# Mortgage Recourse Provisions and Housing Prices*

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**Abstract**

In light of the large swings in housing prices in the United States in recent years, there has been considerable interest in trying to understand the various factors which led to the boom and bust of the housing market. In this paper, we explore the impact of the legal environment from provisions for mortgage default across U.S. states. To do so, we develop a rigorous framework with microeconomic foundations for financial intermediaries. To be specific, we introduce a housing market and a residential mortgage market in the Diamond and Dybvig framework which emphasizes the role of depository institutions to help depositors manage idiosyncratic liquidity risk. Notably, we think of non-recourse provisions as a legal arrangement to protect risk-averse homeowners from the loss of housing value. While housing demand should be higher in markets where mortgage borrowers have full insurance, lenders also adjust the amount of mortgage credit provided to protect their risk-averse depositors. Thus, a priori, there is not an obvious connection between mortgage recourse provisions and housing prices. To draw further insights into the issue, we proceed to look at empirical evidence on housing prices at the MSA-level using the Case-Shiller Home Price Index. Once one controls for regional level unobservables, the evidence suggests that the demand side factors dominate in which prices are higher in non-recourse states, following the prediction from the model that the demand for mortgages would be higher. We next move to obtain more concrete predictions from our theoretical framework with calibration exercises to study the effects of mortgage recourse. Upon calibrating the model to match some stylized evidence on housing market conditions, the theoretical predictions are consistent with the regression analysis. In this manner, our work sheds numerous insights into the implications of the legal landscape regarding mortgage default for housing market activity.

Keywords: Housing, Mortgage Default, Recourse, Strategic Default

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# 1 Introduction

There have been a number of explanations for the recent housing bubble in the United States. Historically low interest rates adopted around the time of the 2001 recession and subsequent weak, jobless recovery have often been cited.[1] Another potential explanation involves government policies to promote housing, especially lower income groups. For example, the Federal Housing Enterprises Regulatory Reform Act of 1992 states: "The purpose of these goals is to facilitate the development in both Fannie Mae and Freddie Mac of ....day-to-day operations to service the mortgage finance needs of low-and moderate-income persons, racial minorities and inner-city residents."[2]

Other explanations focus on developments in financial markets. Bernanke (2005) argues that much of the appreciation of housing prices was a reaction to a "global savings glut" in which the United States ran large current account deficits. For a variety of reasons, large flows of funds came to the United States from the developing world at a time when business spending was low. As a result, much of the capital was invested in the residential sector of the economy. Another possibility was the rise of the "shadow" banking sector in which non-traditional financial intermediaries acquired large amounts of assets, especially in the housing sector.[3] Notably, Gorton and Metrick (2012) present evidence showing that around 80% of subprime mortgages were financed through securitizations in which large pools of mortgage loans were sold to special purpose vehicles. As a consequence, mortgage-related debt became the largest fixed income market in the United States from 2004-2006. Finally, the proliferation of the 30 year fixed rate mortgage has been cited as it allowed borrowers to finance higher priced homes through smaller mortgage payments. According to data from the Federal Housing Finance Agency, the average term to maturity on conventional loans was 24.1 years in 1985. By comparison, in 2007, it was more than 5 years longer at 29.2 years.

Another argument is that the cost of strategic default was too low. That is, homeowners without 'skin in the game' could simply choose to walk away as housing conditions started to deteriorate. For example, Feldstein (2008) argues: "The 'no recourse' mortgage is virtually unique to the United States. That's why falling house prices in Europe do not trigger defaults, since the creditors' potential to go beyond the house to other assets or to a portion of payroll earnings is enough to deter defaults." However, in 2009, Nevada became a limited recourse state in order to protect mortgage borrowers. Thus, there is considerable debate

[1] In December 2000, the target for the federal funds rate stood at 6.5%. In January 2001, the Federal Open Market Committee lowered the target by 100 basis points partly in response to weak business spending. This began a period of unprecedented (at the time) monetary policy accomodation in which the target was lowered all the way to 1% in June 2003. Though the level of accomodation was pulled back beginning a year later, the target has not returned to the rates of the year 2000.

[2] In particular, the Department of Housing and Urban Development (HUD) set a goal target of 40% in 1996 for mortgages to low-moderate families. The number was raised a range of 50%-55% from 2001 to 2004. It was further increased to a range of 51%-56% from 2005-2008.

[3] Geithner (2008) suggests that overnight tri-party repos funded approximately $2.5 trillion of assets in early 2007. Boulware, Ma, and Reed (2014) study the impact of monetary policy shocks on activity in the repo market. In addition, Boulware and Reed (2014) look at the impact of changes in monetary policy on commercial paper market activity which is also cited as an explanation for the growth in housing market activity prior to the financial crisis.

surrounding the legal landscape of the mortgage market. One might argue that borrowers in states without recourse provisions would be tempted to borrow more as it would be relatively easy for them to strategically default on their mortgage obligations. Alternatively, policymakers might consider that protections for mortgage holders are vitally important to protect risk-averse borrowers from weak housing market conditions.[4]

The objective of this paper is to study the implications of the legal environment regarding mortgage default for housing market activity. In many states, lenders have the ability to pursue a deficiency judgement against a mortgage borrower who defaults. In other states, 'non-recourse' states, lenders cannot. Thus, there are significantly different option values to strategic default across the United States.

In order to carefully address this issue, it is important that one develop a rigorous general equilibrium modeling framework capable of illuminating the incentives of different groups of participants in mortgage lending and housing market activity. In this manner, the connections from housing market outcomes to the banking sector and overall economy may be formally developed. To begin, it is critical that the model incorporate a well-defined motivation for financial intermediation in order to adequately articulate the incentives of financial intermediaries and their mortgage lending behavior. That is, following Smith (2003), 'intermediation should be taken seriously.' Towards this goal, we follow a tradition in the microeconomics of financial institutions which emphasizes that financial intermediaries are firms who pool resources so that agents can achieve outcomes which would not be possible at the individual level. For example, Diamond (1984) and Williamson (1986) show how intermediaries can promote credit market activity by pooling funds among lenders in a way that avoids duplication of effort in monitoring the activities of borrowers.

By comparison, Diamond and Dybvig (1983) demonstrate that intermediaries can promote risk-sharing because consumers are subject to idiosyncratic liquidity risk. In fact, they show that in the absence of intermediation, there would not be any risk-sharing between individuals. However, perfectly competitive financial institutions pool deposits together and efficiently distribute funds upon the realizations of liquidity shocks among depositors. Given the attention to liquidity risk in the most recent crisis, we choose to model intermedation following Diamond and Dybvig's seminal contribution. Further, though the scope for monitoring firm behavior as in Diamond and Williamson is large, it has less relevance in the housing sector where borrowers would find it difficult to hide the monetary value and proceeds from the sale of their homes.

In contrast to the Diamond and Dybvig model, the return to the bank's funding opportunities is endogenous in our setup as we construct a general equilibrium framework which incorporates a housing market and mortgage market. In our framework, the mortgage market has two different groups of participants. On the one hand, financial intermediaries obtain resources to lend by issuing short-term liabilities to risk-averse depositors who may withdraw funds at any point in time. On the other hand, potential homebuyers seek access to mortgage credit in order to purchase homes.

[4] As is well-known, the recent housing boom has not been limited to the United States. Consequently, other economies have also struggled with the appropriate implementation of public policies aimed at the housing market. For example, Garriga, Tang, and Wang (2016) provide extensive documentation of policies adopted to target the housing market during its development in China. In related work, Peng and Wang (2009) suggest that the optimal housing policy involves complete elimination of property taxes.

Interestingly, the model incorporates the possibility of strategic default among mortgage borrowers. Risk-averse mortgage borrowers are also subject to idiosyncratic shocks to the value that they obtain from homeownership. If they experience negative utility shocks, the value of owning declines and borrowers may be better off choosing to default on paying back their mortgages. The decision to 'walk away' from their mortgage debt obligations depends on the legal environment regarding mortgage default.[5] If intermediaries do not have the ability to impose a default penalty, the cost of strategic default is very low. That is, non-recourse provisions provide full-insurance to risk averse mortgage borrowers against the loss of housing value. Effectively, the risk is transferred from borrowers to risk-averse depositors who provide resources to intermediaries to extend mortgage funding. In this manner, non-recourse provisions introduce distortions in the banking sector and interrupt the ability of depository institutions to promote risk pooling among their depositors. On the other hand, the decision of a borrower to default is non-trivial if lenders can exact larger penalties for default.

In our general equilibrium framework, borrowers choose the amount of housing demand to maximize their expected lifetime utility. In mortgage markets where borrowers are subject to legal recourse for default, the demand for housing will be lower. On the flip side, credit funding to the mortgage market will be higher if lenders know that they can impose penalties upon buyers ex-post. In this manner, the supply-side incentives of banks in our theoretical framework might reflect the behavior of lenders discussed in recent work by Goodman and Levitin (2014). In their empirical analysis, they find that state variation in the potential for involuntary modifications to be made to mortgages had a significant impact on mortgage interest rates. In particular, interest rates on loans in states where 'cramdown' was allowed were higher than other states. They conclude that lenders were taking into account the risk of principal modification.

