Mortgage Default and House Customization

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July 20, 2011

Abstract

Here I pose a new channel explaining the mortgage defaults. The home owners can customize their house structures whenever they want whereas renters cannot. Hence the owned houses are preferable to the rented ones. That generates a utility cost when moving from an owned to a rented house. If the defaulted households are forced to live in rented homes then the default cost is related to the distance between the rental and house owning markets. By calibrating a model with these features, I was able to qualitatively match the data and the distribution of defaults conditional that the household has negative equity on his house. Moreover, the calibrated results indicate that the effect of unemployment over the foreclosure rates is not very important. Estimates from panel regressions indicate that the new channel can have an important role.

Keywords: mortgage, panel data, portfolio choice. JEL codes: G21, C23, G11.

Abstract

Esse artigo propõe um novo canal explicando a inadimplência de hipotecas. Os indivíduos que moram em casas próprias podem modificar suas residências livremente enquanto os locatários não. Por causa disso morar em uma casa própria gera maior utilidade que morar em uma casa alugada. Esse fato cria um custo em termos de utilidade ao mudar de uma casa própria para uma alugada. Se ao parar de pagar uma hipoteca o indivíduo é forçado a morar em uma casa alugada, então o custo de inandimplência da hipoteca está diretamente relacionado com a diferença entre as casas alugadas e próprias. A distribuição de inadimplência condicional ao fato do agente ter "negative equity" em sua casa gerada pelo modelo calibrado qualitativamente corresponde aos dados. Além disso os resultados da calibração indicam que desemprego não tem grande efeito sobre a taxa de inadimplência. Usando uma regressão de painel os dados indicam que o canal proposto pode ter um papel importante na decisão de não pagar a hipoteca.

Palavras chaves: hipotecas, dados em painel, escolha de portfolio. JEL codes: G21, C23, G11.

1 Introduction

Empirical studies indicate that very few households default if they can afford to pay their mortgages (strategic defaults). For example Foote, Gerardi, Willen 2008 find that only 6.4% of homes with negative equity went in foreclosure when home prices fell 23% in Massachusetts between 1988 and 1993. Their sample has few homes with negative equity bigger than 10% of the value of the house. However using data from the recent housing downturn Guiso, Sapienza, Zingales 2009 show that very few households would default if the equity shortfall is less than 10% of the value of the house. But 17% of households would default, even if they could have kept paying their mortgages, when the equity shortfall reaches 50% of the value of their house.

During the recent fall on house prices, the government created the HOPE for Homeowners Act of 2008 and the HAMP(Home Affordable Modification Program) in 2009. Their intention was to push up the house prices by preventing foreclosured houses to enter the market. None of the programs has got even close to meet their initial expectations. The main focus of both programs was on families who are not paying their mortgages due to liquidity constraints. Hence one of the reasons for their failure might be their neglect on strategic defaults. Given that at the third quarter of 2008 more than 6% of the American homes with a mortgage were under the water by more than 20%, the results from these governmental policies suggest that strategic defaults have an important role in the actual economic scenario. Thus any work that sheds some light over the strategic default decision can lead to important policy implications.

In this paper, I develop a model for strategic defaults that matches the above facts and relies on the idea that people rather live in a owned house than in a rented one.

Given the unmatched intensity of the fall on house prices in the last years, the research on the determinants of the default decision has recently drawn a lot of attentions. Even though the literature proposes a variety of explanations, the question of which are the key elements of the default decision still far from being answered. The simplest model for mortgage defaults, plain vanilla default model, consists of a frictionless world in which agents are not punished for defaulting. In that world the economic agent can default get a new mortgage and buy the same house again. That type of model is strongly contradicted by the data, since it implies that whenever there is negative equity the borrower defaults. Kau, Keenan, Kim 1994 argue that defaulting a mortgage is equivalent to exercising an American put option. Hence the discounted value of the future mortgage payments is lower than what it would be necessary to pre pay the mortgage today. Guiso, Sapienza, Zingales 2009 find that people who declare the default to be immoral are less likely to default. Moreover, those who know someone who has defaulted are more likely to default. They conclude that moral and social considerations are the most important variables in explaining strategic defaults.

