.560	2.320	14.300				
Correlation Matrix									
	MDOG	T10Y	TSLOPE	DRP	HPAG	T10YTR	TSLOPETR	DRPTR	HPAGTR
MDOG	1.000								
T10Y	0.054	1.000							
TSLOPE	0.057	0.184	1.000						
DRP	0.070	0.800	0.307	1.000					
HPAG	0.485	0.398	−0.180	0.306	1.000				
T10YTR	−0.100	0.184	−0.572	0.067	0.201	1.000			
TSLOPETR	−0.192	0.117	0.656	0.482	−0.231	−0.192	1.000		
DRPTR	−0.320	0.079	−0.225	0.437	0.102	0.401	0.325	1.000	
HPAGTR	0.211	−0.313	−0.147	−0.471	0.386	−0.183	−0.433	−0.383	1.000
Serial Correlation	*0.725*	*0.930*	*0.541*	*0.773*	*0.818*	*0.417*	*0.303*	*0.338*	*0.322*

This Exhibit contains summary statistics and the pair wise simple correlation coefficients and autocorrelation coefficients for the following variables: MDOG, Growth rate of SF Market MDO; T10Y, Yield to Maturity of Constant Maturity 10-Year Treasury; TSLOPE, Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-Month Treasury Yield; DRP, Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated Corporate Bonds; HPAG, Growth rate of US National Housing Price.

Source: Federal Reserve Board and Freddie Mac Financial Research.

autocorrelation. Values of around 1.0 for Durbin's *H* in all the regressions suggest that we are not able to reject the null hypothesis of zero residual autocorrelation.

Our discussions (given later) for the statistical significance of the slope coefficients use a 5% significance level. The slope coefficients that are significant at the 5% level are highlighted in the corresponding Exhibits.

Exhibit 5 reports the linear regression results for the contemporaneous (explanatory) equation estimated over the 1956–2002 period. Several observations are noteworthy about these results. First, the fixed income and housing price variables along with the lagged dependent variable explains more than four-fifth (84.20%) of the time variations in the mortgage debt growth rate.[17] A visual inspection of the actual and fitted values of mortgage debt growth in Exhibit 6 confirms the goodness of this fit. Therefore, the contemporaneous explanatory power of the fixed income and housing price variables appears excellent.

Second, the variables that are significant (highlighted) at 5% level are the rate level (T10Y), corporate default premium (DRP), housing price growth (HPAG), trend in corporate default premium (DRP_TR), and lagged mortgage debt growth (LAGMDOG). Interestingly, the term premium or yield curve slope does not seem to have important bearing on mortgage debt growth. In other words, it is the level and not the shape of the yield curve that is most consequential for the short term (annual) growth of mortgage debt.

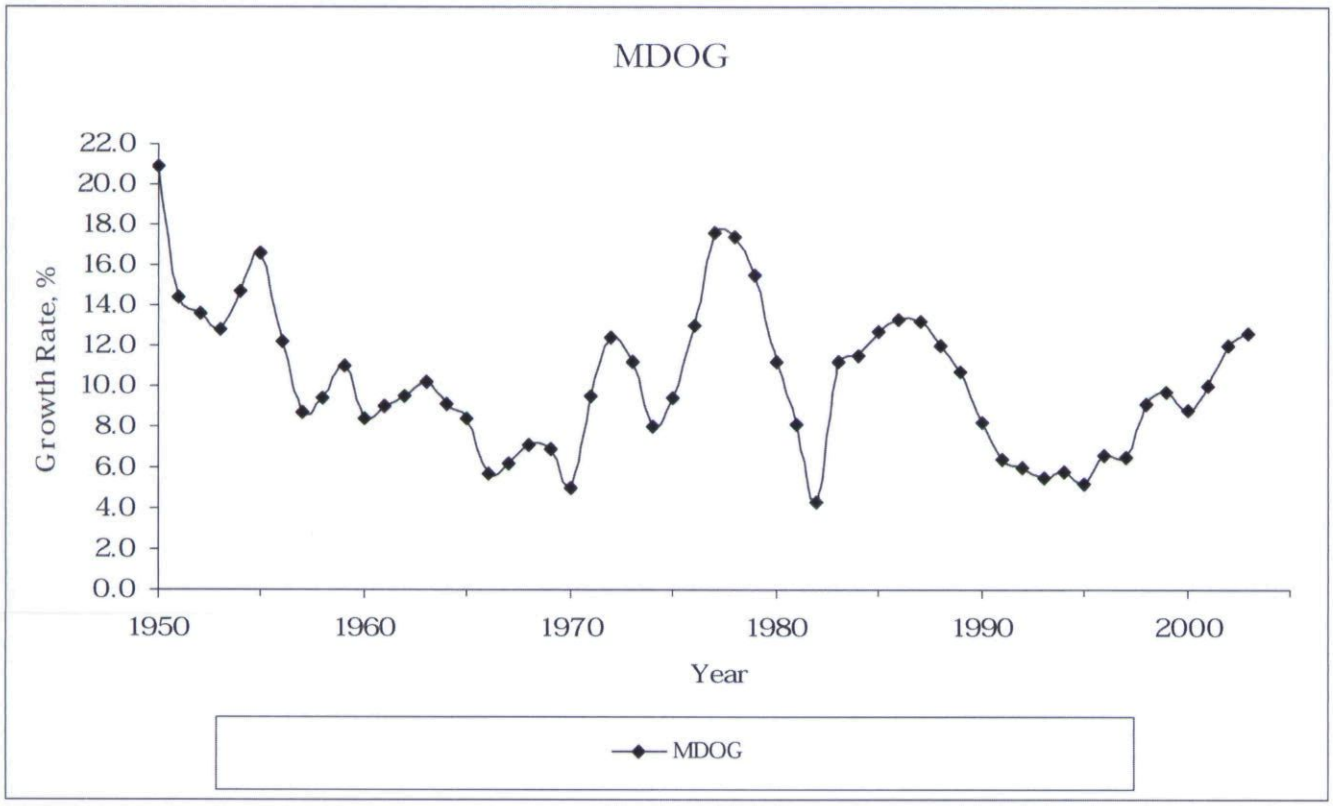
Third, as expected the rate level has a negative impact on mortgage debt growth. Roughly speaking, for every 100 basis points movement in the bell-weather 10-year Treasury rate, mortgage debt growth moves in the opposite direction by about 73 bps.