Thus, a priori, it may be difficult to determine the overall effects of mortgage recourse provisions for housing market activity – the supply and demand-side factors conflict with each other. In order to obtain more direction from our theoretical framework, we look to empirical evidence on the role of non-recourse provisions for housing prices. In response to the interest in understanding the dynamics of the recent housing crisis, there is an emerging

[5] There is also an emerging empirical literature that studies the incidence of strategic default. For example, Foote et al. (2008) conduct a rigorous examination of the behavior of underwater homeowners in Massachusetts in 1991. In particular, they contend that negative equity is not a sufficient condition for strategic default. Instead, they conclude that most underwater homeowners will not choose to default unless they experience a "double trigger," an adverse life event such as a divorce or health shock along with the position of negative equity. Bhutta et. al. (2010) expand upon Foote et. al. by studying non-prime borrowers across four different states: Arizona, California, Florida, and Nevada. Their analysis also supports the "double trigger" hypothesis. Moreover, they find that homeowners do not strategically default unless they owe more than 60% above the value of their home.

In contrast to previous analysis, Ghent and Kudlyak (2011) offer evidence indicating that strategic default *is* a prevalent occurrence. Notably, they find that borrowers in non-recourse states are more likely to default – especially, at high appraisal values. For example, individuals with homes appraised between $500,000 and $750,000 were more than twice as likely to default in states which protect mortgage borrowers. In addition, Demiroglu et al. (2014) conclude that underwater homeowners are more likely to default in states where the foreclosure process is friendly to borrowers. In comparison to the existing literature which examines the incidence of strategic default in mortgage markets, our objective is to show the implications of legal recourse and the possibility of strategic default for conditions in the housing market.

literature on whether the housing market in 'non-recourse' states behaves differently than 'recourse' states.

In this regard, the two most closely empirical papers related to our work are Bao and Ding (2016) and Nam and Oh (2015). Both papers find that housing prices grew faster during the housing 'boom' in non-recourse states than recourse states. For example, Bao and Ding (2016) study the index produced by the Federal Housing Finance Agency which is released every quarter. However, it has a cap on the limit of the mortgage and thus does not account for homes financed by jumbo mortgages. In contrast, Nam and Oh primarily look at zip-code level data from Zillow Real Estate Research. Yet, neither series adjusts for the quality of homes over time. Consequently, we conduct regression analysis on housing prices at the MSA-level using the Case-Shiller Home Price Index. Moreover, both Bao and Ding and Nam and Oh are primarily concerned with whether housing prices grew faster in non-recourse states while we focus on the level of prices. One might worry that their studies may be misleading because it could be suggested that non-recourse areas experienced higher growth rates if prices in these areas were initially lower – the same concern does not apply to our evidence.

In addition, all three papers differ in how they account for spatial level unobservables. Notably, as cited by Bao and Ding, one cannot use state-level fixed effects because the fixed effects would be completely absorbed by the non-recourse dummy variable. While that is true, we control for regional fixed effects by assigning each metro area to one of four different Census codes: (1) East, (2) Midwest, (3) South, and (4) the West. In the absence of our regional fixed effects, we find that prices are either unrelated to non-recourse provisions or may even be lower. Upon accounting for regional fixed effects, the results indicate that prices tend to be higher in non-recourse areas. In contrast, Nam and Oh attempt to control for unovervables through county-level border discontinuity techniques.

Further, in comparison to both papers, we seek to address concerns about endogeneity of mortgage rates in our regression analysis on housing prices. In particular, higher housing prices could feed back into changes in interest rates which would bias our results. Using instrumental variables techniques, we continue to find that housing prices were higher in non-recourse areas during the housing boom years from 2001 - 2005.

Thus, our empirical analysis makes several contributions relative to Bao and Ding and Nam and Oh. First, we study a different housing prices which explicitly tries to account for the quality of homes. Second, we are primarily interested in looking at the level of housing prices rather than the growth rate of housing prices. Third, we account for spatial level unobservables in different ways. Finally, we also include instrumental variables estimates to account for the potential endogeneity of mortgage rates in regressions on housing prices.[6]

[6]In related work, Saengchote (2014) points out that mortgage default is to some extent possible even in recourse states – the reason is the amount of the mortgage deficiency judgment is considered to be an unsecured debt and therefore may be discharged by filing for bankruptcy. Exploiting changes in the bankruptcy code in 2005, Saengchote concludes that increases in bankruptcy protection encouraged banks to increase mortgage credit. However, the measure of lending is along the extensive margin – only the number of loans is considered, not the dollar amount of loans. Thus, there is not any evidence that changes in the bankruptcy code led to increased lending along the intensive margin – it may be that more loans were granted, but in smaller amounts, which was actually a means to diversify risk across borrowers. In turn, the total amount of mortgage exposure by banks might be lower. Further, there is not any evidence that changes in bankruptcy protection led to changes in housing market activity through prices as we show.

As our empirical work indicates that prices were higher in non-recourse areas, we next move to obtain more concrete predictions from our theoretical framework with calibration exercises to study the effects of mortgage recourse. Upon calibrating the model to match some stylized evidence on housing market conditions, the theoretical predictions are consistent with the regression analysis. In this manner, our work sheds numerous insights into the implications of the legal landscape regarding mortgage default for housing market activity. Notably, our framework is suitable for studying the welfare implications from mortgage default – the effects of non-recourse provisions on each group of market participants can be determined in our model. For example, our results indicate that depositors at banks are worse off if non-recourse provisions are in place. It is fairly obvious that sellers obtain greater utility since they obtain higher prices for their homes. Interestingly, the model predicts that borrowers are unaffected – the only thing that recourse provisions do is change the timing of penalties for mortgage default. If lenders are allowed to pursue deficiency judgements, borrowers pay for the costs ex-post upon defaulting. By comparison, if recourse is not allowed, borrowers bear the burden ex-ante in the form of higher mortgage rates. Due to the law of large numbers, aggregate welfare among homebuyers is invariant to the legal landscape regarding mortgage default.

The insights from our theoretical work tie into a number of recent valuable contributions which seek to address various aspects of recent housing market activity. In particular, Corbae and Quintin (2015) develop a life cycle model to capture some key stylized facts surrounding the recent housing boom and bust in the United States. Interestingly, they find that broadening punishment for mortgage default by itself leads to less defaults. Similar to our analysis, this leads to lower interest rates. In turn, lower interest rates can actually expand access to housing. As a result, though increasing punishment leads to less defaults, the effects may not be as strong in the long-run. By comparison to our framework, the interest rate paid to depositors does not depend on the legal structure of mortgage default. Consequently, the analysis in Corbae and Quintin does not address how the absence of punishment shifts the risk of default to depositors from mortgage borrowers. Yet, we show that weaker punishment disturbs activity in the deposit sector and interferes with the ability of intermediaries to provide their important risk pooling functions. In addition, housing prices are exogenous in Corbae and Quintin and therefore do not respond to changes in punishment for default as in our framework. Quintin (2012) also shows that the pool of borrowers may change as punishment increases.

By comparison, Chatterjee and Eyigungor (2015) develop a quantitative framework to study how oversupply of housing in the form of an exogenous supply shock accounts for the declines in housing prices and increases in the foreclosure rate. As in Corbae and Quintin, the rate of return to deposits is invariant to the amount of defaults. Rather than looking at the role of non-recourse provisions as we study, Chatterjee and Eyigungor examine the implications of the time to complete foreclosures for housing market activity.

In terms of comparing our work to both papers, it is well understood that loans secured by real estate are one of the largest assets on the balance sheets of commercial banks which are deposit-based institutions. Notably, commercial banks play important roles in promoting the extension of credit through maturity transformation – banks fund long-term assets such as residential mortgages by issuing short-term liabilities as banks are responsible to respond to idiosyncratic short-term withdrawals by risk-averse depositors. Neither Corbae

and Quintin or Chatterjee and Eyigungor include this function. In other words, neither one of the two frameworks incorporate liquidity risk in the form of random withdrawals by individuals. From this perspecive, there are not any microeconomic foundations for the role of financial intermediaries as in our setup. Due to these shortcomings, the way that mortgage default impacts the supply of resources to intermediaries and the mortgage market cannot be considered. It directly follows that important transmission channels in the commercial banking system and their responses to mortgage default are omitted. That is, it seems it would be quite valuable to develop a framework to capture how mortgage default risk impairs the ability of the banking system to perform a number of its essential economic functions – including risk-pooling which has received a lot of attention in the literature.

The remainder of the paper is as follows. Section 2 discusses additional contributions that are not mentioned in the introduction. Section 3 provides the physical description of the theoretical model. Section 4 focuses on housing market activity while Section 5 looks at the mortgage market. Section 6 studies the economy in general equilibrium. Section 7 looks at the empirical evidence on non-recourse provisions and housing prices. Next, Section 8 conducts calibration exercises which seek to replicate our empirical insights. Finally, Section 9 provides concluding remarks.

# 2 Related Literature

In addition to the interest in the legal landscape over mortgage default in the United States, there have also been discussions regarding recourse provisions in other countries. For example, Castilla (2011) argues that Spain should adopt non-recourse provisions as part of mortgage reform. In particular, Castilla contends that there are inefficiencies in mortgage markets because banks possess more information about future housing market activity than borrowers. By adopting non-recourse provisions, borrowers would be insured against deflation risk and lenders would not excessively lend because they would be forced to internalize potential mortgage default risk. In turn, bubbles would be less likely to develop.

