Subprime Lending and Real Estate Prices

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This paper establishes a theoretical and empirical link between the use of aggressive mortgage lending instruments, such as interest only, negative amortization or subprime, mortgages, and the underlying house prices. Such instruments, which come into existence through innovation or financial deregulation, allow more borrowing than otherwise would occur in previously affordability constrained markets. Within the context of a model with an endogenous rent-buy decision, we demonstrate that the supply of aggressive lending instruments temporarily increases the asset prices in the underlying market because agents find it more attractive to own or because their borrowing constraint is relaxed, or both. This result implies that the availability of aggressive mortgage lending instruments magnifies the real estate cycle and the effects of fundamental demand shocks.

We empirically confirm the predictions of the model using recent subprime origination experience. In particular, we find that regions that receive a high concentration of aggressive lending instruments experience larger price increases and subsequent declines than areas with low concentration of such instruments. This result holds in the presence of various controls and instrumental variables.

Introduction

This paper establishes a link between the availability of aggressive mortgage lending instruments and underlying asset market prices. Industry sources suggest that aggressive lending instruments, such as interest only loans, negative amortization loans, low or zero equity loans, and teaser-rate ARMs, accounted for nearly two-thirds of all U.S. loan originations since 2003.[1] We demonstrate theoretically that the introduction of aggressive lending instruments increases asset prices in the underlying market because agents find it more attractive to switch from renting to owning and take advantage of the low-cost financing and/or because they find their credit constraint relaxed. Aggressive instruments, which come into existence through innovation or financial deregulation, allow more borrowing than otherwise would occur. The greater initial affordability of aggressive instruments relative to traditional mortgages implies that these instruments will be in higher demand in less affordable markets.

The lending sector acquired this new ability to offer aggressive products through financial innovation and deregulation. In particular, risk based pricing became possible through the implementation of automated underwriting models and lending for riskier mortgages became widespread in the late 1990's with the development of private label securitization of non-conforming loans. At the same time, deregulation allowed banks to originate and securitize these mortgages without recourse, that is, without having to

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[1] FDIC Outlook: Breaking New Ground in U.S. Mortgage Lending. December 18th, 2006 <http://www.fdic.gov/bank/analytical/regional/ro20062q/na/2006_summer04.html> Nonprime mortgage originations rose at an even pace from 2001 through 2003 to reach between $25 billion and $30 billion in January 2004. Originations accelerated in 2004 before peaking in March 2005 in a range between $60 billion to $70 billion.
http://www.fdic.gov/bank/analytical/regional/ro20062q/na/2006_summer04_chart03.html

account for the buyback provisions imbedded in these securities. This additional source of funding at the borrower level increases demand for housing that is then translated into higher market prices, with the effect greatest in markets of fixed or inelastic supply.

Because aggressive mortgage instruments are distributed non-uniformly over space, we are able to test for the impact they have on property markets. We use cross-section data to compare outcomes across regions with different concentrations of aggressive mortgage instruments to test for the implications of the model. We further are able to test for the mechanism of the model by linking the market share of aggressive mortgages to price dynamics over time and through the use of two separate instrumental variables.

We use county-level origination data to empirically investigate the hypothesized links. We find that areas with high concentrations of aggressive lending instruments experience larger price run-ups during rising markets, and deeper crashes during down markets. This basic finding holds even when we control for the contemporaneous changes in household income, use lead-lag relationships, and two separate instrumental variables: affordability and share of minority households. Both of these instrumental variables are highly correlated with the use of subprime but are uncorrelated with future price changes in the market. Yet, the subprime share of originations predicted by each of these two instruments is highly significant and explains a great deal of the cross-sectional variation of real estate market price changes.

We proceed as follows: Section 1 is a literature review. Section 2 develops the link between lending and asset markets in a theoretical model. Section 3 presents the data and empirical results, including our robustness checks and instrumental variable estimation. Section 4 concludes with a brief summary.

1. Literature Review

Ours is not the first study to investigate the link between lending and asset markets. Allen and Gale (1998 and 1999), Herring and Wachter (1999), and Pavlov and Wachter (2002, 2005) show that underpricing of the default risk in bank lending leads to inflated asset prices in markets of fixed supply. Furthermore, Pavlov and Wachter (2002, 2005, 2006) show that underpricing of the default risk exacerbates asset market crashes.