Here I propose a mechanism for strategic defaults that is new to the literature. After buying the house, the owner can modify the house so that it perfectly fits his tastes. Since a renter cannot modify the house whenever he wants[1], a household that moves from an owned house to a rented one faces a utility cost. Here agents who default lose access to the credit market and therefore are forbidden from living in an owned house, as in Campbell, Cocco 2003. Therefore a mortgage owner weights the benefits of ending mortgage payments with the utility loss of leaving his house when choosing to default.

The house enters the agent's utility through a CES aggregate of two components: structure and land. Due to the CES aggregation, when agents maximize their utilities the optimal proportion of structure and land is uniquely determined by the relative price of structure and land. Thus when the stochastic prices are known the household decides on the mixture of structure and land. However available houses were built when prices were different, so they do not have the optimal mixture of land and structure. The agents can customize the house after buying and achieve the optimal proportion of structure and land. Hence what enters the house owner's utility is the house after it has been modified. Since renters cannot change their houses after moving in, a rented dwell does not have the optimal proportion of its two components. I also include stochastic labor income in order to see how unemployment affects the household's decision. Now I can outline how the household decides whether to default. Once the uncertainty on prices and labor income is realized, the household calculates the cost of moving from an owned house to a rented house. The household defaults only if the benefit of ending mortgage payments overweights this cost.

The empirical analysis is based on the mechanism below. If available houses were built when the relative price of structure and land was very different from current prices, they would have a ratio of land and structure that is far from the optimum. Thus when the relative price of structure and land has changed a lot, the difference between a rented and an owned home increases. The cost of defaulting goes up, so the number of foreclosures falls. Therefore there should be a negative relationship between foreclosure rates and the absolute value of the change on the relative price of structure and land.

In the calibration I obtain the probabilities of default conditional on that a household has negative equity in his house. After inputting the model with parameters that replicate the U.S. economy during the recent fall of the house prices, I compare these probabilities with the ones implied by the plain vanilla default model. The results show that the my model fits the data much better

[1] The rigidity of the leasing contracts gives less incentives for the landlords to modify the house. The landlord can raise the rent promising the tenant that he will do home improvements. But the tenant might be afraid of paying a higher rent without getting the desired modifications. On the other hand, after the modifications are done the tenant has no incentives to pay before the end of the leasing. Also doing modifications when the house is vacant incurs a cost of not receiving rent for some time.

than the plain vanilla model. In addition, I calculate the probabilities of default conditional on being unemployed or employed. If cash flow constraints are important, the default probabilities when employed and unemployed should be considerably different. The calibrated model shows that these probabilities do not differ by much. Therefore my model suggests that strategic defaults are the most important components for the default decision when a household faces a negative equity situation. That conclusion is in unison with the results of programs as HAMP. And suggests that these programs should put more attention on strategic defaults.

For the empirical analysis I use state level quarterly series from 2005 to 2009 of foreclosure rates, prices of land and prices of structures, unemployment rates and other controls as loan to value ratio and mean credit score. In order to test the model's implications, I run a state level panel regression in which the foreclosure rate is the dependent variable and the absolute variation of the relative price of structure and land is one of the regressors. The estimates for that slope coefficient are significant and negative as expected from the theoretical framework. Moreover, the absolute variation of the relative price of structure and land seems to explain the variation of foreclosures by the same order of magnitude as the other regressors. So the new channel seems to have an important role in the default decision. The estimation yields a non-significant coefficient for the unemployment rate. As in the calibration, the labor income seems to have little influence over the default rates.

One of the reasons why mortgagers who have negative equity in their homes do not default is the potential appreciation of their houses. As a matter of fact, a big deal of the strategic default literature is about analyzing the effect of future house prices over the default decision. In order to compare that effect with the one produced by the house customization, I have included the forecasts of the change of house prices on the regression. The results are the same as when the forecasts are not included. Hence the effects of future of house prices over foreclosure rates do not seem to offset the ones from house customization.

In terms of policy implications, my results suggest that the government should not try to lower the number of foreclosures by focusing on reducing households' cash flow problems ignoring the negative equity problem. One way to do so is to facilitate the renegotiation of the terms of the mortgages so that the troubled house owners face a lower amount of negative equity.