By comparison, using longitudinal data on homeowners in Japan, Seko et al. (2012) find that homeowners with negative equity have less mobility. This is similar to Cunningham and Reed (2013) who observe that workers with negative equity earn lower wages than other homeowners, potentially because of their lower labor market mobility. Consistent with our current work, the simulation exercises in Seko et al. reveal that mortgage rates would be higher if Japan switched to a non-recourse system. They also find residential mobility among homeowners who are underwater would be substantially higher if the full recourse system is eliminated.

There are a number of other theoretical papers besides Corbae and Quintin and Chatterjee and Eyigungor which are related to our work. For example, Chen et al. (2006) study forbearance lending in the presence of moral hazard among borrowers (firms). To be specific, moral hazard in the model emerges because borrowers can hide a proportion of investment returns. While this is certainly applicable in the context of firm behavior, it has less relevance in looking at housing market activity – it would not be possible to hide the purchase price of a home sale which may induce banks to forgive some mortgage debt. Moreover, all agents in Chen et al. are risk-neutral while borrowers and depositors are both risk-averse in

our model so that we can study the role of insurance against default risk. Notably, we show that the introduction of full insurance in the form of non-recourse provisions to borrowers impacts the extent of risk-sharing among all individuals in our framework – depositors and homeowners – within the banking sector.

Moreover, including risk aversion introduces additional non-linearities in our framework which affects incentives while Chen et al. fail to do so. That is, in contrast to our work, 'banks' in Chen et al. do not improve allocations in a way that individual borrowers and lenders could not do. From this perspective, they do not provide any special services and simply act as a veil in the transactions between agents.

Chen and Leung (2008) develop a framework with households and leveraged entrepreneurs in a multi-period framework to illustrate that there may be a spillover effect from commercial real estate to residential real estate prices. They show that negative realizations of productivity could lead to entrepreneurs liquidating their commercial properties in order to raise funds to service their debt obligations. The unloading of commercial real estate can spillover to the residential sector so that activity in the production sector triggers lower housing prices. It is also possible that households default on their mortgage obligations. Though the model includes creditors, homeowners, and entrepreneurs, there are not any intermediaries as in our model. All transactions take place directly between agents rather than indirectly through banks. Yet, it would be interesting to explore the implications of limitations on mortgage recourse for the feedback mechanisms between the housing and production sectors in their framework.

Perhaps the closest paper to our theoretical framework is Jin et al. (2012). In the spirit of Williamson and Huybens and Smith (1998), banks have an advantage in monitoring over households. That is, in-line with our approach, banks help depositors achieve outcomes which are not possible individually. The introduction of a costly state verification problem gives rise to a standard debt contract where monitoring by banks occurs in the event of low income reports by borrowers. As is standard in the costly state verification literature, banks recover all borrower income in such cases. However, as in Chen et al, the potential for moral hazard lies at the firm level while we consider the potential for strategic default by homeowners. Moreover, Jin et al develop a discrete stochastic general equilibrium framework which is solved numerically whereas most of our results are determined analytically so that existence and uniqueness can be formally demonstrated.

In other research, Fang et al. estimate a dynamic structural model of behavior by subprime adjustable rate mortgage holders using loan level data. In particular, their dataset includes borrowers' credit bureau information when looking at mortgage payment decision making by borrowers. They find that mortgage modification in environments where housing prices decline may impact delinquency and foreclosure rates. However, they consider housing prices to be exogenous. Hence, they do not study how mortgage modification can affect equilibrium prices. Additionally, in contrast to our work, they do not consider the implications of mortgage modification on the ability of lenders to raise funding resources and extend mortgage credit. Further, as in Corbae and Quintin and Chatterjee and Eyigungor, the existence of financial intermediaries lacks microfoundations. Thus, the connections between the performance of the housing sector and other important activities within the banking system are not considered like our framework. In turn, there are limited welfare implications from all three studies.

Next, Halket and Vasudev (2014) also develop a quantitative framework to examine housing market activity, but their model is constructed to examine household mobility and homeownership over the life cycle. In comparison to our analysis, strategic default is either explicitly ruled out or the calibration exercises are constructed so that default does not occur in equilibrium. As a result, they do not look at the potential implications of limitations on mortgage recourse for mobility or life cycle asset purchases.

In contrast to our approach, Kim (2015) develops a model with two sources of debt: mortgage debt and unsecured debt. In this way, Kim studies how the different penalties across the modes of default affect households' default decisions. Nevertheless, in comparison to our framework, Kim does not model how lenders access funding – it is exogenously imposed that any type of lender can simply obtain funding at a risk-free rate. Rather, in our model, banks obtain funds to lend from risk-averse depositors. As in similar quantitative modeling, the housing price series in Kim's work follows an exogenously given stochastic process. Therefore, there is no analysis as to how penalties would endogenously feed into housing prices as we do. Further, there is not any room to look at how relieving penalties for default would feed into demand for either type of credit.

In a similar work to Kim, Mitman (2016) also develops a model with both mortgage debt and unsecured debt. However, in the spirit of Saeengchote (2014), Mitman's focus is to explore the implications of changes in bankruptcy laws that occurred in 2005 for mortgage defaults. Contrary to standard intuition, increases in bankruptcy penalties are found to actually increase bankruptcy rates and foreclosure rates. Yet, Mitman concludes that such increases were associated with higher welfare.

It is important to emphasize that both Kim and Mitman assume that intermediaries who supply funds to credit markets are risk-neutral. However, our framework incorporates both the roles of risk-pooling and maturity transformation as in Diamond and Dybvig. That is, the sources of funding come indirectly and collectively from risk-averse 'lenders.' Thus, the counterintuitive results that one sometimes sees in the literature studying various penalties for default may be driven by different attitudes towards risk than in our analysis.

Finally, in contrast to the previous papers which look at various aspects of mortgage default policy for borrower behavior, Garriga et al. develop a quantitative model to examine how the extent of nominal rigidities across fixed rate versus adjustable rate mortgages impacts the transmission channels of monetary policy. In particular, they show that monetary policy has a larger impact on housing investment under an adjustable rate mortgage regime than fixed rate mortgages. However, in contrast to our analysis, strategic default on loans is not considered.

To briefly place our paper relative to other research in this area, we offer three main arguments. First, we believe it is important to model the effects of mortgage non-recourse on loan contracts in a framework with microfoundations for financial intermediaries. Many of the models mentioned do not model intermediaries as special types of institutions such as in Diamond and Dybvig (1983), Diamond (1984), and Williamson (1986) which promote activity – this seems particularly important for understanding the welfare implications from the legal landscape in the mortgage sector. Second, some of the loan contracts in firm behavior are not applicable to housing because sellers would find it difficult to hide the monetary value and sales price of their homes. Finally, DSGE frameworks can only be solved numerically while we are able to prove existence and uniqueness of equilbria in our

approach.

# 3 Theoretical Model

In this section, we present our theoretical model of mortgage default and recourse provisions. The structure we adopt is similar to that of Diamond-Dybvig (1983). However, our model includes a market for housing and does not focus on bank runs. Instead, we analyze the effects of mortgage recourse on the supply and demand of mortgages. In general equilibrium, mortgage recourse provisions affect housing prices. Our model economy consists of depositors, homebuyers, homesellers, and competitive banking and housing markets.

## 3.1 Depositors

The economy lasts for three periods, $t = 0, 1, 2$. There is a continuum of depositors indexed by $i \epsilon [0, 1]$. Each depositor has constant relative risk aversion preferences:

$$u(c_1 + \psi_i c_2) = \frac{(c_1 + \psi_i c_2)^{1-\theta}}{1-\theta}$$

where $c_t$ is equal to consumption in period $t$ and $\theta < 1$. Similar to Diamond-Dybvig, depositors in our model economy face liquidity risk. That is, they face uncertainty regarding their desire to consume. As a reflection of this risk, the parameter $\psi_i$ is a random variable with support $\{0, 1\}$ which is realized in period 1. In contrast to standard Diamond-Dybvig models which look at run behavior, an individual's realization of $\psi_i$ is publicly known. The probability that $\psi_i = 0$ where the depositor is impatient is equal to $\pi$. Each depositor is endowed with $y_0$ units of the consumption good in period 0.

## 3.2 Homebuyers

Homebuyers do not have endowments in period 0 or period 1. However, they are endowed with $y_2$ units of the consumption good in period 2. Their preferences over consumption and housing services are:

$$(1-q)\left[\phi\frac{(c_2)^{1-\theta}}{1-\theta} + (1-\phi)\frac{(h_2)^{1-\theta}}{1-\theta}\right] + q\left[\frac{(c_2)^{1-\theta}}{1-\theta}\right]$$

Similar to depositors, homebuyers are subject to idiosyncratic risk. In contrast to depositors, homebuyers are subject to idiosyncratic risk from the utility of homeownership. With probability $q$, they only value consumption. With probability $(1-q)$, they derive utility from consumption and housing where the weight placed on consumption is equal to $\phi$. As in the case of depositors, $\theta < 1$. The total population of homebuyers is equal to $B$.

### 3.3 Homesellers

Homesellers are endowed with a stock of homes in time 0. However, they do not obtain any utility from homeownership. In contrast, they obtain utility from consumption in period 0: $u(c_0) = \frac{(c_0)^{1-\theta}}{1-\theta}$. The size of each seller's endowment is equal to $H_0$. As the total population of homesellers is equal to 1, it is also equal to the total housing supply that will be available in period 0.