One unifying feature of this prior literature on the link between lending and asset markets is that the asset-backed loans are mispriced, either rationally or not. Our point of departure in this paper is that lenders react to current information on risks which may change over the cycle. In other words, the pricing of loans can be rational. Yet, asset prices increase because some borrowers see their borrowing constraint relaxed. If loans are underpriced, this effect is magnified, because then even previously unconstrained borrowers optimally choose to buy rather than rent. It is the time variation of this constraint or loan underpricing, or both that generates our finding that aggressive lending magnifies the effect of negative demand shocks.

A handful of empirical investigations directly study the impact of aggressive lending on real estate, whether these instruments are priced correctly or not. Hung and Tu (2006) find that the increase in the use of adjustable rate mortgages in California is associated with an increase in median home prices. They make no comment on whether this increase is temporary and will reverse with the business cycle or whether it is a one-time permanent positive shock. Similarly, the September 2004 IMF report on World Economic Issues suggests that countries with higher use of adjustable rate mortgages (ARMs) have more volatile housing markets (Chapter II, page 81). The mechanism they conjecture to explain this finding is that higher use of ARM-like instruments makes real estate markets more sensitive to interest rate changes. This report, however, does not consider the fluctuation in availability of ARMs or aggressive instruments throughout the real estate market cycle. Even though the empirical findings of both studies do not provide a direct test of our model, they are indeed consistent with its implications. Coleman, LaCour-Little, and Vandell (2007) provide an additional test for the role of mortgage instruments using data from the recent US experience. They regress price change on fundamentals and a variety of mortgage indicators, with mixed findings.

This study is distinct from a related literature which estimates the fundamental price of an asset directly and detects asset price inflation by comparing the estimated to the observed price, such as Himmelberg, Mayer, and Sinai (2005).[2] Rather we develop here an

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[2] For others, see instance Smith, Smith, and Thompson (2005) for a direct estimation of real estate values in Los Angeles. Other studies of the fundamental real estate values include Case and Shiller (2003), Krainer and Wei (2004), Krugman (2005), Leamer (2002), McCarthy and Peach (2004), Shiller (2005), Edelstein (2005) and Edelstein, Dokko, Lacayo, and Lee (1999).

observable implication and mechanism for a specific cause of asset price changes and potentially a credit induced bubble.

2. Model

This section presents a model of borrower demand and lending behavior in the presence of both traditional mortgages and aggressive lending instruments in the context of a competitive real estate market. The quantity of housing services consumed by each household is fixed and exogenous to our model. The borrower can rent or purchase the housing services for each period. The evolution of wealth for the borrower is given by:

$$W_t = \begin{cases} W_{t-1} + Y_t - \delta P_{t-1} & \textit{if rent} \\ W_{t-1} + Y_t - rP_{t-1} + P_t - P_{t-1} & \textit{if own} \end{cases} \tag{1}$$

where t denotes the time period, W_t denotes the total wealth at time t, Y_t is the stochastic income at time t, δ denotes the rent payment, r is the non-stochastic interest rate, and P_t is the equilibrium price of housing. Each period the agent chooses to rent or purchase the housing services in order to maximize the expected utility of terminal wealth:

$$U(W_T) = \frac{W_T^{1-\gamma}}{1-\gamma}, \ \gamma > 1 \tag{2}$$

where γ denotes the risk-aversion parameter and T denotes the final period. If at any point in time the wealth of the agent becomes zero or negative, then the agent is in

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default. Note that this is the total wealth of the agent, not just equity in the home. This is

consistent with the lack of ruthless default as discussed in Stegman and Quercia (1992),

Pavlov (2001), and Deng, et.al. (2007).

If the agent defaults, their wealth resets to a small amount above zero and their credit

score, C, goes down to 500.[3] Each period the agent maintains wealth above zero, their

credit score increases by 30, to a maximum of 850. Therefore in addition to maximizing

expected utility of terminal wealth the agent considers the probability that they have to

default in the future, and the negative consequences of default, namely, the inability to

purchase a home in the future until the credit score improves.

Lenders require a minimum credit score to fund a mortgage. This constraint is analogous

to the wealth and loan-to-value (LTV) constraints. These three constrains are

conceptually similar because they all can eliminate a particular set of agents from

becoming home owners regardless of their optimal choice. For numerical tractability in

what follows we only consider the credit score constraint. Adding the LTV constraint

directly would require modeling consumption of non-housing services, which is beyond

the scope of this paper. For evidence of the importance of the credit score constraint, as

well as wealth and income constraints, see Calem, Firestone, and Wachter (2009). The

credit score represents the constraint in our model, and thus the rent-versus-buy decision,

and the resulting equilibrium price of ownership, is solved through constrained

optimization. When minimum credit score requirements are lowered through aggressive

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[3] The score of 500 is purely arbitrary and is designed to match the FICO score for illustration purposes
only.

lending practices, the entire group of borrowers with credit scores above the new constraint, but below the original one, would then be considered unconstrained, and thus be able to purchase housing at the prevailing equilibrium price.