The remaining sections are structured in the following way: Evidence from the governmental policies, which shows how strategic defaults can have big policy implications. Literature review. The theoretical model. Results, which contains both the calibration results and the empirical analysis. The conclusion.

2 Evidence from the governmental policies

The failure of the actual governmental programs aiming to reduce the number of foreclosures is a strong evidence in favor of the importance of strategic defaults. Since the main focus of the present paper is on that type of default, it is interesting to do a quick survey about these programs.

After the house prices have soured, the government has created several programs aiming to help households to keep their homes. One of the first post subprime crisis program was the HOPE for Homeowners Act of 2008. Among others it authorized the FHA(Federal Housing Administration) to insure up to $300 billion of 30 year fixed rate and refinance loans up to 90% of appraised value for distressed borrowers. The initial expectation was that around 400000 households would choose to participate, however by February 2009, only 451 applications had been received and 25 loans finalized.

In January 2009 the government launched the HAMP(Home Affordable Modification Program). The goal was to achieve from 3 millions to 4 millions loan modifications and keep homes off the market by preventing foreclosures. Similarly to the HOPE the number of modified loans was much lower than the initial estimate. In order to join the program, the current principal, interest, property taxes and homeowner's insurance payments must be costing the borrower over 31% of his gross monthly household income. Hence the loan modification protocol in the program was intended to help the households to keep their monthly payments close to the 31% threshold. By March 2011, less than 800000 home owners have entered the program. Moreover, the number of HAMP new trials has declined by 84% compared with an year before.

The HOPE excluded households facing home negative equity. The HAMP has initially limited its participation to home owners with loan to value ratios up to 105%. That value was later extended to 125%. But the program still aims at families who are not paying their mortgages due to liquidity constraints. In a scenario where 6% of the American homes with a mortgage are under the water by more than 20%, the importance of the strategic defaults is likely to be big.

The government says that his objective is to reduce the number of houses available on the market and prevent further drops in house prices. In order to achieve that the government's strategy is to help households who are likely to default to renegotiate their mortgages. The failure of the HOPE and HAMP shows that the government's programs were not able to screen the households who really have the intention of defaulting their mortgages. Maybe if the criterion for joining these programs does not rule out households who can afford their mortgage payments, the government would do a better job in reducing the number of foreclosures.

3 Literature review

This paper seems to be the first to model the choice between owning and renting a house based on the possibility of customizating an owned house. Moreover it seems to be the first to relate the preference for owned houses with strategic defaults of mortgages. For these reasons, I am going to review both the literature about the decision between owning and renting a house and mortgage defaults.

A house can be priced in the same way as any other asset by calculating its present value of the future cash flows that are going to be yielded from the asset. In a firm the cash flows are given by the dividends. A house does not pay dividends to its owner but a household who owns his own home does not pay rent, so the dividends received by the owner are the rents that he will be avoiding to pay. Hence the value of a house today should be the discounted values of the future rents. If the price of the house is bigger than the present value of the future rents then it is better to rent. However it is not an easy task to estimate the present value of future cash flows, moreover there are other market frictions, such as tax exemptions for mortgages and liquidity restrictions, that affect the house owning decision. In addition to that the existence of bubbles, the price goes up not due to an increase of the future cash flows but only because people believe that future prices are going to be even higher, might decouple the present value of the future rents and the house prices. Himmelberg, Mayer, Sinai 2005 relate the costs of owning and renting taking in consideration elements as tax exemptions and variations on the interest rates. They found that periods in which house prices have grown by more than the present value of the future rents are followed by periods with considerable depreciation of the house values. That suggests that bubbles might be a significant component of the decision of buying a house. Hurst, Stafford 2002 argue that the agents who own houses have more instruments to smooth consumption. If the value of the house is bigger when the liquidity constraints are binding, like being unemployed, the household can borrow using his house equity as collateral. By using data from the PSID they are able to support their theory. Sinai, Souleles 2005 proposes a model in which the agent who buys a house does not bear the risk of fluctuations on the rents. In their model the down side of buying is the fact that the owner faces the risk of variations on the house prices. Their data analysis indicates that the hedge against fluctuations in rental cost dominates the asset price risk associated with the house.