### 3.4 Timeline

In period 0, homesellers receive their endowments of the housing stock. Depositors also receive their endowments of the consumption good and deposit their income in financial intermediaries. Next, homebuyers seek access to mortgage financing from intermediaries. With their mortgage credit, they purchase homes from homesellers in the housing market. With the income they receive from sales of their homes, consumption among homesellers occurs. In period 1, depositors experiencing liquidity shocks withdraw their funds from banks. In period 2, homebuyers observe their utility from housing. Depending on the realization of the value of homeownership and the legal environment regarding mortgage default, homebuyers repay their mortgage obligations. Financial intermediaries transfer all of the income they receive from mortgage settlement to their remaining depositors.

## 4 Housing Market Activity

As previously mentioned, the housing market is in operation in period 0 as that is the timeperiod in which sellers seek to gain income from the sale of their homes and obtain utility from consumption. The price of a unit of housing is equal to $P$. As we describe below, the housing market is in operation in period 0 before homebuyers know how much they will value housing. In order to purchase a home in period 0, homebuyers will need to borrow funds from financial intermediaries. The interest rate in the mortgage market is equal to $(1 + r)$.

The desire of individuals to repay their mortgage obligations depends on two factors. The first is the utility that they obtain from remaining in the home. The second is the legal environment regarding mortgage recourse. If $\phi = 1$, individuals will not obtain any utility from housing. However, if there are mortgage recourse provisions in place, financial intermediaries will be able to recover a proportion $\delta$ of the funds that homeowners promised to repay.

In this context, the income available for consumption is state-dependent. If $\phi = 1$, income allocated to consumption is:

$$c_2 = y_2 - \delta(1 + r)Ph_2$$

However, if individuals receive utility from housing services where $\phi \in (0, 1)$ :

$$c_2 = y_2 - (1 + r)Ph_2$$

Individuals will choose the amount of housing to maximize their expected lifetime utility:

$$\underset{h_2}{Max}\ (1-q)\left[\phi\frac{(c_2)^{1-\theta}}{1-\theta}+(1-\phi)\frac{(h_2)^{1-\theta}}{1-\theta}\right]+q\left[\frac{(c_2)^{1-\theta}}{1-\theta}\right]$$

The first order condition reveals:

$$(1-q)(1-\phi)h_2^{-\theta}=(1-q)\phi\left[y_2-(1+r)Ph_2\right]^{-\theta}(1+r)P+q\left[y_2-\delta(1+r)Ph_2\right]^{-\theta}\delta(1+r)P \quad (1)$$

The left-hand side reflects the expected marginal utility from housing while the right-hand side is the expected marginal utility from consumption.

Let an individual's housing demand function be denoted as $h^d(P,r,\delta,y_2)$. In order to completely characterize a homebuyer's demand function for housing, we offer the following Lemma:

**Lemma 1.** (*Housing Demand Comparative Statics in the Presence of Mortgage Recourse*). *Suppose that* $h^d<\frac{y_2}{(1+r)P}$. *A homebuyer's demand function behaves as follows:* $\frac{dh^d}{dP}<0$, $\frac{dh^d}{dr}<0$, $\frac{dh^d}{d\delta}<0$, $\frac{dh^d}{dy_2}>0$.

We begin by discussing the effects of housing prices on housing demand. As can be observed from the right-hand side of (1), an increase in housing prices raises the expected marginal utility from consumption. To counter this increase, the demand for housing will be lower. Similar logic applies to the effects of mortgage rates. In terms of the mortgage recourse parameter ($\delta$), it raises the expected marginal utility from consumption in the event that the homebuyer draws a negative shock from the utility of housing services. Consequently, the marginal utility in this state is the lowest in economies where legal recourse for mortgage default is not possible ($\delta=0$). In this manner, housing demand would be higher the lower the penalties from mortgage default. An increase in income ($y_2$) lowers the expected marginal utility from consumption and thereby raises housing demand.

An equilibrium in the housing market occurs when the total demand for housing is equal to total supply. Noting that the total population of homebuyers is equal to $B$ and the total population of homesellers is equal to $H_0$, an equilibrium in the housing market occurs at a price ($P$) where $Bh^d(P)=H_0$.

Substituting the supply of housing into the demand for housing implies that:

$$(1-q)(1-\phi)\left(\frac{H_0}{B}\right)^{-\theta}=(1+r)P\left[(1-q)\phi\left[y_2-(1+r)P\left(\frac{H_0}{B}\right)\right]^{-\theta}+q\delta\left[y_2-\delta(1+r)P\left(\frac{H_0}{B}\right)\right]^{-\theta}\right] \quad (2)$$

From this condition, we are able to derive a relationship between $P$ and $r$ where the housing market is in equilibrium:

**Lemma 2.** (*Housing Market Equilibrium Locus*). *The housing market equilibrium relationship is given by:*

$$\frac{dP}{dr} = \frac{-\left[\theta(1-q)\phi\Pi\left(\frac{H_0}{B}\right)[\Psi]^{-\theta-1} + \theta q\delta^2\Pi\left(\frac{H_0}{B}\right)[\Omega]^{-\theta-1} + q\delta[\Omega]^{-\theta}P + (1-q)\phi[\Psi]^{-\theta}P\right]}{\left[\theta(1-q)\phi\Phi\left(\frac{H_0}{B}\right)[\Psi]^{-\theta-1} + \theta q\delta^2\Phi\left(\frac{H_0}{B}\right)[\Omega]^{-\theta-1} + (1-q)\phi(1+r)[\Psi]^{-\theta} + q\delta(1+r)[\Omega]^{-\theta}\right]}$$

*where* $\Psi = y_2 - \delta(1+r)\left(\frac{H_0}{B}\right)P$, $\Omega = y_2 - \delta(1+r)\left(\frac{H_0}{B}\right)P, \Pi = (1+r)P^2$ *and* $\Phi = (1+r)^2P$. *Along this locus,* $\frac{dP}{dr} < 0$ *iff* $y_2 > (1+r)P\left(\frac{H_0}{B}\right)$.

We observe an inverse relationship between housing prices and interest rates in order for the housing market to be in equilibrium. As observed in (1), an increase in interest rates raises the expected marginal utility from consumption. For a given level of housing in which the market is in equilibrium, the expected marginal utility must fall back to the initial level. This only occurs if the price of housing falls. Consequently, the housing market equilibrium locus would be downward-sloping.

By way of driving down the demand for housing, higher interest rates reduce the price of housing. We turn to the role of recourse provisions on the housing market equilibrium locus:

**Lemma 3.** (*Partial Equilibrium Effects of Recourse Provisions through Housing Market Activity*). *Assume that the condition in Lemma 2 holds. Along the housing market equilibrium locus,*

$$\frac{dP}{d\delta} = \frac{-\theta q\delta(1+r)^2P^2\left(\frac{H_0}{B}\right)[\Omega]^{-\theta-1}}{\theta(1-q)\phi(1+r)^2\left(\frac{H_0}{B}\right)P[\Psi]^{-\theta-1} + (1-q)\phi(1+r)[\Psi]^{-\theta} + \theta q\delta^2(1+r)^2P\left(\frac{H_0}{B}\right)[\Omega]^{-\theta-1}}$$

*Consequently,* $\frac{dP}{d\delta} < 0$.

The impact of mortgage recourse is straightforward. An increase in $\delta$ raises the marginal utility of consumption when individuals receive negative shocks to housing utility. Similar to the effects of mortgage rates, housing prices must fall in order to maintain the demand for housing. Therefore, an increase in the costs of mortgage default shifts the housing market equilibrium locus down. In this manner, the partial equilibrium effects of mortgage recourse are clear.

# 5 Mortgage Market Activity

The mortgage market is open in period 0 as that is the period in which homebuyers will seek mortgage funding to buy homes from sellers. As mortgage credit is extended by financial intermediaries, we turn to their behavior.

## 5.1 The Bank's Problem

Financial intermediaries pool risk on behalf of depositors in a perfectly competitive market. Since the banking sector is perfectly competitive, financial intermediaries must offer a return schedule to maximize their expected utility:

$$\pi\left(\frac{(c_1)^{1-\theta}}{1-\theta}\right)+(1-\pi)\left(\frac{(c_2)^{1-\theta}}{1-\theta}\right)$$

As the population of depositors is equal to 1, the deposit base of a representative intermediary is also equal to 1.

The balance sheet constraint of an intermediary is:

$$1 = R_0 + BM_0$$

where $R_0$ denotes reserves, $M_0$ is the amount of mortgage credit extended to an individual homebuyer, and $BM_0$ represents total mortgage lending. Payments to early depositors are such that:

$$\pi c_1 = R_0$$

The interest rate in the mortgage market is $r$. Although the mortgage rate is fixed, realized mortgage income depends on more than mortgage rates. To clarify, idiosyncratic credit risk for each borrower is present in the sense that borrowers may choose to default on their loans in which case banks only recover a portion ($\delta$) of the mortgage interest obligations. The probability that a borrower would prefer to walk away from their obligations is $q$ as that is the probability that a homebuyer realizes zero utility from housing services. Though each homebuyer experiences idiosyncratic risk to utility from housing, the law of large numbers applies so that the total income from the mortgage market is deterministic and equal to $q(1+r)\delta BM_0 + (1-q)(1+r)BM_0$. Therefore, payments to patient depositors satisfy:

$$(1-\pi)c_2 = q(1+r)\delta BM_0 + (1-q)(1+r)BM_0$$

Consequently, the bank's choice of mortgage lending seeks to maximize the expected utility of its depositors:

$$\underset{M_0}{Max}\ \pi\left[\frac{(1-BM_0)^{1-\theta}}{1-\theta}\right]+(1-\pi)\left[\frac{(q\delta(1+r)BM_0+(1-q)(1+r)BM_0)^{1-\theta}}{1-\theta}\right]$$

For impatient depositors, their consumption is equal to $1 - BM_t$. While patient individuals consume the amount $q\delta(1+r)BM_0 + (1-q)(1+r)BM_0$. It is clear that consumption for patient depositors is a function of loan repayment. The first order condition for this problem is:

$$\pi\left(1-BM_0\right)^{-\theta}B = (1-\pi)\left[q\delta(1+r)BM_0+(1-q)(1+r)BM_0\right]^{-\theta}\left[q\delta(1+r)B+(1-q)(1+r)B\right] \tag{3}$$

The left-hand side represents the loss of utility for impatient depositors if the bank issues more credit to a homebuyer. By comparison, the right-hand side represents the increase in utility among the patient depositors should the bank extend higher levels of mortgage funding. Consequently, (3) is effectively an optimal risk-sharing condition between impatient and patient depositors.