This mechanism is also the source of endogenous cycles in the economy. Incomes are stochastic, and real estate prices respond to changes in income. On top of this response, if lenders relax and tighten the minimum credit score requirements pro-cyclically and/or if they re-price their products pro-cyclically, we get a magnified real estate cycle above and beyond what could be justified by shifts in incomes.

Our model further assumes that the stock of owner-occupied homes is constant and rental properties cannot be converted to owner-occupied. In reality, these two assumptions would not hold perfectly. However, we justify their use in our model by the fact that when lending rates fall the demand for both rental and owner-occupied housing increases either through increased household formation and/or through increased demand for second homes. We do not explicitly model these effects here.

2.1 Solution Methodology

The main mathematical complication of the above model lies in the ability of the agent to predict the future price distribution of property prices and choose whether to rent or buy given this future price distribution. In our model agents account for the fact that incomes fluctuate, and, therefore prices fluctuate. However, the mistake borrowers make is that

they do not foresee if, when, and by how much lenders will withdraw credit. Since an explicit solution for the future real estate price distribution is not available we employ a version of the Longstaff and Shwartz (2001) Least Squares Simulation approach. First we generate simulation paths for future personal income. We assume future income follows a zero-mean Brownian motion of the form:

$$dY_{t+1} = \sigma_Y dZ \tag{3}$$

where σ_Y denotes the volatility of income. We start by assigning random wealth levels for each simulation path and time period. We then assume that the terminal real estate price level is half of the terminal wealth. We justify this last assumption by appealing to the stylized fact that at retirement people tend to spend half of their total wealth, including present value of expected future retirement payments, on housing, and the other half they use for consumption. We have solved our model for various other levels of final prices, and while the level of real estate prices change, the comparative statics we report below remain unchanged. Another way of stating this assumption is that the rate of substitution between housing services and other consumption at retirement is constant and certain. While the exact rate of substitution does not matter, the fact that it is constant is important to our model. Absent this assumption, the rate of substitution between housing services and other consumption becomes an additional source of uncertainty, which needs to be explicitly modeled as a stochastic process. This would, in turn, add an additional stochastic state variable to our model, thus greatly increasing the computational demands of the solution.

At each time period between *T-1* and 2, going backwards, we regress the future price on each path on the income and wealth level on that path. In our base model we utilize regression of the form:

$$\log(P_{t+1}) = \alpha_0 + \alpha_1 Y_t + \alpha_2 Y_t^2 + \alpha_3 W_t + \alpha_4 W_t^2 + \varepsilon. \tag{4}$$

We then use the estimated regression for each period to derive a distribution of prices for period *t+1* conditional on the state variables at time *t*.

The conditional future distribution of real estate prices allows us to determine the current price, P_t, that numerically equates the expected utility of renting (which is certain) to the expected utility of buying (which involves price risk). In this model the total demand for rental and owner-occupied housing does not change, nor does the supply of each type of housing. Instead, the price of owner-occupied housing changes to make sure that the utility of renting and owning is the same, thus ensuring that the total demand and supply of the two types of hosing are equated.

Once we have the price P_t which equates the utilities of rent and own, we can solve for the current level of wealth, W_t, using the evolution of wealth given in Equation (1). Given this new levels of current wealth, W_t, we repeat the regression estimation (Equation (4)) and re-compute current wealth levels until we reach a fixed point for which current wealth levels do not change anymore.

We then repeat the above described algorithm until time 2. At the first time period we have only one level of income and wealth, so we do not estimate regression equation (4) but rather use the prices in period 2 to compute the price in period 1 that equates the expected utilities of renting and buying.

We then go forward through our simulation and set the credit score to 500 for any path for which wealth level falls below zero. We also increase the credit score by 30 for every period the agent maintains wealth above zero. If the wealth level does fall below zero, it is reset to a small positive amount. For numerical tractability we cannot set the wealth level exactly at zero. The agent is then not allowed to purchase on that path until their credit score improves above the pre-determined minimum. In our solutions we do not re-set the price in that period if some paths result in negative wealth. Nonetheless, credit scores do impact prices because they impact the ability of the agent to purchase real estate on that path until their credit score improves.