Fourth, in contrast, for every 100 bps move in the corporate default premium, mortgage debt grows in the same direction and by an enormous magnitude of 398 bps (536 bps in the 6-variables model). The direct (posi-

EXHIBIT 4

Annual Growth of U.S. Aggregate Single Family Mortgage Debt Outstanding 1950–2003

This chart shows the Annual Growth Rate of U.S. Aggregate Single Family Mortgage Debt Outstanding (MDOG) for the 1950–2003 period.



Source: Federal Reserve Board.

tive) marginal effect lends support to the supply and demand effects induced by lenders/household investors (concerned about corporate future) substituting away from corporate investing to home lending/ownership. In other words, to the extent credit concerns are localized (not pervasive throughout corporate and household sectors), home mortgage offers a popular (credit) risk shifting mechanism. However, to the extent acceleration in corporate default premium (higher DRP_TR) embodies pervasive credit concerns, its adverse effect (negative coefficient) indicates home mortgage loses its risk shifting benefit in such circumstances.

Fifth, as expected, housing price growth has a beneficial impact on mortgage debt growth. However, the marginal impact on mortgage debt growth is only 54 bps for every 100 bps extra in housing price growth. Also, sharper acceleration in housing price growth (higher HPAG_TR) affects mortgage debt growth negatively. This suggests that contrarian feelings may dominate momentum effects when housing prices start rocketing.

In summary, fixed income and housing price variables do explain a major portion of time variation in annual mortgage debt growth. Among these pricing variables, the corporate default premium, representing the credit risk pricing seems more consequential for mortgage debt growth than either the interest rate level, yield curve slope (term premium), or the housing price growth.

MDO/UPB Growth Equation: Lagged (Predictive)

Our previous analysis did shed light on what fixed income and housing price variables (explanatory behavioral equation) help explain contemporaneous variation

EXHIBIT 5

Explanatory or Contemporaneous Linear Regression Results for the Annual Growth of the U.S. Aggregate Single Family Mortgage Debt Outstanding, 1956–2002

Variable		Estimated Coefficient	Standard Error	*T*-Ratio 37 DF	*P*-Value
LAGMDOG	β_1	0.5186	0.0751	6.9060	0.0000
T10Y	β_2	−0.7562	0.2225	−3.3990	0.0020
TSLOPE	β_3	0.1267	0.3064	0.4135	0.6820
DRP	β_4	4.2620	1.8190	2.3430	0.0250
HPAG	β_5	0.5125	0.1003	5.1120	0.0000
T10YTR	β_6	−0.1663	0.2090	−0.7956	0.4310
TSLOPETR	β_7	0.0920	0.3255	0.2827	0.7790
DRPTR	β_8	−6.0514	1.1450	−5.2850	0.0000
HPAGTR	β_9	−0.2695	0.1383	−1.9490	0.0590
CONSTANT	α	3.0570	0.9485	3.2230	0.0030

This Exhibit reports the linear regression results for the Annual Growth of US Aggregate Single Family Mortgage Debt Outstanding (MDOG) in terms of contemporaneous values of variables from the Fixed Income and Housing Markets plus the 1-year Lagged Value of MDOG:

$$MDOG(t) = \alpha + \beta_1 MDOG(t-1) + \beta_2 T10Y(t) + \beta_3 TSLOPE(t) + \beta_4 DRP(t) + \beta_5 HPAG(t) + \beta_6 T10Y_TR(t) + \beta_7 TSLOPE_TR(t) + \beta_8 DRP_TR(t) + \beta_9 HPAG_TR(t) + \varepsilon(t)$$

where MDOG(t), Growth rate of SF Market MDO; MDOG(t − 1), One period (year) lagged value of MDOG, named LAGMDOG; T10Y(t), Yield to Maturity of Constant Maturity 10-Year Treasury; TSLOPE(t), Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-Month Treasury Yield; DRP(t), Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated corporate bonds; HPAG(t), Growth rate of US National Housing Price; T10Y_TR(t), T10Y(t) − [0.5 T10Y(t (1) + 0.5 T10Y(t − 2)]; TSLOPE_TR(t), TSLOPE(t) − [0.5 TSLOPE(t − 1) + 0.5 TSLOPE(t (2)]; DRP_TR(t), DRP(t) − [0.5 DRP(t − 1) + 0.5 DRP(t − 2)]; HPAG_TR(t), HPAG(t) − [0.5 HPAG(t − 1) + 0.5 HPAG(t − 2)]; ε(t), Regression error.