Let the mortgage supply function of an intermediary be defined as $M^s(\pi, r, \delta, q)$. The mortgage supply function by the intermediary is given by:

**Lemma 4.** (*Mortgage Supply Function). The mortgage supply function of an intermediary is given by:*

$$M^s(\pi, r, \delta, q) = \frac{(\pi B)^{\frac{-1}{\theta}}}{[(1-\pi)(1+r)B\left[q\delta + (1-q)\right]]^{\frac{-1}{\theta}}\left(1+r\right)B\left[q\delta + (1-q)\right] + (\pi B)^{\frac{-1}{\theta}} B}$$

The comparative statics of the mortgage supply function are summarized in the following Lemma:

**Lemma 5.** *(Mortgage Supply Comparative Statics). The mortgage supply function of an intermediary behaves as follows:* $\frac{dM^s}{d\pi} < 0$, $\frac{dM^s}{dr} > 0$, $\frac{dM^s}{d\delta} > 0$, $\frac{dM^s}{dq} < 0$.

An increase in the degree of liquidity risk among depositors lowers the gains from lending to the mortgage market as there will be less patient depositors who would receive income from mortgage lending by the intermediary. Consequently, mortgage supply is decreasing in $\pi$. By comparison, an increase in mortgage rates raises the marginal utility to be experienced by patient depositors. An increase in the likelihood that homebuyers ultimately experience negative shocks to housing utility lowers mortgage lending as it reduces expected income in the mortgage market.

As our focus is on the implications of mortgage recourse, an increase in the ability of intermediaries to recover their mortgage losses raises the marginal utility of patient depositors. In turn, banks supply more funding to the mortgage market.

Next, we turn to our mortgage market equilibrium condition. Setting mortgage supply equal to mortgage demand, $M^d = P\left(\frac{H_0}{B}\right)$, yields the following relationship between housing prices and mortgage rates in the mortgage market:

$$P\left(\frac{H_0}{B}\right) = \frac{(\pi B)^{\frac{-1}{\theta}}}{[(1-\pi)\left[q\delta(1+r)B + (1-q)(1+r)B\right]]^{\frac{-1}{\theta}}\left[q\delta(1+r)B + (1-q)(1+r)B\right] + (\pi B)^{\frac{-1}{\theta}} B} \tag{4}$$

**Lemma 6.** (*Mortgage Market Equilibrium Conditions*). *Along the mortgage market equilibrium locus,*

$$\frac{dP}{dr} = \frac{\frac{1}{\theta}\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1-\theta}{\theta}}\left[(1-\pi)q\delta+(1-q)\right](1+r)B^3\left[q\delta+(1-q)\right]}{\left[\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1}{\theta}}(1+r)B\left[q\delta+(1-q)\right]+(\pi B)^{\frac{-1}{\theta}}B\right]^2 H_0}$$
$$-\frac{q\delta B^2\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1}{\theta}}}{\left[\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1}{\theta}}(1+r)B\left[q\delta+(1-q)\right]+(\pi B)^{\frac{-1}{\theta}}B\right]^2 H_0}$$

*Since* $\theta < 1$, $\frac{dP}{dr} > 0$.

As shown in the optimal risk-sharing condition, higher mortgage rates raise the marginal utility among the patient depositors. At the higher level of mortgage rates, the only way to maintain a given level of mortgage lending would be through a reduction in mortgage income. This takes place if housing prices are higher because higher housing prices reduce mortgage demand. Consequently, the mortgage market equilibrium locus would be upward-sloping.

Our main focus is on understanding the impact of mortgage recourse provisions on both housing demand and mortgage supply. The impact of mortgage recourse is described in the following Lemma:

**Lemma 7.** (*Partial Equilibrium Effects of Recourse Provisions through the Mortgage Market*). The impact of mortgage recourse on the mortgage market equilibrium locus is:

$$\frac{dP}{d\delta} = \frac{\frac{1}{\theta}\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1-\theta}{\theta}}q(1+r)^2B^3\left[q\delta+(1-q)\right]}{\left[\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1}{\theta}}(1+r)B\left[q\delta+(1-q)\right]+(\pi B)^{\frac{-1}{\theta}}B\right]^2 H_0}$$
$$-\frac{\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1}{\theta}}q(1+r)B^2}{\left[\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1}{\theta}}(1+r)B\left[q\delta+(1-q)\right]+(\pi B)^{\frac{-1}{\theta}}B\right]^2 H_0}$$

*Since* $\theta < 1$, $\frac{dP}{d\delta} > 0$.

On the supply side, we find that higher recourse penalties would be associated with higher housing prices. The impact of higher recourse penalties is similar to an increase in mortgage rates as both would lead to higher levels of mortgage income. Consequently, higher penalties shift the mortgage market equilibrium locus higher and show that banks would lend more if they had greater protection from mortgage default.

# 6 General Equilibrium

Having described activity in both the housing and mortgage markets on a partial equilibrium basis, we seek to study behavior in general equilibrium. Recall that the relationship between housing prices and mortgage rates in which the housing market is in equilibrium is given by:

$$(1-q)(1-\phi)\left(\frac{H_0}{B}\right)^{-\theta} = (1+r)P\left[(1-q)\phi\left[y_2-(1+r)P\left(\frac{H_0}{B}\right)\right]^{-\theta} + q\delta\left[y_2-\delta(1+r)P\left(\frac{H_0}{B}\right)\right]^{-\theta}\right] \tag{5}$$

By comparison, the mortgage market equilibrium is described by:

$$P\left(\frac{H_0}{B}\right) = \frac{(\pi B)^{\frac{-1}{\theta}}}{\left[(1-\pi)\left[q\delta(1+r)B+(1-q)(1+r)B\right]\right]^{\frac{-1}{\theta}}\left[q\delta(1+r)B+(1-q)(1+r)B\right]+(\pi B)^{\frac{-1}{\theta}}B} \tag{6}$$

We will prove existence and uniqueness of an equilibrium through standard intermediate value theorem arguments. First, as $r \to 0$, $P \to \infty$ in order for the right-hand side of (5) to line-up with the left-hand side. By comparison, as implied by (6) $P$ converges to:

$$\left(\frac{1}{\pi B}\right)^{\frac{1}{\theta}}\left(\frac{1}{\left[(1-\pi)\left[q\delta B+(1-q)B\right]\right]^{\frac{-1}{\theta}}\left[q\delta B+(1-q)B\right]+(\pi B)^{\frac{-1}{\theta}}B}\right)$$

In stark contrast, as $r \to \infty$, $P \to 0$ in order for the housing market to be in equilibrium. The mortgage market is the exact opposite. Consequently, there are unique values of $P^*$ and $r^*$ where both the housing and mortgage markets are in equilibrium.

However, the model does not deliver unambiguous conclusions regarding mortgage recourse. That is, the model reveals a discrepancy between the demand-side effects and supply-side effects of lender protection. On the demand-side, more lender protection lowers housing prices. Conversely, an increase in lender protection drives up housing prices from the supply-side. A priori, it is difficult to determine which effect dominates. Given our impasse, we turn to empirical analysis to provide further insights.

# 7 Data

The primary point of our work is to examine the implications of recourse provisions for the level of price appreciation during the recent housing bubble in the United States. As we are seeking to study the potential for strategic default on prices, it is important that we examine a price series which is relatively homogeneous over time. Thus, we use the (seasonally-adjusted) Standard and Poor's Case-Shiller Home Price Index (HPI) which is often cited in economic releases on housing market conditions. This index looks at average

monthly changes in home prices across twenty metropolitan areas, measured in year 2000 dollars.

There are a variety of housing price series available. For example, Bao and Ding (2016) study the index produced by the Federal Housing Finance Agency which is released every quarter. However, it has a cap on the limit of the mortgage and thus does not account for homes financed by jumbo mortgages. Moreover, the Case-Shiller HPI accounts for jumbo mortgages and adjusts for quality of homes over time.

As is well-known, there was a substantial amount of regional variation in the extent of price appreciation during the years of the housing boom. Our objective is to investigate whether protection for mortgage borrowers in some real estate markets was part of the reason. Based upon the classifications in Ghent and Kudlyak (2011), there are eleven states which are non-recourse states during our sample period: 1. Alaska, 2. Arizona, 3. California, 4. Iowa, 5. Minnesota, 6. Montana, 7. North Carolina, 8. North Dakota, 9. Oregon, 10. Washington, and 11. Wisconsin.