By following the above methodology the initial wealth level is different on each path. We then alter the final period wealth and repeat the entire procedure until the initial wealth level on all simulation paths equals the original wealth level, set to 100 in our case. Once this is achieved, we have a solution of the model in which wealth levels are consistent on each path and for each time period and prices on each path and time period are set to equate the utility of renting and owning.

We provide step by step description of our solution algorithm in the appendix.

2.2 Model Solution

Table 1 reports the base parameters we use in the numerical solution. In additional to the parameters already mentioned above, we set the number of time periods to 10, each one representing roughly 3 to 5 years of the agent's life, and we set the number of simulations to 10,000. While we would have like to increase the number of simulation paths, the above procedure is computationally very demanding and increasing the simulation paths greatly increases the time to find a solution.

Figure 1 reports the equilibrium real estate price at time 1 as a function of the lending rate for minimum credit score requirement of 600 and 700. In both cases, higher borrower cost relative to the cost of renting results in lower prices today. In other words, with high borrowing costs, agents require high expected future price appreciation to make the decision to buy.

Furthermore, the high minimum credit score requirement of 700 places a potential future burden on homeowners as it increases the penalty if they are forced into default in the future. The penalty is increased because it would take longer for an agent to recover their credit score and borrow again.

Importantly, the minimum credit score requirement has a relatively larger impact for very low interest rates because the penalty of not being able to borrow in the future is larger when homeownership is relatively more attractive.

Figure 2 focuses on the effect of minimum credit score requirement on initial prices for three levels of the borrowing rate: 3, 4, and 5 percent. The higher the minimum credit score requirement, the more reluctant are agents to borrow and own. This is particularly true if interest rates are low relative to the cost of renting, in which case the penalty of being unable to buy real estate is significant and very restrictive.

The overall conclusion of the above analysis is that eased lending terms, either in the form of low borrowing costs, low credit score requirements, or both, have a positive impact on the real estate markets and push prices higher.

3.0 Empirical Evidence

The theoretical model described above links deterioration of credit standards to real estate price increases. The deterioration of credit standards can take the form of lower credit score requirements, lower cost of borrowing relative to the rental cost, or both. In this section we test these empirical implications using a dataset of subprime originations. In particular we show that asset prices rise more and decline more in markets with high concentrations of aggressive instruments and that the use of aggressive instruments declines the most for markets that experience the largest price declines.

In our empirical analysis we utilize county-level subprime share of total mortgage originations (percent of dollar volume of loans) from HMDA. We also use the county-level Economy.com home price indices, and Census median household income.

Table 2 reports the impact of the county-level share of subprime originations on real estate market price changes, controlling for change in median household income. Panel A reports the results using lagged originations, and Panel B reports the results using contemporaneous originations. Each cross-sectional regression is based on subprime originations and real estate price changes in 336 counties. The results reported in both tables are consistent with our hypothesis that subprime loans, as an example of aggressive lending, induce higher price appreciation in up markets, and larger price depreciation in down markets. For instance, subprime originations, either contemporaneous (Panel B) or lagged (Panel A), have a strongly positive impact on price appreciation in all years of

rising property markets (2001 to 2005). Subprime originations, on the other hand, have a strong negative impact on the real estate markets in 2007, which is the only full year of price declines in our sample. These relationships are strongly significant, even when controlling for the contemporaneous change in household income in a county.

To address a potential endogeneity problem due to persistency in subprime originations through time, we replace subprime originations in the above regression with two separate instruments that are highly correlated with subprime originations but uncorrelated with future price changes. The first instrument we use is housing affordability. Affordability is highly correlated with subprime originations because borrowers in less affordable markets are more likely to resort to aggressive lending instruments so that they can enter the housing market. At the same time, affordability has no implications for future house price appreciation. In the first stage estimation, reported in Table 3, we regress the share of subprime originations on the on the NAHB/Well Fargo Housing Opportunity Index. The housing opportunity index (HOI) reports the percent of sold homes in an MSA that can be purchased by a median income family. Our data includes 93 MSAs. Low levels of the index indicate low affordability and are associated strongly with higher use of subprime mortgages. In the second stage estimation, reported in Table 4, we use the predicted share of subprime originations based on the contemporaneous level of the HOI to explain house price appreciation, controlling for the contemporaneous change in household income. Both the lagged (Panel A) and contemporaneous (Panel B) instrumental variable (predicted subprime originations) are related to higher price appreciation during up markets and larger price depreciation during down markets.

We further use percent minority (African American and Hispanic) population as an alternative instrument for subprime originations. Analogously to the HOI index, percent minority population is highly correlated with subprime originations but has no implications for contemporaneous or future house price appreciation. Table 5 reports the first stage cross-sectional regression estimation of subprime originations on percent minority (African American and Hispanic) population, one per year. While the explanatory power of these regressions is relatively low, between 18 and 20%, the percent minority population is a highly significant variable in all regressions.