R^2, *84.08%; Adj* R^2, *80.21%; Durbin* H, *0.8769; Residual Autocorrelation, 0.1097.*

Source: Federal Reserve Board and Freddie Mac Financial Research.

in mortgage debt growth. For practical applications such as prediction or forward simulation, however, it would be more convenient if lagged values of the driving variables (predictors) can be used. To this end, we report in Exhibit 7 the regression results of Equation (2), where one period (year) lagged, instead of contemporaneous, values of the fixed income and housing price variables are used along with the lagged dependent variable.

Several noteworthy points are as follows. First, the explanatory power of the lagged (predictive) equation is nearly as strong (78% versus 84%) as the contemporaneous (explanatory) equation discussed previously. Plotting the actual and predicted values of mortgage debt growth using Equation (2) visually shows how closely the projections track the actual values most of the times (Exhibit 8).

Second, the rate level, the corporate default premium, and the housing price growth along with the lagged dependent variable continue to be significant. Among the trends in variables, as before, only the trend in default risk premium is significant.

Third, the signs of the marginal impacts of the rate level, the corporate default premium, and the housing price growth remain unaffected, switching from the explanatory (contemporaneous) to the predictive (lag) version. Only the magnitude of the marginal impact of housing price growth drops noticeably (by about 20–23 bps).

Lastly, the corporate default premium remains the most consequential even with a lag considering the marginal impact (643 bps) of a 100 bps move in a fixed income or housing price variable. This further attests to the importance of corporate credit risk pricing for mortgage debt growth.

The estimated predictive equation mentioned earlier uses nine predictors, including the lagged dependent variable. However, for practical purposes, it may be useful to have a more parsimonious regression model. To this end, we estimate the following regression equation

$$MDOG(t) = \phi + \gamma_1 MDOG(t-1) + \gamma_2 T10Y(t-1) + \gamma_3 TSLOPE(t-1) + \gamma_4 DRP(t-1) + \gamma_5 HPAG(t-1) + \gamma_8 DRP_TR(t-1) + u(t) \quad (3)$$

EXHIBIT 6

Annual Growth of U.S. Aggregate Single Family Mortgage Debt Outstanding and the Fitted Values from the Explanatory or Contemporaneous Linear Regression, 1956–2002

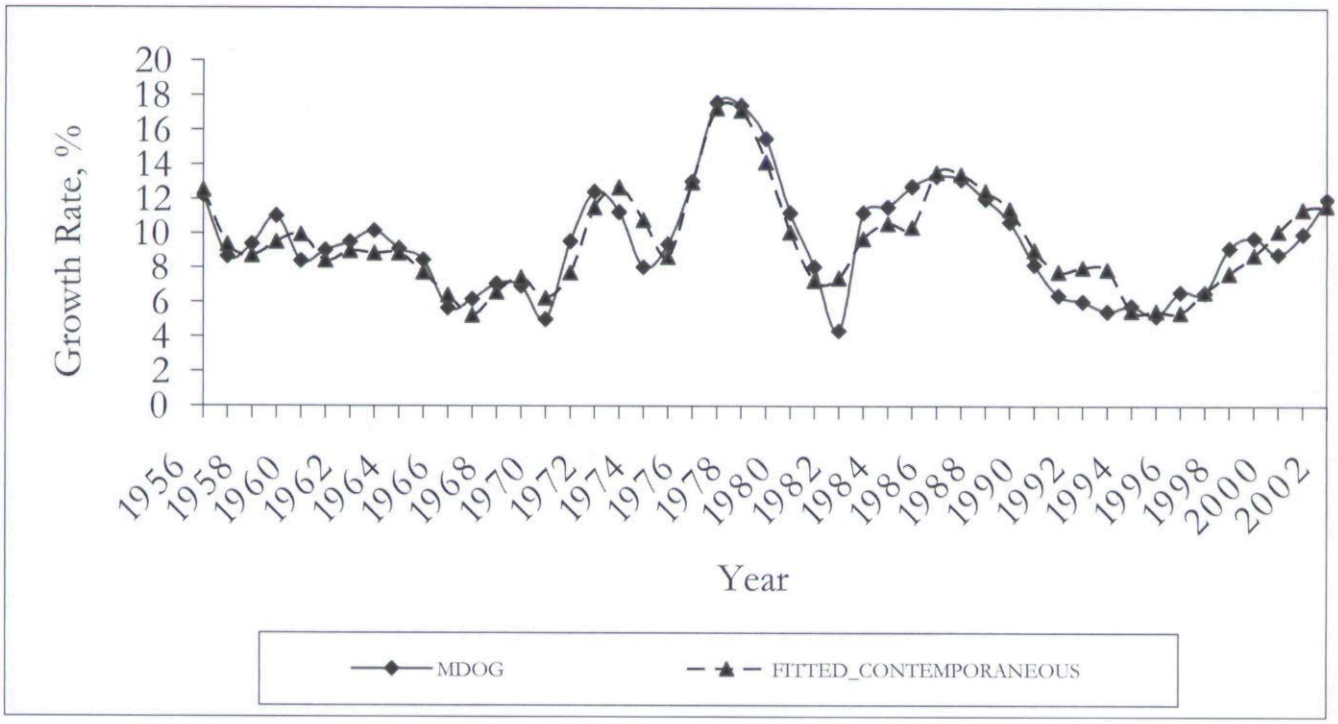
This chart shows the Annual Growth of US Aggregate Single Family Mortgage Debt Outstanding (MDOG) and its fitted values (FITTED_CONTEMPORANEOUS) from the following contemporaneous regression equation

$$MDOG(t) = \alpha + \beta_1 MDOG(t-1) + \beta_2 T10Y(t) + \beta_3 TSLOPE(t) + \beta_4 DRP(t) + \beta_5 HPAG(t) + \beta_6 T10Y_TR(t) + \beta_7 TSLOPE_TR(t) + \beta_8 DRP_TR(t) + \beta_9 HPAG_TR(t) + \varepsilon(t)$$