As a benchmark, Figure 1 presents the HPI data for the metro areas in recourse states. As the index is based upon year 2000 prices, most of the data is relatively close to 100 in 2001. Most housing markets in recourse metro areas peak in 2006. For example, Miami, Tampa-St. Petersburg, and Washington, D.C. were the most expensive housing markets in recourse states and peak at that time. Prices from 2001 - 2006 increased by 137% in Miami and doubled during the same time in Tampa-St. Petersburg. After the bust, however, many markets experienced little appreciation relative to 2001. In fact, prices in the Detroit metro area were substantially lower in 2010 than 2001.

We turn to price behavior in the non-recourse metropolitan areas. As in the case of markets in recourse states, most of the non-recourse markets peaked in 2006. Los Angeles, San Diego, and Phoenix were the most expensive markets at their peak. Prices in Los Angeles and San Diego more than doubled from 2001 - 2006. Relative to 2001, again, most markets experienced much less appreciation after the bust than over the bubble period. Since 2006 appears to be the peak in prices for most markets, we refer to the first half of the sample (2001 - 2005) as the 'boom' period and the second half (2006 - 2010) as the 'bust' period.

# 8 Empirical Results

We present summary statistics for all of our variables in Table 1. Newly available data from the BLS on metro GDP begins in 2001 while our sample period ends in 2010. Thus, for each metro area we have 10 years of annual data. The data on metroarea GDP is reported in real terms, based upon year 2000 prices. It is measured in millions of dollars. Thus, the average metro GDP is just over $250 billion and the maximum is around $1 trillion (New York - Northern New Jersey - Long Island in 2010). We also include data from Davis and Palumbo (2008) on the share of land prices in housing costs.[7] Mortgage interest rates and housing market indicators come from the monthly interest rate survey released by the

[7]Davis, Morris A. and Jonathan Heathcote, 2007, "The Price and Quantity of Residential Land in the United States," Journal of Monetary Economics, vol. 54 (8), p. 2595-2620; data located at Land and Property Values in the U.S., Lincoln Institute of Land Policy; http://www.lincolninst.edu/resources/

Federal Housing Finance Agency. Unfortunately, data on Charlotte, North Carolina and Las Vegas, Nevada is not available in the survey so we only have observations for eighteen metro areas. As shown in the table, about 40% of our observations come from housing markets in non-recourse states.

Our principal objective is to study the implications of strategic default for housing prices. To do so, we include a dummy variable according to whether non-recourse provisions were in place in a given market. Since each MSA is in a state where mortgage recourse provisions do not change over the course of the sample period, it is not possible to use MSA-level fixed effects. Simply, there is no way to separate the effects of the MSA-level unobservables from the effects of the mortgage recourse provisions. However, as we describe below, we can account for unobservables by including regional fixed effects. This is accomplished by assigning each metro area to one of four regional Census codes: (1) East, (2) Midwest, (3) South and (4) the West. Nevertheless, our analysis begins by applying simple ordinary least squares ignoring unobservables. As a benchmark, we begin with a specification in column (I) of Table 2 that attempts to look at the determination of housing prices across the full sample period. As one would expect, the results show that higher levels of local income support higher housing prices.

We continue by studying the role of supply-side factors in the regression equation. In particular, we look at the share of housing costs that come from land. The coefficient estimate for the variable is highly significant. Next, credit market conditions play an important role in housing prices. In order to consider such factors, we add the effective interest rate and the term to maturity of mortgage loans. The results indicate that conditions in the mortgage market certainly played an important role in housing prices. In fact, it appears that the trend towards 30-year mortgages was an important factor. As mentioned in the introduction, the average maturity on conventional fixed-rate loans increased by five years from 1985 - 2007. The point estimate indicates that such an increase in term length would be associated with a substantial increase in the housing price index. Interest rates do not seem to matter.

Our initial results do not show that recourse provisions affect housing prices. For example, the coefficient estimate for the non-recourse dummy is not statistically different from zero. However, we note that the U.S. experienced two very different housing markets from 2001-2010. Moreover, we are particularly interested in understanding the role of protection for borrowers during the boom years. Thus, we proceed by looking at the determinants of housing prices during the first half of the sample. The results begin in column (III) where again it does not appear that mortgage recourse provisions played any role in the boom phase from 2001-2005. However, in column (IV) we consider the unemployment rate rather than Metro-GDP as an indicator of local economic activity. The results suggest that higher unemployment would drive housing prices lower. Moreover, the specification in column (IV) indicates that non-recourse provisions would drive housing prices lower. Presumably, this might occur because financial intermediaries restrict mortgage lending in non-recourse states.

However, none of the regressions in Table 2 account for regional unobservables. Consequently, the regressions in Table 3 include regional fixed effects where the East is the omitted regional category. To begin, please see the results in columns (I) and (II). While the coefficient estimates for nearly all of the control variables in the regression possess the same sign as in the previous regressions and are statistically significant, the sign on the non-recourse variable is now positive and statistically significant. Thus, the results now suggest that

increased demand by borrowers in non-recourse states fueled the incentives of homeowners to acquire housing and thereby led to higher prices. Consequently, it appears that the demand side of housing market conditions was very important in accounting for housing price appreciation during the boom years.

Next, one might also be concerned about endogeneity in both of the specifications in columns (I) and (II). For example, higher housing prices could feed back into changes in interest rates which bias our results. In order to account for this possibility, we also apply instrumental variables estimation in column (IV) which satisfies exclusion restrictions for our instruments. In particular, we use local bank concentration as measured by the number of people per bank in each state along with aggregate discount window lending from the Board of Governors of the Federal Reserve System as instruments for the effective interest rate. As can be observed from column (III), many of the variables remiain statistically significant with similar point estimates. However, there are two primary differences. First, interest rates no longer seem to matter for housing prices. In addition, the coefficient estimate for the non-recourse variable is also insignificant indicating that mortgage recourse provisions may not have any influence on housing prices.

However, mortgage recourse provisions do appear to be important during the boom years from 2001-2005. For example, the coefficient estimate in column (IV) is positive and statistically significant at the 5% level. Moreover, it remains positive and significant even when one instruments for the effective instrument rate in column (VI).

# 9 Calibration Exercises

As previously mentioned, the theoretical predictions regarding mortgage recourse from the model are ambiguous. While housing demand would be expected to be higher in markets with less legal control, lenders also adjust the amount of mortgage credit provided. Thus, a priori, there is not an obvious connection between mortgage recourse provisions and housing prices. However, the empirical evidence in the previous section suggests that the demand side factors dominate whereby prices are higher in non-recourse states, following the prediction from the model that mortgage demand would be higher if there are restrictions against mortgage recourse. We proceed to calibrate the model to attempt to replicate the relative price of housing and interest rates in the data. In this manner, we argue that the mechansims and welfare implications from our analysis are clearly important in policy debates.

We are especially interested in trying to understand if the model can be used to explain the role of mortgage non-recourse provisions for housing market activity during the recent housing boom in the United States. Thus, as we explain below, the model is paramaterized to match data for 2003. Moreover, in addition to studying how the model offers insights into housing market performance, we are also able to conduct welfare analysis among the different groups of agents in our model: depositors, homebuyers, and sellers.

As explained above, the parameter $\delta$ is equal to one if there are recourse provisions in place while it is equal to zero if there are protections against mortgage default. We next turn to our measure of the degree of liquidity risk, $\pi$. As discussed in other papers such as Ghossoub and Reed (2017), it is common to set $\pi = 1/2$ in order to correspond to a long-run average of the M2-GDP ratio in the United States. As for the value of $\phi$, the weight placed

on consumption in household utility, we set it equal to 0.7 so that it roughly corresponds to the idea that housing expenditure is generally around 30% of household income. The mortgage default rate in the United States was 1.83% in 2003 so we set $q = 0.0183$. We select homebuyers' income, $y$, so that it corresponds to average household income at the monthly frequency which is obtained by adjusting per capita GDP in the United States for the average number of members in a household in 2003. In this manner, our calculations put $y = \$8,497$ in 2003. In addition, the total measure of homebuyers is normalized to one.

This leaves us with two "free" parameters, $\theta$ and $H_0$. We simultaneously pin these values down by calibrating the model to match housing prices and mortgage interest rates in 2003. Unlike the Case-Shiller index, $P$ is the price of housing relative to consumption in the model. Thus, we look to the consumer price index in 2003 to determine our target value of $P$. In 2003, the price index for shelter was equal to 213.1 while the index for all items in the consumer price index was equal to 184. Consequently, the target value for $P = 1.16$. Next, the contract interest rate for all property types in 2003 was 5.83%.[8] Our calibration analysis reveals that $\theta = .108$ and $H_0 = 0.485$ best approximates the data if recourse provisions are in place. While we are able to produce results where the relative price of a home lines up with its target value, the estimate for the mortgage rate is a bit below the rate in 2003.

We now consider the predictions of the model if there are protections for defaulting homeowners. The results from the analysis are available in Tables 5 and 6. Consistent with the empirical evidence, the price of a home is higher if recourse is not permitted. Further, mortgage rates are higher which lines up with Goodman and Levitin.