The second stage estimation uses the predicted subprime origination to explain house price appreciation, controlled for change in personal income. The results of this estimation are reported in Table 6. During up markets, the predicted subprime originations have a positive and significant impact on the underlying real estate markets. The regressions for 2006 provide mixed and insignificant results because 2006 was a pivotal year, with positive appreciation during the first 6 to 9 months, and house price declines late in the year. The regressions for the only down market in this sample, the year 2007, result in negative and significant coefficient of predicted subprime originations on house price changes.

The overall implications of both the direct and the IV estimation is consistent with aggressive lending, in the form of subprime mortgages, having an impact on the underlying real estate markets and ultimately exacerbating their cycle. Note that this

result holds even before we observe large default levels, which did not occur until late 2007 and early 2008. This implies that it is the fluctuation in the supply of aggressive lending instruments that increases the long-term house price changes rather than default experience.

4.0 Conclusion

In this paper we show, both theoretically and empirically, that the presence of aggressive lending instruments magnifies real estate market cycles. Markets with high concentrations of aggressive lending instruments are at a risk of relatively larger price declines following a negative demand shock. At the same time, markets that decline the most following a negative demand shock tend to suffer greater withdrawal of aggressive lending. These two findings are consistent with the prevalence of aggressive instruments that enables recent realizations of the market and magnifies the effects of negative demand shocks.

This magnifying effect on the downside is present even in the absence of sizeable default rates. In other words, it is the fluctuation of the use of aggressive instruments that exacerbates market downturns, not necessarily the fact that such instruments generate relatively higher default rates. Of course, this effect is magnified if the aggressive instruments generate higher levels of default. Either way, the impact of the initial share and subsequent repricing of aggressive lending exacerbates the cycle. In fact, the

markets that have highest concentration of aggressive lending instruments are currently experiencing the largest price declines.

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Appendix: Solution Algorithm

This appendix provides a more mechanical description of the solution algorithm discussed in Section 2.1 of the paper. Specifically, we take the following steps:

1. Generate simulation paths for personal income following Equation 3. In our solution implementation we generate 10,000 paths.
2. Assign random levels of wealth at the final period on each path.
3. Use the final levels of wealth to derive the final period real estate prices on each path. In our implementation we assume real estate prices are at 50% of total wealth on each path. Our solution works with any level, but the level needs to be known in advance and is certain. For a justification of this assumption see Section 2.1, below Equation 3.
4. For each time period between *T-1* and *2,* going backwards, regress the future price on each path on the income and wealth level on that path. The particular regression form that we use is given in Equation 4, although many other specifications work equally well.
5. On each path, use the estimated regression for each period to derive a distribution of prices for period *t+1* conditional on the state variables at time *t*.
6. Determine the current price, P_t, that numerically equates the expected utility of renting (which is certain) to the expected utility of buying (which involves price risk).
7. Solve for current level of wealth, W_t, using the evolution of wealth given in Equation (1).
8. Repeat regression estimation in step 5 above until the current level of wealth does not change anymore. In our implementation we use tolerance level of .1%.
9. Repeat steps 5 – 8 for each time period back to period 2.
10. For period one use the prices in period 2 to compare the marginal utility of owning and renting. Solve for price at time 1 that equates these two marginal utilities.
11. Go forward and set the credit score to 500 for any path that reaches zero total wealth. (For numerical tractability, set the minimum wealth to a small amount above zero. In our implementation we use $.01.)
12. Going forward, increase the credit score by 30 for each period during which the agent's wealth is above zero.
13. Examine the initial wealth level on each path and adjust the final wealth level by the difference ($W_0 - 100$). If the initial wealth is too high, reduce the final period wealth, and vice versa.
14. Go back to step 3 and repeat until the initial levels of wealth converge. Once that occurs, the price obtained in step 10 is the real estate price given the model parameters.