Where

$MDOG(t)$	: Growth rate of SF Market MDO
$MDOG(t-1)$	: One period (year) lagged value of MDOG
$T10Y(t)$	:Yield to Maturity of Constant Maturity 10-year Treasury
$TSLOPE(t)$	: Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-month Treasury Yield
$DRP(t)$	: Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated corporate bonds
$HPAG(t)$	: Growth rate of U.S. National Housing Price
$T10Y_TR(t)$	: $T10Y(t) - [0.5\,T10Y(t-1) + 0.5\,T10Y(t-2)]$
$TSLOPE_TR(t)$	: $TSLOPE(t) - [0.5\,TSLOPE(t-1) + 0.5\,TSLOPE(t-2)]$
$DRP_TR(t)$	: $DRP(t) - [0.5\,DRP(t-1) + 0.5\,DRP(t-2)]$
$HPAG_TR(t)$	: $HPAG(t) - [0.5\,HPAG(t-1) + 0.5\,HPAG(t-2)]$
$\varepsilon(t)$	: Regression error

The last charted point is for 2002. The regression equation is estimated over 1956–2002.



The variables chosen here are the ones we have found significant in Equations (1) and (2). For the sake of completeness and for use in other related fixed income applications, we have also included the term premium (TSLOPE) although we did not find this variable to be significant.

A couple of noteworthy aspects of the parsimonious model results in Exhibit 9 are as follows. First and foremost, there is virtually no loss in explanatory power using the parsimonious lagged model in Equation (3) instead of the full lagged model in Equation (2). The 78% R^2 of Equation (3) is literally the same as found for Equation (2).

EXHIBIT 7

Predictive or Lagged Linear Regression Results for the Annual Growth of the U.S. Aggregate Single Family Mortgage Debt Outstanding, 1956–2002

Variable		Estimated Coefficient	Standard Error	*T*-Ratio 37 DF	*P*-Value
LAGMDOG	γ_1	0.4482	0.1103	4.0620	0.0000
LT10Y	γ_2	−0.8607	0.3202	−2.6880	0.0110
LTSLOPE	γ_3	0.4296	0.3938	1.0910	0.2820
LDRP	γ_4	5.9549	2.0860	2.8550	0.0070
LHPAG	γ_5	0.3643	0.1668	2.1830	0.0350
LT10YTR	γ_6	−0.1037	0.2512	−0.4128	0.6820
LTSTR	γ_7	0.3317	0.3609	0.9190	0.3640
LDRPTR	γ_8	−3.0571	1.3900	−2.1990	0.0340
LHPAGTR	γ_9	−0.0829	0.2535	−0.3271	0.7450
CONSTANT	φ	3.1628	1.3540	2.3360	0.0250

This Exhibit reports the predictive linear regression results for the Annual Growth of US Aggregate Single Family Mortgage Debt Outstanding (MDOG) in terms of 1-year lagged values of variables from the Fixed Income and Housing Markets plus the 1-year Lagged Value of MDOG:

$$MDOG(t) = \phi + \gamma_1 MDOG(t-1) + \gamma_2 T10Y(t-1) + \gamma_3 TSLOPE(t-1) + \gamma_4 DRP(t-1) + \gamma_5 HPAG(t-1) + \gamma_6 T10Y_TR(t-1) + \gamma_7 TSLOPE_TR(t-1) + \gamma_8 DRP_TR(t-1) + \gamma_9 HPAG_TR(t-1) + e(t)$$

where MDOG(t), Growth rate of SF Market MDO; MDOG(t − 1), One period (year) lagged value of MDOG, named LAGMDOG; T10Y(t), Yield to Maturity of Constant Maturity 10-Year Treasury; TSLOPE(t), Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-Month Treasury Yield; DRP(t), Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated corporate bonds; HPAG(t), Growth rate of the U.S. National Housing Price; T10Y_TR(t), T10Y(t) − [0.5 T10Y(t − 1) + 0.5 T10Y(t − 2)]; TSLOPE_TR(t), TSLOPE(t) − [0.5 TSLOPE(t − 1) + 0.5 TSLOPE(t − 2)]; DRP_TR(t), DRP(t) − [0.5 DRP(t − 1) + 0.5 DRP(t − 2)]; HPAG_TR(t), HPAG(t) − [0.5 HPAG(t − 1) + 0.5 HPAG(t − 2)]; e(t), Regression error.

R^2, *78.48%; Adj* R^2, *73.24%; Durbin* H, *1.1891; Residual Autocorrelation, 0.1134.*

Source: Federal Reserve Board and Freddie Mac Financial Research.

It can also be visually observed from Exhibit 10 that the projections from the parsimonious model track the actual values most of the times. Thus, there is a strong practical motivation for using the parsimonious model in forward simulation applications.

Second, the direction and the statistical significance of the slope coefficients remain the same as in Equations (1) and (2). However, there is some strengthening in their magnitudes, i.e., in the marginal effects. Most noteworthy is the improvement in the marginal effect of the lagged yield curve slope, with its coefficient moving from +0.4296 (Equation (2)) to +0.6621 (Equation (3)). Its *t*-ratio also improves from 1.091 (Equation (2)) to 1.876 (Equation (3)), a level that is close to significance at 5%. We, therefore, recommend that the lagged yield curve slope be retained in the parsimonious model although it is not significant, strictly speaking.