We proceed to studying the welfare implications from mortgage default – the effects of non-recourse provisions on each group of agents are presented in the last three lines of Table 6. Notably, our results indicate that depositors at banks are worse off if non-recourse provisions are in place. It is fairly obvious that sellers obtain greater utility since they obtain higher prices for their homes. Interestingly, the model predicts that borrowers are unaffected – the only thing that recourse provisions do is change the timing of penalties for mortgage default. If lenders are allowed to pursue deficiency judgements, borrowers pay for the costs ex-post upon defaulting. By comparison, if recourse is not allowed, borrowers bear the burden ex-ante in the form of higher mortgage rates. Due to the law of large numbers, aggregate welfare among homebuyers is invariant to the legal landscape regarding mortgage default.

In contrast to other theoretical contributions, our framework emphasizes the implications of mortgage recourse in a setting where banks provide important risk-pooling services for risk-averse depositors as emphasized by Diamond and Dybvig (1983). Though the calibration work points to a relatively low level of risk-aversion, we are able to study how the implications of mortgage default depend on the level of risk aversion. Table 7 presents the results for the effects of risk aversion if recourse is allowed. By comparison, Table 8 shows the results for non-recourse. The third line of Table 8 shows the difference in housing prices between recourse and non-recourse economies – regardless of the level of risk-aversion, housing prices are always higher if there are protections for those who default. Similarly, in line with the benchmark results, mortgage rates are also higher. The welfare implications are also the same as in Table 6.

[8] See www.fhfa.gov.

# 10 Conclusions

There has been considerable debate about the various factors which contributed to the recent housing bubble in the United States. By understanding the forces which led to the bubble and the ensuing "Great Recession," we may be less inclined to revisit the mistakes of the past. A number of explanations have been put forward – unprecedented easy monetary policy, 'innovations' in financial markets and the rise of the "shadow banking system," large capital account deficits, and government interventions promoting homeownership.

Another argument is that the cost of strategic default was too low. That is, homeowners did not have enough 'skin in the game' and simply chose to walk away as housing conditions started to deteriorate. However, in 2009, Nevada became a limited recourse state in order to protect mortgage borrowers. Thus, there is considerable debate surrounding the legal landscape of the mortgage market.

In order to thoroughly understand how mortgage recourse provisions affect housing market activity, we develop a rigorous general equilibrium model with four different groups of housing market participants: homebuyers, homesellers, depositors, and financial intermediaries. It is also important that the model include microeconomic foundations for the existence of financial institutions in order to clearly demonstrate how housing market activity affects activity in the banking sector and overall economy. In particular, both depositors and homebuyers are risk-averse and would benefit from the provision of insurance against idiosyncratic risk. As in Diamond and Dybvig (1983), depositors are subject to idiosyncratic liquidity risk and value the risk-pooling services provided by financial intermediaries. By comparison, risk-averse homebuyers are subject to idiosyncratic risk regarding the utility from housing. For this reason, non-recourse provisions provide full insurance against the risk that they encounter. After individuals purchase homes, there is the possibility that they eventually would receive zero utility from housing and therefore would like to walk away from their mortgage obligations to intermediaries.

Notably, our theoretical framework offers ambiguous conclusions regarding mortgage recourse. On one hand, mortgage recourse limits housing demand as homebuyers are leery about their exposure to housing risk. On the other, intermediaries increase their supply of funding to mortgage markets if they are able to recover a greater proportion of their mortgage-related losses.

Empirical analysis seeks to help resolve the debate. Once one controls for regional level unobservables, the evidence suggests that the demand side factors dominate in which prices are higher in non-recourse states, following the prediction from the model that the demand for mortgages would be higher. We next move to obtain more concrete predictions from our theoretical framework with calibration exercises to study the effects of mortgage recourse. Upon calibrating the model to match some stylized evidence on housing market conditions, the theoretical predictions are consistent with the regression analysis. In this manner, our work sheds numerous insights into the implications of the legal landscape regarding mortgage default for housing market activity.

# References


Bao, T. and L. Ding, 2016. Non-Recourse Mortgage and Housing Price Boom, Bust, and Rebound. Real Estate Economics 44, 584-605.

Bernanke, Ben S., 2005. The Global Savings Glut and the Current Account Deficit. Speech at the Virginia Association of Economists, Richmond, Virginia, April 14.

Bhutta, N., J. Dokko, and H. Shan, 2010. The Depth of Negative Equity and Mortgage Default Decisions. Working Paper, Finance and Economics Discussion Series, Federal Reserve Board, WP 2010-35.

Boulware, K.D., J. Ma and R. Reed, 2014. How Does Monetary Policy Affect Shadow Banking Activity? Evidence from Security Repurchase Agreements. Mimeo, University of Alabama.

_____, and R. Reed, 2014. Monetary Policy and the Non-Bank Financial Sector: A Look at Commercial Paper. Mimeo. University of Alabama.

Castilla, M. 2011. Non-Recourse Mortgages and the Prevention of Housing Bubbles. Mimeo, SSRN.

Chatterjee, S. and B. Eyigungor, 2015. A Quantitative Analysis of the U.S. Housing and Mortgage Markets and the Foreclosure Crisis. Review of Economic Dynamics 18, 165-84.

Chen, N.K. and C. Leung, 2008. Asset Price Spillover, Collateral and Crises: with an Application to Property Market Policy. Journal of Real Estate Finance and Economics 37, 351-185.

Chen, N.K., H.L. Chu, T. Liu, and K.H. Wang, 2006. Collateral Value, Firm Borrowing, and Forbearance Lending: An Empirical Study of Taiwan. Japan and the World Economy 18, 49-71.

Corbae, D. and E. Qunitin, 2015. Leverage and the Foreclosure Crisis. Journal of Political Economy 123, 1-65.

Cunningham, C. and R. Reed, 2012. The Role of Housing Equity for Labor Market Activity. Mimeo, University of Alabama.

_____ and _____, 2013. Negative Equity and Wages. Regional Science and Urban Economics 43, 841-849.

Davis, M. and J. Heathcote, 2007. The Price and Quantity of Residential Land in the United States. Journal of Monetary Economics 54, 2595-2620.

Davis, M.A. and M.G. Palumbo, 2008. The Price of Residential Land in Large U.S. Cities. Journal of Urban Economics 63, 352-384.

Demiroglu, C., E. Dudley, and C.M. James, 2014. State Foreclosure Laws and the Incidence of Mortgage Default. Journal of Law and Economics 57, 225-280.

Diamond, D. and P. Dybvig, 1983. Bank Runs, Deposit Insurance, and Liquidity. Journal of Political Economy 85, 191-206.

Diamond, D., 1984. Financial Intermediation and Delegated Monitoring. Review of Economic Studies 51, 393-414.

Fang, H., Y.S. Kim, and W. Li, 2016. The Dynamics of Subprime Adjustable-Rate Mortgage Default: A Structural Estimation. Mimeo, Federal Reserve Bank of Philadelphia.

Feldstein, M., 2008. How to Help Negative Equity Homeowners. Mimeo, National Bureau of Economic Research.

Foote, C.L., K. Gerardi, and P. Willen, 2008. Negative Equity and Foreclosure: Theory and Evidence. Journal of Urban Economics 64, 234-45.

Garriga, C., F. Kydland, and R. Sustek, 2013. Mortgages and Monetary Policy. Mimeo, Federal Reserve Bank of St. Louis.

Garriga, C., Y. Tang, and P. Wang, 2016. Rural-Urban Migration, Structural Transformation, and Housing Markets in China. Mimeo, Federal Reserve Bank of St. Louis.

Geithner, T.F., 2008. Reducing System Risk in a Dynamic Financial System. Speech before the Economic Club of New York, 9 June.

Ghent, A. and M. Kudlyak, 2011. Recourse and Residential Mortgage Default: Evidence from U.S. States. Review of Financial Studies 24, 3139-3186.

Ghossoub, E. and R. Reed, 2017. Banking Competition, Production Externalities, and the Effects of Monetary Policy. Forthcoming, Economic Theory.

Glaeser, E.L., J. Gyourko, and A. Saiz, 2008. Housing Supply and Housing Bubbles. Journal of Urban Economics 64, 198-217.

Goodman, J. and A. Levitin, 2014. Bankruptcy Law and the Cost of Credit: The Impact of Cramdown on Mortgage Interest Rates. Journal of Law and Economics 57, 139-158.

Gorton, G. and A. Metrick, 2012. Securitized Banking and the Run on Repo. Journal of Financial Economics 104, 425-451.

Halket, J. and S. Vasudev, 2014. Saving Up or Settling Down: Home Ownership over the Life Cycle. Review of Economic Dynamics 17, 345-366.

Hatchondo, J., L. Martinez, and J. Sanchez, 2015. Mortgage Defaults. Journal of Monetary Economics 76, 173-190.

Huybens, E. and B.D. Smith, 1998. Inflation, Financial Markets and Long-Run Real Activity. Journal of Monetary Economics 43, 283-315.

Jin, Y., C.K.Y. Leung, and Z. Zeng, 2012. Real Estate, the External Finance Premium and Business Investment: A Quantitative Dynamic General Equilibrium Analysis. Real Estate Economics 40, 167-195.

Kim, J., 2015. Household's Optimal Mortgage and Unsecured Loan Default Decision. Journal of Macroeconomics 45, 222-244.

Mitman, K., 2016. Macroeconomic Effects of Bankruptcy and Foreclosure Policies. American Economic Review 106, 2219-55.

Nam, T. and S. Oh, 2015. Recourse Mortgage Law and Housing Speculation. Mimeo, SSRN.

Quintin, E., 2012. More Punishment, Less Default? Annals of Finance 8, 427-454.