Table 1: Base model parameters

Variable	Base Level
Risk-aversion γ	5
Rent yield δ	5%
Mortgage interest rate r	5%
Volatility of Income	30%
Credit score after default	500
Credit score improvement if no default	50
Minimum credit score to borrow	700
Number of time periods	10
Number of simulations	10000

Table 2: Subprime lending and real estate markets

A. Lagged Originations

	2002	2002	2003	2003	2004	2004	2005	2005	2006	2006	2007	2007
Intercept	**4.29**	**3.99**	**4.43**	**4.37**	1.54	1.14	**5.27**	**4.43**	**2.96**	**3.80**	**3.02**	**2.97**
Std Error	0.83	0.83	0.74	0.75	1.11	1.10	1.54	1.56	0.54	0.66	0.72	0.69
Subprime Originations	**0.31**	**0.32**	**0.29**	**0.28**	**0.78**	**0.78**	**0.48**	**0.44**	**0.10**	**-0.08**	**-0.69**	**-0.72**
Std Error	0.06	0.06	0.05	0.05	0.08	0.08	0.09	0.09	0.03	0.03	.04	.04
Change in Income		15.5		7.57		**32.2**		**32.4**		**23.3**		13.5
Std Error		7.59		9.57		9.80		12.3		10.3		9.1
Adj R2	7.02	8.18	9.34	9.52	23.3	25.7	7.90	9.80	3.03	4.50	28.2	28.9

B. Same Year Originations

	2001	2001	2002	2002	2003	2003	2004	2004	2005	2005	2006	2006
Intercept	**5.13**	**5.00**	**3.08**	**2.74**	**2.79**	**2.81**	-1.13	-1.39	**3.44**	2.75	**2.12**	**2.78**
Standard Error	0.50	0.49	0.80	0.81	0.73	0.74	1.25	1.23	1.53	1.54	0.49	0.61
Subprime Originations	**-0.04**	**-0.04**	**0.38**	**0.39**	**0.42**	**0.42**	**0.81**	**0.80**	**0.59**	**0.55**	**0.09**	**-0.09**
Standard Error	0.04	0.04	0.05	0.05	0.05	0.05	0.07	0.07	0.09	0.09	.03	.03
Change in Income		**13.2**		**17**		-1.51		**29.3**		**28.9**		**21.1**
Standard Error		3.81		7.56		8.86		9.59		12.1		9.8
Adj R2	0.34	3.81	13.1	14.5	16.9	16.9	27	29	11.7	13.2	4.8	5.6

Table 2 reports the impact of county-level share subprime originations on real estate market price changes, controlling for change in median household income. Panel A reports the results using lagged originations, and Panel B reports the results using contemporaneous originations. The subprime share originations by county is available from HMDA, and was provided to us by economy.com. We use the Economy.com house price change by county. Changes in median household income are available from the census. Each cross-sectional regression is based on subprime originations and real estate price changes in 336 counties. The results reported in both tables are consistent with our hypothesis that subprime loans, as an example of aggressive lending, induce higher price appreciation in up markets, and larger price depreciation in down markets. The relationship is strongly significant, even when controlling for the contemporaneous change in household income in a county.

Table 3: Affordability as an instrument for subprime lending

	2001	2002	2003	2004	2005	2006
Intercept	22.085	26.445	25.980	28.650	25.125	24.251
Std Error	1.557	1.402	1.186	0.967	0.844	0.941
HOI	-0.131	-0.180	-0.173	-0.177	-0.144	-0.164
Std Error	0.024	0.021	0.018	0.015	0.015	0.016
Adj R2	0.257	0.460	0.531	0.621	0.514	0.490

Table 3 reports the results of a single-variable regression, one per year, of subprime origination on the Housing Opportunity Index (provided by NAHB and Wells Fargo). The housing opportunity index (HOI) reports the percent of sold homes in an MSA that can be purchased by a median income family. Our data includes 93 MSAs. Low levels of the index indicate low affordability, and are associated strongly with higher use of subprime mortgages. We use the predicted subprime originations as an instrument in the regressions reported in Table 4.

Table 4: Affordability and subprime lending

A. Lagged Originations

	2002	2002	2003	2003	2004	2004	2005	2005	2006	2006	2007	2007
Intercept	-5.72	**-7.45**	0.78	0.77	**-11.9**	**-12.5**	3.79	2.16	**6.98**	**6.59**	4.56	4.31
Standard Error	3.15	3.14	2.29	2.29	3.49	3.48	5.19	5.26	1.60	1.80	2.58	3.31
Subprime Originations	**1.03**	**1.13**	**0.57**	**0.53**	**1.76**	**1.76**	**0.69**	**0.66**	**-0.36**	**-0.37**	**-1.12**	**-1.13**
Standard Error	0.22	0.22	0.15	0.15	0.22	0.22	0.28	0.28	0.09	0.09	.19	.19
Change in Income		37		24.1		37.5		50.4		31.3		33.4
Standard Error		15.5		22.5		23.7		32.5		28.4		29.1
Adj R2	19.1	24.5	14.1	15.3	42.4	44.1	6.61	9.19	15.7	15.9	46.2	48.5