Yao, Zhang 2004 use the fact that when a house owner has to unexpectedly move he has to pay liquidation costs, such as brokerage fees. On the other hand a renter does not faces these costs. The benefit from having a house is the gain from possible increases in the price of the houses. They also analyze how the presence of bonds and stocks affect the consumption of housing services. The only work that I have found in which house prices are explained by home customization is Portov, Odish, Fleishman 2005. Their argument is that home improvement investment generates a positive externality in the neighborhood.

Hence locations with more house modifications should have bigger appreciation on the house prices. They use data about houses at Haifa in Israel, since there several neighborhoods consist of big residential complexes with units that were homogeneous at the time of their construction. Because of that they were able to measure the amount of house improvement investment in different areas of the city. Their conclusion is that the neighborhoods with more home modifications had bigger increases on the house prices.

The most basic model of mortgage defaults, which I call here as the plain vanilla model and is also often called roughness default model, consists of a world in which the household faces no costs due to the default. So after stopping to pay a mortgage the agent can buy the same house by contracting a new mortgage. If these assumptions are true then every household that has negative equity in his house would default. The data strongly contradicts that model. Foote, Gerardi, Willen 2008 find that only 6.4% of borrowers with amounts of negative equity that are smaller than 10% of the value of the house default. Guiso, Sapienza, Zingales 2009 show that very few households would default if the equity shortfall is less than 10% of the value of the house. Under the house owner's point of view the house equity is equal to the house value minus the present value of the future mortgage payments. However what is reported in the data is the house value minus the amount necessary to pre pay the mortgage. For a fixed payment mortgage the outstanding debt is the present value of a stream of a cash flow of constant payments over time that are discounted by an interest rate determined at the origination date. But the mortgager can default at any time, hence the present value of his future mortgage payments is smaller than the amount necessary to pre pay his debt. Becasue of that several of the houses that are reported as having negative equity might in fact have a positive amount of equity. That idea is developed by Kau, Keenan, Kim 1994. If the reported value of the negative equity is small, 10% of the value of the house, their model does a good job in explaining why most of the households do not stop paying their mortgages when in negative equity. However that channel alone cannot explain why some people with high levels of negative equity still do not default. Guiso, Sapienza, Zingales 2009 claim that if a household lives in a environment where no one has defaulted their mortgages, he fells ashamed of stopping to pay his mortgage. In a scenario where the mortgager is surrounded by people who have defaulted their mortgages, the social pressure against the default is going to be much smaller. Thus the number of foreclosures in a neighborhood should have a positive effect over the default probability of a household who lives in the area.

Yao, Zhang, 2006 propose a theoretical framework that incorporates both the choice between owning and renting and the possibility of defaulting a mortgage. However their focus is on how the portfolio choice over the life cycle is affected by mortgage defaults. Moreover, the default cost is as an exogenous factor.

4 The theoretical model

The theoretical framework consists of a two period model in which the agent decides how much of consumption (C) and housing services (H) he wants. The house H is composed of two pieces, land H^L and structure H^S. And is given by

$$H = \left[(H^L)^{\frac{\varepsilon-1}{\varepsilon}} + \omega (H^S)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

By modeling the house in the above way, the concept of customization is therefore defined as the possibility of changing the mixture of structure and land in the house.

In the first period the agent buys a house and chooses how much mortgage to contract. In the second period the new prices of structure and land are realized. Because of that the agents would like to live in a home where the proportion of structure and land is in accordance with the new prices. However the available houses at the beginning of period 2 were modified in the previous period when the prices differed from the current. Hence the households would like to modify the actual houses. Only those who own a house can do so. Therefore the renters are going to have to live in a dwell that has a structure to land ratio that yields less housing services than the owned houses.

Right after the agents know the new prices they have the option of not paying their mortgages and give their homes to the lenders. If they choose to do so they are forced to live in a rented houses[2]. Since the owned houses are preferred, in the model the cost of defaulting is the disutility that comes from moving from an owned to a rented house. Therefore a mortgage owner only defaults one the benefits of ending mortgage payments overweights the disutility of moving to a rented house.