Key potential applications of the predictive Equations (2) or (3) include forward simulation of a mortgage portfolio, retained or securitized. For that matter, in any top-down exercise of projecting/simulating the profile (size, mix, risk, income, or other attributes) of a mortgage or mortgage debt linked/contingent portfolio, the predictive MDO/UPB Growth Equation can be useful.

As an example, suppose around the end of 2005, we simply wish to project the size of Freddie Mac's or Fannie Mae's Single Family Securitized (Sold) Portfolio for the Year 2006. This amounts to projecting the growth of Total UPB of the Sold Portfolio. First, using the predictive MDO/UPB Growth Equation (the full version in Equation (2) or the parsimonious version in Equation (3)), and the known or predicted value of the predictors (regressors), we would project the growth and hence the 2006 size (given 2005 size) of the Total SF Mortgage Debt Outstanding at the market level. Then, assuming a projected 2006 market share for the Agency, we would project the Agency's Sold Portfolio UPB at the end of 2006.[18] Instead of producing a point forecast for 2006, we could also pro-

EXHIBIT 8

Annual Growth of U.S. Aggregate Single Family Mortgage Debt Outstanding and the Fitted (Predicted) Values from the Predictive/Lagged Linear Regression, 1956–2002

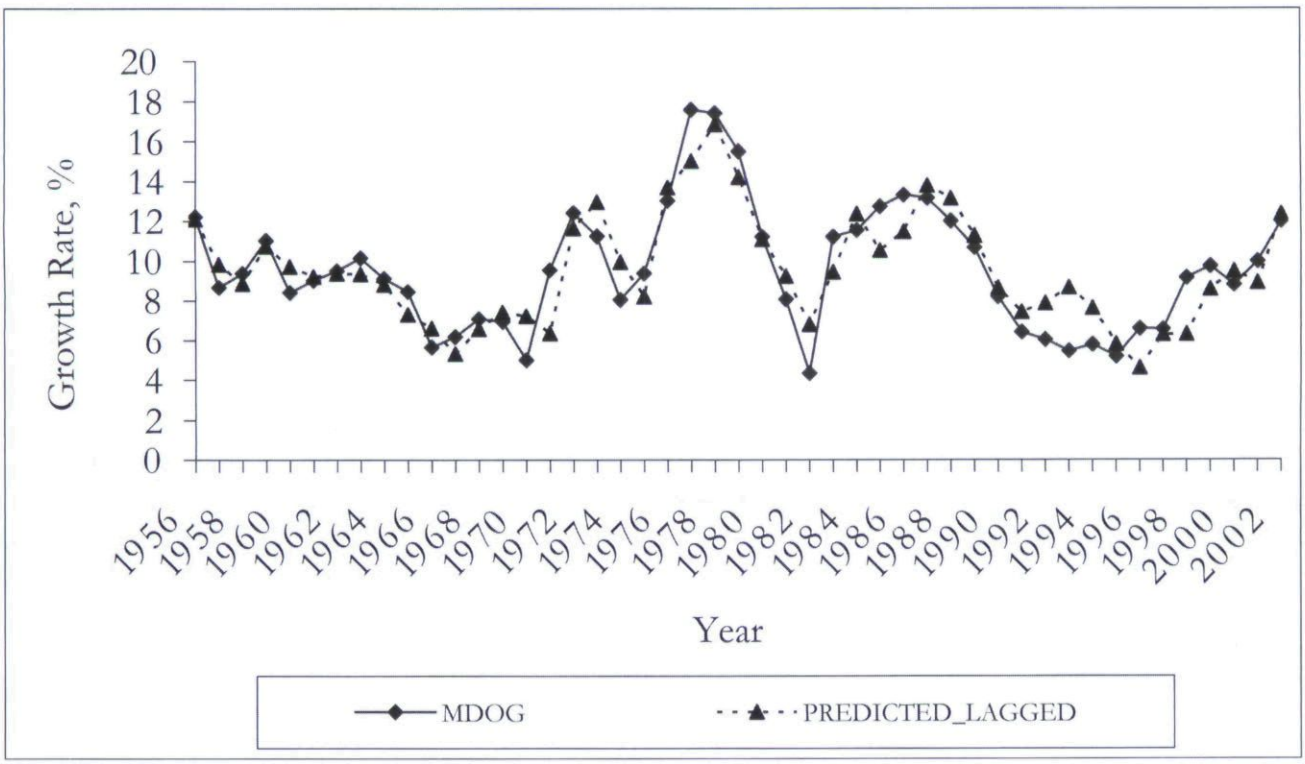
This chart shows the Annual Growth of US Aggregate Single Family Mortgage Debt Outstanding (MDOG) and its fitted values (PREDICTED_LAGGED) from the following lagged regression equation:

$$MDOG(t) = \phi + \gamma_1 MDOG(t-1) + \gamma_2 T10Y(t-1) + \gamma_3 TSLOPE(t-1) + \gamma_4 DRP(t-1) + \gamma_5 HPAG(t-1) + \gamma_6 T10Y_TR(t-1) + \gamma_7 TSLOPE_TR(t-1) + \gamma_8 DRP_TR(t-1) + \gamma_9 HPAG_TR(t-1) + e(t)$$