B. Same Year Originations

	2001	2001	2002	2002	2003	2003	2004	2004	2005	2005	2006	2006
Intercept	**4.23**	**5.29**	-3.81	-4.34	-3.91	-3.76	**-16.1**	**-16.6**	-7.65	-9.13	-3.20	-3.31
Standard Error	2.10	2.05	2.19	2.21	2.01	2.02	3.65	3.64	5.25	5.35	2.18	2.21
Subprime Origination	0.03	-0.05	**0.83**	**0.85**	**0.89**	**0.86**	**1.72**	**1.71**	**1.34**	**1.32**	**-0.49**	**-0.52**
Standard Error	0.05	8.69	0.27	0.29	0.36	0.36	0.46	0.47	0.18	0.20	0.13	0.14
Change in Income		21.4		20.1		16.5		31.4		39.0		49.4
Standard Error		7.41		14.7		20.2		22.4		30		35.0
Adj R2	0.05	8.69	27.5	29	36.5	37	46.7	48	19	20.5	18.3	19.1

Table 4 reports the results of the cross-sectional two-stage regression for each year in our sample. The first stage regresses the HMDA-reported subprime originations on the Housing Opportunity Index (provided by NAHB and Wells Fargo). The housing opportunity index (HOI) reports the percent of sold homes in an MSA that can be purchased by a median income family. Our data includes 93 MSAs. Low levels of the index indicate low affordability, and are associated strongly with higher use of subprime mortgages. In the second stage, we use the predicted share of subprime originations based on the contemporaneous level of the HOI to explain house price appreciation, controlling for the contemporaneous change in household income. Both the lagged (Panel A) and contemporaneous (Panel B) instrumental variable (predicted subprime originations) are related to higher price appreciation during up markets and larger price depreciation during down markets.

Table 5: Minority concentration as an instrument for subprime lending

	2001	2002	2003	2004	2005	2006
Intercept	10.52	11.35	10.64	13.06	13.39	12.2
Std Error	0.51	0.56	0.51	0.52	0.52	0.51
% minority	**8.60**	**9.90**	**12.08**	**13.53**	**11.70**	**12.9**
Std Error	1.93	2.12	1.93	1.97	1.97	1.94
Adj R2	0.09	0.09	0.16	0.18	0.14	0.17

Table 5 reports the results of a single-variable regression, one per year, of subprime origination on minority (Black and Hispanic) share of the CBSA population, as provided by the 2000 census. Our data includes 215 CBSAs. While the explanatory power of these regressions is relatively low, the percent minority is a highly significant predictor of subprime originations. We use the predicted subprime originations as an instrument in the regressions reported in Table 6.

Table 6: Minority concentration and subprime lending

A. Lagged Originations

	2002	2002	2003	2003	2004	2004	2005	2005	2006	2006	2007	2007
Intercept	0.55	0.94	2.84	1.59	-0.36	0.09	3.66	2.11	0.86	2.86	.76	2.21
Standard Error	3.02	3.02	2.83	2.86	3.79	3.77	4.52	4.57	1.79	1.90	2.66	3.18
Subprime Originations	**0.54**	**0.50**	0.38	**0.42**	**0.94**	**0.86**	**0.62**	**0.63**	0.05	0.05	**-.39**	**-.41**
Standard Error	0.25	0.25	0.21	0.21	0.29	0.29	0.28	0.28	0.11	0.11	.13	.13
Change in Income		13.2		**29.6**		31		32.5		**-43.6**		33.1
Standard Error		9.08		13.3		14.6		17.8		15.4		24.4
Adj R2	0.76	4.34	0.55	2.90	1.47	4.48	1.18	1.41	0.15	0.16	4.2	4.8

B. Same Year Originations

	2001	2001	2002	2002	2003	2003	2004	2004	2005	2005	2006	2006
Intercept	**4.04**	**4.72**	1.04	1.39	3.75	2.59	-1.32	-0.80	2.17	0.59	1.20	2.83
Standard Error	1.70	1.71	2.80	2.80	2.33	2.36	4.08	4.06	5.20	5.24	4.8	3.54
Subprime Origination	0.01	-0.05	**0.46**	**0.42**	0.32	0.35	**0.84**	**0.77**	**0.71**	**0.73**	0.06	0.06
Standard Error	0.14	0.14	0.21	0.21	0.18	0.18	0.26	0.26	0.33	0.33	0.11	0.12
Change in Income		10.3		13.2		**29.6**		31		32.5		**-43.4**
Standard Error		4.60		9.08		13.3		14.6		17.8		15.3
Adj R2	0.01	2.34	0.76	4.35	0.56	2.91	1.47	4.48	1.19	1.41	0.16	0.16