Another feature of the model is stochastic labor income. That creates a framework in which it is possible to compare the effects of cash flow restrictions and the customization channel in what regards the default decision. If the default rates during the high labor income states are similar as when labor income is low, we can say that the customization is the most important component of the default decision. Of course, when the number of defaults does vary a lot with labor income then we can conclude the opposite.

The next section solves the maximization problem faced by the agent at the second period. After that I use the results from the second period's solution to solve the agent's problem at the initial period.

[2] The assumption that a defaulted agent has to live in a rented house follows Campbell and Cocco 2003.

4.1 The second period

The agent starts the period living in the house that he chose during period 1, which has H_0^L of land and H_0^S of structure. He also begins the period with a mortgage balance of $R^f M$ and $R^f B$ in bonds that he saved from period one, where R^f is the risk free gross interest rate that captalizes at the beginning of each period. The agent is allowed to get another mortgage[3] with value no bigger than $P^L H_0^L + P^S H_0^S$. However at the time he receives the new loan he has to pay his previous mortgage which has an outstanding debt of value $R^f M$. If the household defaults the mortgage then he is forced to live in a rented house. Those who do not default can decide between to stay in their house or move to another owned house. In addition, the house owner has to pay a maintenance cost of $\Psi \times (P^L H_1^L + P^S H_1^S)$, which is also equal to the value of the rent. Hence in case the household decides to pay the mortgage and get the new loan, he faces the following maximization problem:

$$\max_{C_1, H_1^L, H_1^S} C_1^\alpha \left[\left[(H_1^L)^{\frac{\varepsilon-1}{\varepsilon}} + \omega (H_1^S)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \right]^{1-\alpha} \tag{1}$$

$$s.t. \begin{cases} C_1 + \Psi \times (P^L H_1^L + P^S H_1^S) = P^L H_0^L + P^S H_0^S - R^f M + Y + R^f B \\ H_1^S = \theta^* H_1^L. \end{cases}.$$

If he chooses to default then he maximizes

$$\max_{C_1, H_1^L, H_1^S} C_1^\alpha \left[\left[(H_1^L)^{\frac{\varepsilon-1}{\varepsilon}} + \omega (H_1^S)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \right]^{1-\alpha} \tag{2}$$

$$s.t. \begin{cases} C_1 + \Psi \times (P^L H_1^L + P^S H_1^S) = Y + R^f B \\ H_1^S = \theta H_1^L. \end{cases}.$$

At the very beginning of the period the prices (P^L, P^S) and the labor income (Y) are realized. After that the household decides whether to default and chooses his bundle of consumption goods (C) and housing services.

Without the second restrictions the agent's optimum choice of the ratio between structure and land would be $\frac{H^S}{H^L} = \left(\omega \frac{P_1^L}{P_1^S} \right)^\epsilon = \theta^*$. Thus from (1) it is clear that the owners live in the house that better fits his preferences. The second restriction on (2) characterizes the rental market. Hence the second restrictions define the differences between the rented and owned houses. The above framework implies that owned houses are always preferable. Moreover as

[3] This new mortgage works in this way, the household receives the value of the house and promises to give the house to the bank by the time of his death. Since the agent only lives for one period, the cost of such contract is zero for the bank. Which is consistent with a competitive banking system.

$|\theta - \theta^*|$ increases so does the utility loss of moving from an owned house to a rented one[4]. Later I am going to show that such property will be a key element to test the model's implications against the data.

The figures below illustrates the default mechanism. The θ ray is the set of houses available for the renters. The θ^* ray is the set of owned houses achievable by the owners. Point A indicates the optimal owned houses and point B represents the optimal rented house.

Figure 1.1 shows how the budget set changes as the agent defaults when the value of outstanding mortgage is bigger than the house value ($P^L H^L + P^S H^S - M < 0$). Therefore by defaulting the agent receives extra income.

Figure 1.2 illustrates that by keeping the budget fixed the renters achieve less utility than the owners.