Where

$MDOG(t)$	: Growth rate of SF Market MDO
$MDOG(t-1)$	: One period (year) lagged value of MDOG
$T10Y(t)$	:Yield to Maturity of Constant Maturity 10-Year Treasury
$TSLOPE(t)$	: Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-month Treasury Yield
$DRP(t)$	: Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated corporate bonds
$HPAG(t)$	: Growth rate of US National Housing Price
$T10Y_TR(t)$	: $T10Y(t) - [0.5\,T10Y(t-1) + 0.5\,T10Y(t-2)]$
$TSLOPE_TR(t)$	: $TSLOPE(t) - [0.5\,TSLOPE(t-1) + 0.5\,TSLOPE(t-2)]$
$DRP_TR(t)$	: $DRP(t) - [0.5\,DRP(t-1) + 0.5\,DRP(t-2)]$
$HPAG_TR(t)$	: $HPAG(t) - [0.5\,HPAG(t-1) + 0.5\,HPAG(t-2)]$
$e(t)$	: Regression error

The last charted point is for 2002. The regression equation is estimated over 1956–2002.



duce UPB forecasts for arbitrary 2006 economic scenarios defined in terms of specific values for the predictors (regressors) of the MDO/UPB Growth Equation. Forecasts along different scenarios or simulated paths are of course essential ingredients of risk (e.g., Value at Risk) and capital (e.g., risk based economic and regulatory capital, stress tests) estimation of mortgage-related instruments and portfolios. The simulated results can also

EXHIBIT 9

Parsimonious Predictive or Lagged Linear Regression Results for the Annual Growth of the U.S. Aggregate Single Family Mortgage Debt Outstanding, 1956–2002

Variable		Estimated Coefficient	Standard Error	*T*-Ratio 40 DF	*P*-Value
LAGMDOG	γ_1	0.4387	0.0878	4.9960	0.0000
LT10Y	γ_2	−0.9301	0.2156	−4.3150	0.0000
LTSLOPE	γ_3	0.6621	0.3528	1.8760	0.0680
LDRP	γ_4	6.8164	1.4920	4.5690	0.0000
LHPAG	γ_5	0.3152	0.0838	3.7620	0.0010
LDRPTR	γ_8	−2.8580	1.1580	−2.4680	0.0180
CONSTANT	φ	2.8258	1.0020	2.8210	0.0070

This Exhibit reports the results of a parsimonious version of the predictive linear regression model for the Annual Growth of US Aggregate Single Family Mortgage Debt Outstanding (MDOG) in terms of one-year lagged values of variables from the Fixed Income and Housing Markets plus the one-year Lagged Value of MDOG:

$$MDOG(t) = \phi + \gamma_1 MDOG(t-1) + \gamma_2 T10Y(t-1) + \gamma_3 TSLOPE(t-1) + \gamma_4 DRP(t-1) + \gamma_5 HPAG(t-1) + \gamma_8 DRP_TR(t-1) + u(t)$$

where MDOG(t), Growth rate of SF Market MDO; MDOG(t − 1), One period (year) lagged value of MDOG, named LAGMDOG; T10Y(t), Yield to Maturity of Constant Maturity 10-Year Treasury; TSLOPE(t), Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-Month Treasury Yield; DRP(t), Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated corporate bonds; HPAG(t), Growth rate of US National Housing Price; DRP_TR(t), DRP(t) − [0.5 DRP(t − 1) + 0.5 DRP(t − 2)]; u(t), Regression error.

R^2, *77.95%; Adj* R^2, *74.65%; Durbin* H, *1.0009; Residual Autocorrelation, 0.1166.*

Source: Federal Reserve Board and Freddie Mac Financial Research.

be used for the planning of funding capital for retained portfolios, determining a pricing strategy, or dollar investment allocation among different strands of mortgage products/businesses.

CONCLUSIONS

In this article we have investigated the role of well-known asset pricing factors in explaining and predicting the year to year variations of aggregate residential (single family) mortgage debt in the U.S. Our analysis over the 1955–2002 period shows that linear regression models in terms of key fixed income and housing price variables can capture more than three-quarters of the contemporaneous as well as one year ahead variations in the growth of mortgage debt outstanding. This supports the view that in the short run (year), mortgage debt growth is a financial phenomenon, although the long term growth is primarily determined by structural factors such as demographic trends and incidence of home ownership.

As expected, we find interest rate level (yield to maturity of the benchmark 10-year Treasury) to have a negative effect and housing price growth to have a positive effect on mortgage debt growth. High persistence also makes the lagged growth rate of mortgage debt an important variable. However, corporate credit risk or default premium (Moody's Baa–Aaa) appears to be the most consequential in terms of the marginal impact of a 100 bps move in an explanatory variable or predictor. An increase in corporate default premium seems to be beneficial for mortgage debt growth perhaps due to risk shifting benefits of the home mortgage market. But acceleration in corporate default premium increase may signal pervasive credit concerns and hence can adversely affect expansion of the mortgage debt market. Interestingly, the yield curve slope (Treasury 10 Year–3 months) does not appear to matter much for mortgage debt growth although its positive role is elevated in a parsimonious predictive model with 1-year lag.