Table 6 reports the results of the cross-sectional two-stage regression for each year in our sample. The first stage regresses the HMDA-reported subprime originations on the percent minority population (as reported by the 2000 census). The results of the first stage are reported in Table 11. In the second stage, we use the predicted share of subprime originations based on the percent minority to explain house price appreciation, controlling for the contemporaneous change in household income. Both the lagged (Panel A) and contemporaneous (Panel B) instrumental variable (predicted subprime originations) are related to higher price appreciation during up markets and larger price depreciation during down markets.

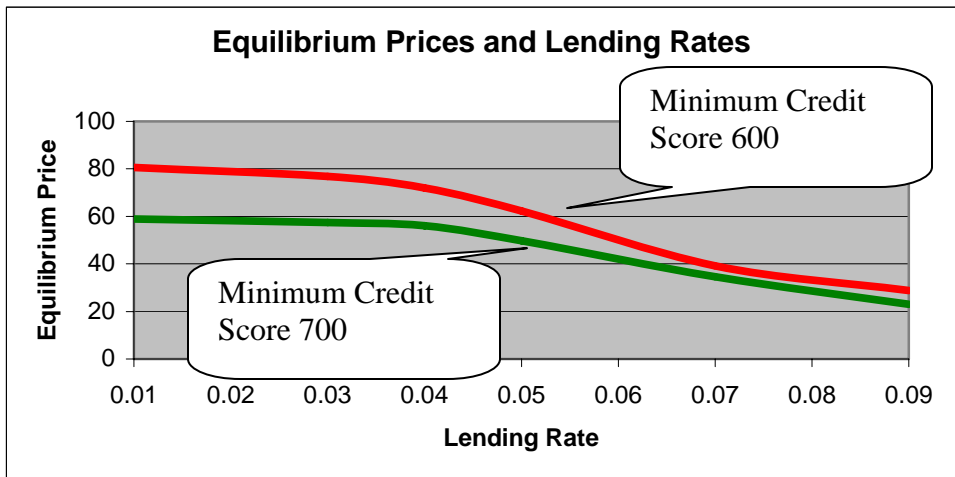**Figure 1: Equilibrium Prices and Lending Rates**

Figure 1 depicts the equilibrium real estate prices as a function of the lending rate for two cases: minimum required credit score of 600 and 700. As expected, prices increase with lower lending rates and are uniformly higher for lower minimum credit score requirements.

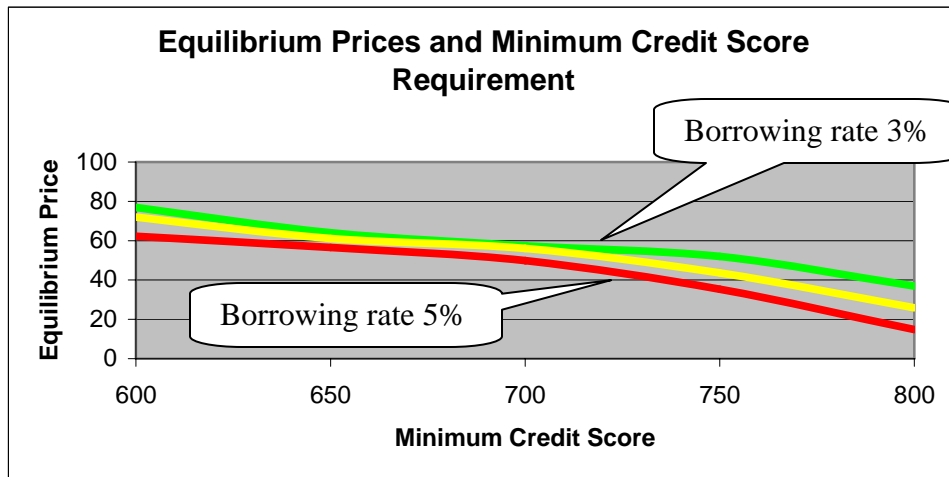**Figure 2: Equilibrium Prices and Minimum Credit Score Requirements**

Figure 2 depicts the evolution of equilibrium real estate prices as a function of the minimum credit score required to obtain a loan. The three cases depicted are for interest rates of 3, 4, and 5%. As expected, reducing the minimum required credit score increases the equilibrium price of real estate. Furthermore, prices are uniformly higher for lower cost of borrowing.