Figure 1.3 shows the total effect. As the house gets deeper under the water the monetary gain of defaulting increases until the agent becomes indifferent between defaulting and paying the mortgage. After the value of the house drops beyond that point then default becomes the household's best choice. In the above pictured case, the monetary gain is smaller than the utility cost and the agent is better by not defaulting.

[4] See the First Appendix for details.

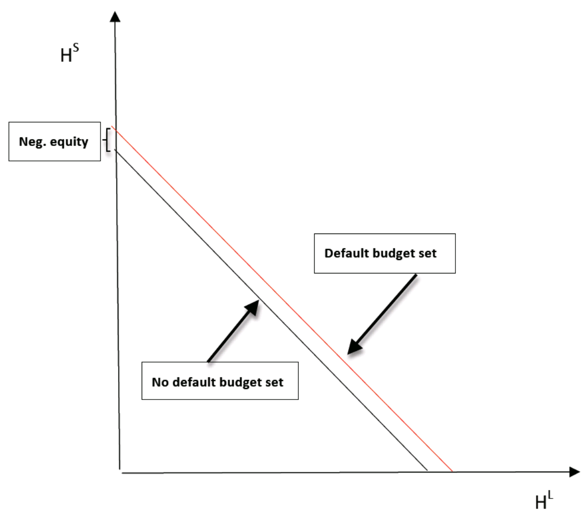

Figure 1: The Gain from Defaulting

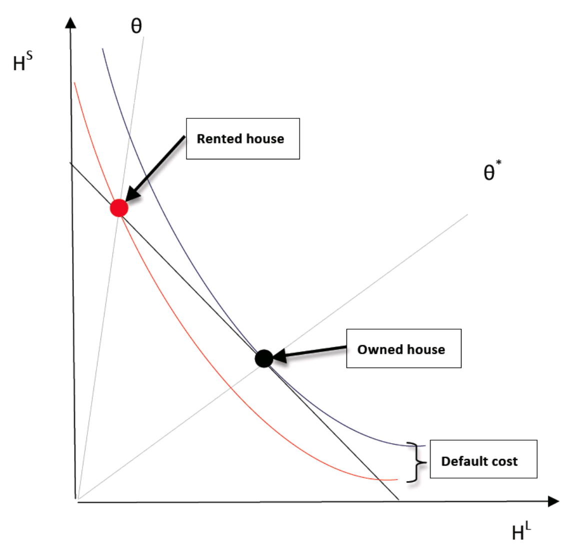

Figure 2: The Cost of Default

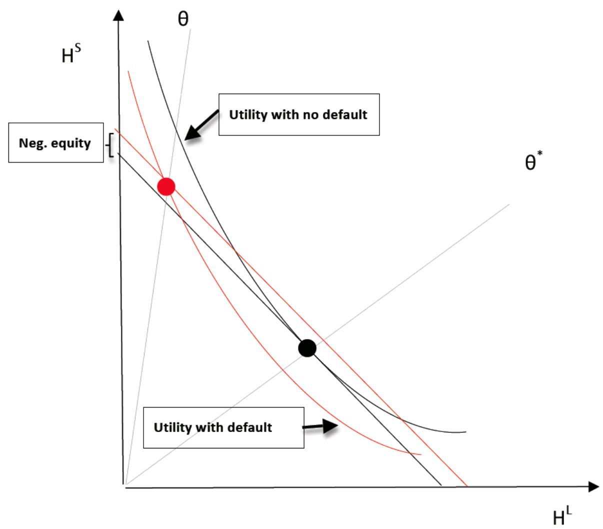

Figure 3: The Default Decision

4.2 The first period

The second period's solution describes the values of C_1, H_1^S, H_1^L and I_D every state of nature given the values of the first period's choices. The first period's maximization problem uses these results to find the optimal choice of the period 1's variables. At the initial period the agent chooses B, M, H_0^L and H_0^S. All the uncertainty comes from the prices (P^L, P^S) and labor income (Y). At the initial period the agent maximizes the following

$$\max \frac{(C_0^\alpha H_0^{1-\alpha})^{1-\gamma}}{1-\gamma} + \beta \mathbb{E}_0 \left[\frac{(C_1^\alpha H_1^{1-\alpha})^{1-\gamma}}{1-\gamma} \right]$$