An important policy implication of our findings is that if government policies, notably the Federal Reserve interest rate (Federal Funds Rate) actions and commentaries, were to influence the growth of mortgage debt, it is essential that the benchmark 10-year rate move sufficiently in the desired direction. Neither the short end of the yield curve nor the slope of the curve is much consequential in this respect. Latest experience seems consistent with this policy implication. Since the start of the

EXHIBIT 10

Annual Growth of U.S. Aggregate Single Family Mortgage Debt Outstanding and the Fitted (Predicted) Values from the Parsimonious Version of the Predictive/Lagged Linear Regression Model, 1956–2002

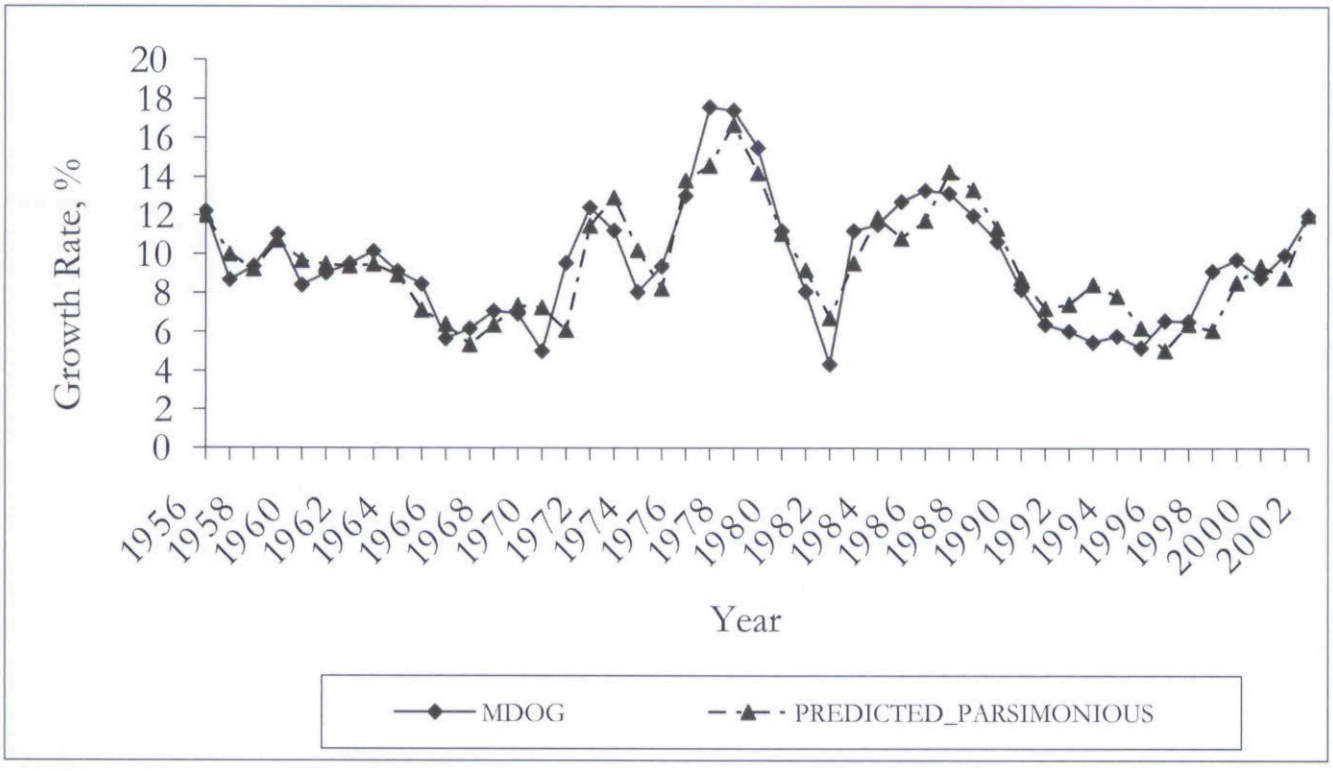
This chart shows the Annual Growth of US Aggregate Single Family Mortgage Debt Outstanding (MDOG) and its fitted values (PREDICTED_PARSIMONIOUS) from the following lagged regression equation:

$$MDOG(t) = \phi + \gamma_1 MDOG(t-1) + \gamma_2 T10Y(t-1) + \gamma_3 TSLOPE(t-1) + \gamma_4 DRP(t-1) + \gamma_5 HPAG(t-1) + \gamma_8 DRP_TR(t-1) + u(t)$$

Where

$MDOG(t)$	: Growth rate of SF Market MDO
$MDOG(t-1)$	: One period (year) lagged value of MDOG, named LAGMDOG
$T10Y(t)$	:Yield to Maturity of Constant Maturity 10-year Treasury
$TSLOPE(t)$	: Slope of the Treasury yield curve estimated as the spread of T10Y over the 3-month Treasury Yield
$DRP(t)$	: Default Risk Premium estimated as the yield to maturity spread of Moody's Aaa and Baa rated corporate bonds
$HPAG(t)$	: Growth rate of U.S. National Housing Price
$DRP_TR(t)$	: $DRP(t) - [0.5\ DRP(t-1) + 0.5\ DRP(t-2)]$
$u(t)$	: Regression error

The last charted point is for 2002. The regression equation is estimated over 1956–2002.



Federal Reserve's tightening cycle in 2004, the short rates have gone up consistently without much impact on the 10-year and 30-year rates and consequently without any sizeable effect on mortgage purchase originations and refinancing. For much of 2004 and 2005, the benchmark 10-year rate bounced around between 4.00 and 4.50%, and only around early March of 2006 the 10-year rate has made a decided move beyond this range. It seems that finally there are some signs of the residential mortgage market cooling off in 2006.[19]

A second policy implication of our results is that the credit risk structure of interest rates, as embodied in the corporate default risk premium, should be included in forward simulations by mortgage related businesses and by their regulators. Traditionally the credit loss and delinquency information for mortgages have been emphasized

to indicate the credit risk prospects of mortgage portfolios. Although this practice is certainly warranted, our results suggest that the level and trend of default risk pricing in the financial market may be valuable in projecting changes in the size of the mortgage debt market itself. This is particularly important for businesses, such as that of Fannie Mae and Freddie Mac, where the market share variations are minor and the growth of the market itself is a major determinant of the business volume and as such of the portfolio size.