Peng, S.K. and P. Wang, 2009. Normative Analysis of Housing-Related Tax Policies in a General Equilibrium Model of Housing Quality and Prices. Journal of Public Economic Theory 11, 667-696.

Saengchote, 2014. Recourse to Non-Housing Assets and Mortgage Credit Supply. Mimeo, SSRN.

Seko, M., K. Sumita, and M. Naoi, 2012. Residential Mobility Decisions in Japan: Effects of Housing Equity Constraints and Income Shocks Under the Recourse Loan System. Journal of Real Estate Finance and Economics 45, 63-87.

Smith, B.D., 2003. Taking Intermediation Seriously. Journal of Money, Credit and Banking 35, 1319-1357.

Williamson, S.D., 1986. Costly Monitoring, Financial Intermediation, and Equilibrium Credit Rationing. Journal of Monetary Economics 18, 159-179.

Table 1: Summary Statistics

| Variable | N | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| 1. Effective Interest Rate | 180 | 5.98 | .644 | 4.77 | 7.13 |
| 2. Housing Price Index | 180 | 151 | 40.4 | 69.6 | 277 |
| 3. Land Share | 180 | .501 | .211 | .050 | .887 |
| 4. Metro GDP | 180 | 255154 | 209674 | 72314.5 | 1018478 |
| 5. Unempl. Rate | 180 | 6.10 | 1.98 | 3.2 | 15 |
| 6. Nonrecourse | 180 | .389 | .489 | 0 | 1 |
| 7. Term | 180 | 28.4 | .997 | 25.7 | 30.6 |
| 8. Census Code | 180 | 2.94 | 1.03 | 1 | 4 |

Table 2: Recourse Provisions and Housing Prices (with Emphasis on Boom Period)

| | (I) | (II) | (III) | (IV) |
|---|---|---|---|---|
| Estimator | OLS | OLS | OLS | OLS |
| Sample Period | Full Sample | Full Sample | Boom Period | Boom Period |
| | | | | |
| Metro-GDP | $2.51*10^{-5***}$<br>$(7.60*10^{-6})$ | $2.18*10^{-5**}$<br>$(8.95*10^{-6*})$ | $1.46*10^{-5}$<br>$(1.03*10^{-5*})$ | |
| Unempl. Rate | | | | $-6.00^{**}$<br>(2.51) |
| Landshare | $113.3^{***}$<br>(9.14) | $119.0^{***}$<br>(10.6) | $116.8^{***}$<br>(16.8) | $123.9^{***}$<br>(15.5) |
| Term | $19.6^{***}$<br>(1.86) | $19.6^{***}$<br>(1.84) | $14.6^{***}$<br>(2.39) | $11.7^{***}$<br>(2.57) |
| Effective Interest Rate | -4.86<br>(2.98) | $-5.51^{**}$<br>(2.93) | $-21.3^{***}$<br>(3.02) | $-25.7^{***}$<br>(3.28) |
| Non-Recourse | | -4.89<br>(4.42) | -7.44<br>(5.10) | $-12.2^{***}$<br>(4.66) |
| | | | | |
| Constant | $-439.2^{***}$<br>(56.8) | $-434.9^{***}$<br>(56.0) | $-200.3^{***}$<br>(71.1) | -59.0<br>(85.9) |
| N | 180 | 180 | 90 | 90 |
| R-Squared | .666 | .669 | .695 | .703 |

Table 3: Recourse Provisions and Housing Prices with Regional Fixed Effects

| | (I) | (II) | (III) | (IV) | (V) | (VI) |
|---|---|---|---|---|---|---|
| Estimator | OLS | OLS | IV | OLS | OLS | IV |
| Sample Period | Full Sample | Full Sample | Full Sample | Boom Period | Boom Period | Boom Period |
| Metro-GDP | $3.83*10^{-5***}$ ($9.05*10^{-6}$) | | $3.97*10^{-5**}$ ($9.06*10^{-6*}$) | $3.07*10^{-5***}$ ($1.04*10^{-5}$) | | $3.07*10^{-5***}$ ($9.85*10^{-6}$) |
| Unempl. Rate | | -2.16** (.931) | | | -2.13** (2.61) | |
| Landshare | 130.3*** (11.7) | 133.6*** (12.1) | 123.9*** (13.9) | 128.8*** (18.0) | 139.3*** (18.5) | 129.0*** (17.1) |
| Term | 20.4*** (1.71) | 19.8*** (1.75) | 20.0*** (1.64) | 16.8*** (2.36) | 14.8*** (2.76) | 16.8*** (2.25) |
| Effective Interest Rate | -7.51** (2.95) | -12.6*** (3.49) | -2.16 (5.45) | -22.1*** (2.91) | -23.8*** (3.37) | -21.9*** (3.47) |
| Midwest | 17.5*** (6.48) | 6.77 (7.00) | 15.1* (7.30) | 13.5* (7.19) | 7.36 (8.32) | 13.6* (6.84) |
| South | 37.0*** (6.00) | 25.0*** (6.41) | 35.1*** (6.44) | 33.1*** (7.24) | 23.6 (7.73) | 33.1*** (6.88) |
| West | 4.79 (5.60) | -7.62 (5.78) | 4.01 (5.93) | 1.41 (6.27) | -7.08 (7.22) | 1.45 (5.98) |
| Non-Recourse | 9.35** (3.03) | 7.30** (3.46) | 10.6 (3.43) | 7.70** (3.96) | 4.39 (4.85) | 7.69** (3.73) |
| Constant | -477.1*** (51.7) | -397.6*** (58.2) | -495.4*** (52.9) | -285.1*** (72.3) | -59.0 (85.9) | -286.5*** (72.4) |
| N | 180 | 180 | 180 | 90 | 90 | 90 |
| R-Squared | .743 | .722 | .737 | .789 | .769 | .789 |
| First Stage F-Statistic (p-value) | | | 30.8 (0.00) | | | 255.2 (0.00) |
| Wooldridge Score Test Over-Identifying Restrictions (p-value) | | | .073 (.788) | | | .658 (.417) |

**Table 4: Parameter Values**

| Parameter symbol | Parameter value | Parameter |
|---|---|---|
| $\delta$ | 1 | Recourse |
| $\theta$ | 0.108 | Risk aversion |
| $\pi$ | 0.5 | Liquidity shock (M2-GDP 2003) |
| $\phi$ | 0.7 | Weight placed on consumption |
| $q$ | 0.0183 | 2003 mortgage default rate |
| $y$ | 8,497 | 2003 median household income |
| $B$ | 1 | Number of home-buyers normalized to 1 |
| $H_0$ | 0.485 | Housing Stock |

**Table 5: Recourse**

| $\delta$ | 1 |
|---|---|
| Price of Home ($P$) | 1.163 |
| Mortgage Rate ($r$) | 0.030 |

**Table 6: Non-Recourse**

| $\delta$ | 0 |
|---|---|
| Price of Home ($P$) | 1.170 |
| Mortgage Rate ($r$) | 0.050 |
| $\Delta P$ | .007 |
| $\Delta r$ | .020 |
| $\Delta EU_D$ | -.012 |
| $\Delta U_S$ | .003 |
| $\Delta EU_B$ | 0 |

**Table 7: Risk Aversion and Housing Prices** ($\delta = 1$)

| $\theta$ | 0.10 | 0.12 | 0.13 | 0.14 |
|---|---|---|---|---|
| Price of Home ($P$) | 1.094 | 1.266 | 1.351 | 1.433 |
| Mortgage Rate ($r$) | 0.014 | 0.065 | .101 | 0.144 |

**Table 8: Risk Aversion and Housing Prices** ($\delta = 0$)

| $\theta$ | 0.10 | 0.12 | 0.13 | 0.14 |
|---|---|---|---|---|
| Price of Home ($P$) | 1.101 | 1.273 | 1.358 | 1.441 |
| Mortgage Rate ($r$) | .034 | .087 | .124 | .168 |
| $\Delta P$ | .007 | .007 | .007 | .008 |
| $\Delta r$ | .020 | .022 | .023 | .024 |
| $\Delta EU_D$ | -.001 | -.002 | -.002 | -.001 |
| $\Delta U_S$ | .004 | .003 | .003 | .004 |
| $\Delta EU_B$ | 0 | 0 | 0 | 0 |

**Table 9: Income and Housing Prices** ($\delta = 1$)

| $y$ | 7,500 | 8,500 | 9,500 | 10,500 | 11,500 |
|---|---|---|---|---|---|
| Price of Home ($P$) | 1.150 | 1.163 | 1.174 | 1.183 | 1.193 |
| Mortgage Rate ($r$) | .029 | .032 | .034 | .037 | .039 |

**Table 10: Income and Housing Prices** ($\delta = 0$)

| $y$ | 7,500 | 8,500 | 9,500 | 10,500 | 11,500 |
|---|---|---|---|---|---|
| Price of Home ($P$) | 1.157 | 1.170 | 1.181 | 1.191 | 1.20 |
| Mortgage Rate ($r$) | .050 | .053 | .055 | .058 | .060 |
| $\Delta P$ | .007 | .007 | .007 | .008 | .007 |
| $\Delta r$ | .021 | .021 | .021 | .021 | .021 |
| $\Delta EU_D$ | -.002 | -.001 | -.001 | -.001 | -.001 |
| $\Delta U_S$ | .004 | 0.003 | 0.004 | .004 | .004 |
| $\Delta EU_B$ | 0 | 0 | 0 | 0 | 0 |