$$s.t.$$

$$C_0 + \Psi \times (P_0^L H_0^L + P_0^S H_0^S) + B = W + M - P_0^L H_0^L - P_0^S H_0^S$$

$$B \geq 0,\ 0 \leq M \leq (1-\delta)(P_0^L H_0^L + P_0^S H_0^S)$$

$$if\ I_D = 1\ then$$

$$\begin{cases} C_1 + \Psi \times (P_1^L H_1^L + P_1^S H_1^S) = R^f B + Y \\ H_1^S = \theta H_1^L \end{cases}$$

$$if\ I_D = 0\ then$$

$$\begin{cases} C_1 + \Psi \times (P_1^L H_1^L + P_1^S H_1^S) = R^f B + (P_1^L H_0^L + P_1^S H_0^S - R^f M) + Y \\ H_1^S = \theta^* H_1^L \end{cases},$$

where I_D is an indicator variable that is 1 if the agent decides to default, otherwise it equals 0. W is the initial wealth and Y is the stochastic labor income.

Moreover

$$H_1 = \left[(H_1^L)^{\frac{\varepsilon-1}{\varepsilon}} + \omega(H_1^S)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

,

$$H_0 = \left[(H_0^L)^{\frac{\varepsilon-1}{\varepsilon}} + \omega(H_0^S)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

And B is a risk free bond that cannot be shorted, with gross return R^f. The agent's mortgage debt contracted at period 0 is M, its gross interest rate is R^f and its down payment is of at least δ. The house owner has to pay a maintenance cost of $\Psi(P^L H_0^L + P^S H_0^S)$, which is also equal to the value of the rent. The values of the prices of structure, land and the labor income (P_1^L, P_1^S and Y) are known at the beginning of the terminal period.

As previously said, the restrictions $H_1^S = \theta H_1^L$ and $H_1^S = \theta^* H_1^L$ define the differences between the rented and owned houses. Even though the owned house market may not offer exactly the house that the agent desires, he makes his decision between buying and renting based on the modifications that he can do on his own house right after moving. That is why the owned houses enter the household's utility as if it has the optimal mixture between land and structure, $\frac{H_1^S}{H_1^L} = \left(\omega \frac{P_1^L}{P_1^S}\right)^\epsilon = \theta^*$. The other hand the renters cannot modify the house right after moving. The rigidity of the leasing contracts gives less incentives for the landlords to modify the houses. The landlord can raise the rent promising the tenant that he will do home improvements. But the tenant might be afraid of paying a higher rent without getting the desired modifications. On the other hand, after the modifications are done the tenant has no incentives to pay before the end of the leasing. Also doing modifications when the house is vacant incurs a cost of not receiving rent for some time. For these reasons I assume that the rental market takes one period to adjust to the new prices. That assumption implies that $\theta = \left(\omega \frac{P_0^L}{P_0^S}\right)^\epsilon$

The uncertainty over P_t^S and P_t^L is described by the following process:

$$\begin{array}{c} \ln(P_t^S) - \ln(P_{t-1}^S) \\ \ln(P_t^L) - \ln(P_{t-1}^L) \end{array} \sim N\left[\left(\begin{array}{c} \mu_S \\ \mu_L \end{array}\right), \left(\begin{array}{cc} \sigma_S^2 & \rho\sigma_S\sigma_L \\ \rho\sigma_S\sigma_L & \sigma_L^2 \end{array}\right)\right].$$

The labor income can assume two values $\bar{Y}$ when the agent is employed and $\underline{Y}$ when he is unemployed, where $\bar{Y} > \underline{Y}$, the unconditional unemployment probability is given by u. The above parameters plus the correlation $\tilde{\rho}$ between Y and $|\Delta \ln(P_t^L/P_t^S)|$ characterize the joint distribution of the labor income and the prices[5].

Let $\ln(P_{t+1}^L/P_{t+1}^S) = \ln(P_t^L/P_t^S) + \epsilon_{t+1}$. At the terminal period, if ϵ_{t+1} is positive then the difference between the rental and the home owning markets

[5]For details see the Third Appendix.

increases with ϵ_{t+1}. If ϵ_{t+1} is negative the difference between the two markets increases as ϵ_{t+1} decreases. The graphs below show the intuition behind that.