In terms of implementing our predictive regression model, we find that a more parsimonious model of six variables does not cost much in terms of explanatory power when compared with the full nine variables model. By and large the economic structure of the regression relationship also remains unchanged (except that the trend variables lose their importance). This is certainly good news for application of the regression equations in a prediction/forward simulation context. The special benefit of using these equations is that the explanatory/predictive variables relate exclusively to fixed income and housing price variables as opposed to pricing plus macroeconomic variables in a detailed structural approach. To price and to assess the returns, risks and capital assignment/requirement of mortgage related instruments and their portfolios, complex multiperiod simulations of interest rates, and housing prices are extensively used by practitioners and regulators. The exclusive and yet simple structure of reliance on interest rates and housing price variables in forecasting the size of the mortgage debt market could provide a convenient framework in this context. Together with a forecast of the market share and the portfolio mix, one could determine then the dollar magnitudes of returns, risks, and required capital at the portfolio level in a coherent manner.

ENDNOTES

Thanks to Henry Cassidy and Frank Nothaft for helpful comments.

This work originated while the author was a Principal Economist with Freddie Mac. However, the views expressed in this paper are those of the author and not of Freddie Mac.

[1]Home mortgage debt in the U.S. has increased every quarter since the end of World War II. According to Nothaft [2004] and Syron [2004], U.S. residential mortgage debt is projected to grow a rate of 8.25% per annum and will be north of $17 trillion by 2013.

[2]In comparison, the outstanding amounts of interest-bearing U.S. Treasuries and Corporate Bonds stood at $4.1 and $4.9 trillion, respectively.

[3]According to the Commerce Department, the household savings rate for 2005 was −0.5%. The last negative rates occurred in 1932, a drop of 0.9 percent, and a record 1.5% decline in 1933. One major reason for the negative savings rate in 2005 is the double digit growth in home prices that made households feel wealthier and hence spend more. Nothaft and Chang [2004] find that the extraction of home equity built up by home price appreciation may dampen wealth accumulation by households.

[4]At the Federal Reserve, former Chairman Alan Greenspan repeatedly voiced concerns about the systemic risk posed by the unfettered growth of the GSE portfolios. In particular, Greenspan argued that the concentration of massive interest rate and credit risks at the GSEs and the hedging transactions associated with the management of these risks could potentially destabilize the U.S. financial system. In his first hearing at the Congress, the new Chairman Ben Bernanke reiterated the same concerns.

[5]See Syron [2004].

[6]See, for example, Nothaft [2004], Christie [2004], and Barsons [2005].

[7]Follain and Dunsky [1997] examine the effect of U.S. mortgage interest tax deduction policy on the demand for residential mortgage debt. Jappelli and Psitaferri [2003] investigate tax policy effect on demand for mortgage debt in Italy. Tax policy changes are, however, quite rare to explain the variations of annual growth of mortgage debt.

[8]We also entertained the stock market return (S&P 500) and its trend as additional factors. However, we found these factors to be quite noisy and not consequential for MDO growth. Accordingly, we exclude these variables here.

[9]See, for example, Chen, Roll, and Ross [1986], Keim and Stambaugh [1986], and Fama nd French [1993]. Literature surveys can be found in Campbell [2000] and Cochrane [2001]. Generally speaking, term premium and default premium are common to the dynamics of the stock and bond markets, the bond market is primarily driven by these two factors and the interest rate level, and the stock market is additionally sensitive to two to three macroeconomic and/or stock market factors [Fama and French, 1993].

[10]The CMHPI database was jointly developed by Freddie Mac and Fannie Mae, based on mortgages purchased or securitized by these companies since January, 1975. The regulatory organization OFHEO (Office of Federal Housing Enterprises Oversight) publishes a national series HPI (House Price Index) using the same joint data base. The differences between these indices are minor.

[11]The CMHPI series is from the latest release available on the website of Freddie Mac Economic and Housing Research

as of early 2006. The data is quarterly and ends at the third quarter of 2005. The mean annual growth rate in national housing price over the 1970–2002 period is 6.07% according to CMHPI data. Over the same period, the growth rate is 6.13% according to the series that we use.

[12]By the same token, flatter yield curves, especially inverted yield curves are widely viewed as precursors to economic slow down. Accordingly, a lower TSLOPE is expected to lower the growth of MDO.

[13]See, for example, Dossani [2004] and Syron [2004].

[14]This is especially so if it is possible to layoff some of the undesirable credit risk of mortgage investing at a relatively low cost.

[15]In a way, the inclusion of trend variables allow for the possibility of non-Markovian evolution of the MDO/UPB growth.

[16]The highest growth rate of mortgage debt was actually recorded at 20.9% in 1950. This falls outside Our regression estimation period of 1955–2002.

[17]A similar regression without the lagged dependent variable has R^2 of 64.09%. Thus the lagged dependent variable plays a vary important role in explaining the annual variation of mortgage debt growth.

[18]The projected/simulated SF Sold Portfolio UPB for 2006 has implicit in it the net effect of the runoffs from the 2005 Portfolio and the 2006 Purchases. However, these components are not modeled in the MDO/UPB Growth Equation.

[19]See the March 15, 2006 Press Release by the Mortgage Bankers Association, http://www.mortgagebankers.org/NewsandMedia/PressCenter/40185.htm.

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