Figure 1.4 shows the case when $\epsilon_{t+1} = 0$. In that scenario there is no difference between the owned and rented homes. Hence the cost of defaulting is zero and the agent best choice is to default as soon as the house gets into negative equity.

Figure 1.5 shows that as ϵ_{t+1} goes away from zero the cost of default increases and the agent may not default when there is negative equity.

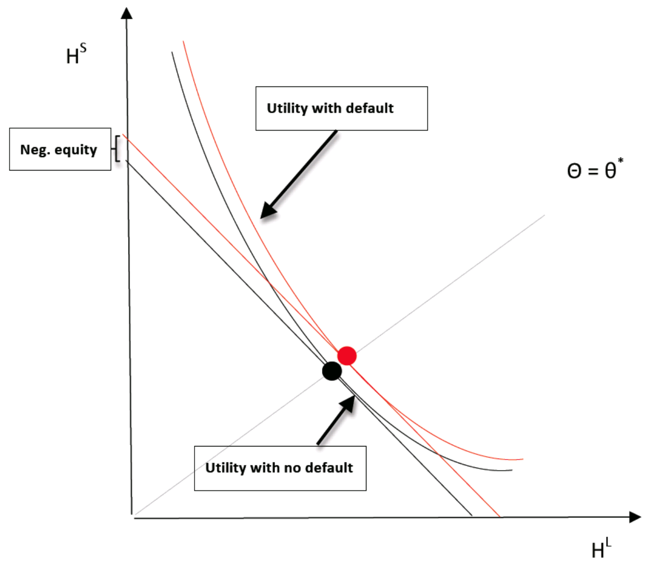

Figure 4: The Default Decision when Relative Prices Have not Changed

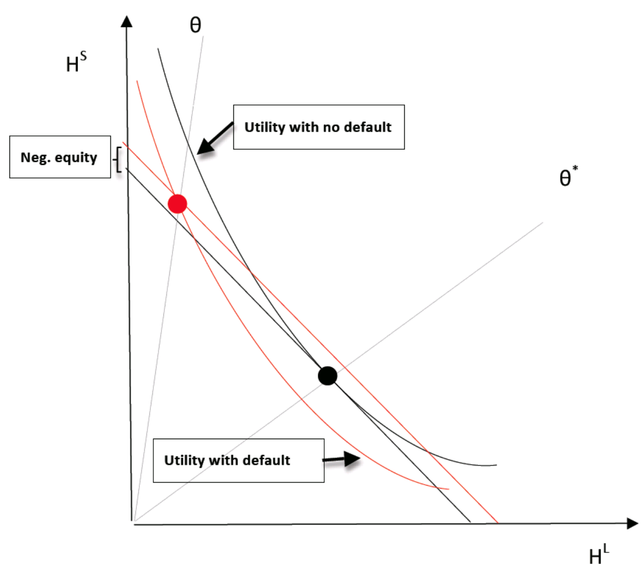

Figure 5: The Default Decision when Relative Prices Have Changed

5 Results

5.1 Data description

All the series are state level and have quarterly frequency. The data from 1975:q1 to 2008:q4 on prices and quantities of land and structure was provided to me by Morris Davis. The method used to construct the data is in Davis and Heathcote 2007.The data from 2005:q1 to 2009:q2 on foreclosures comes from The National Delinquency Survey, which is a quarterly publication prepared by the Mortgage Bankers Association (MBA) and focus on first lien mortgages on one to four units in the property. The data on unemployment, unemployment rate of the state, comes from the Bureau of Labor and Statistics. The remaining series come from Equifax, the loan to value ratio and the credit score are state averages.

The follow notation describes the variables used on the next section

$$
\begin{aligned}
fore_{i,t} &= \ln(fraction\ of\ prime\ loan\ in\ foreclosures_{i,t}) \\
sub\_fore_{i,t} &= \ln(fraction\ of\ subprime\ loan\ in\ foreclosures_{i,t}) \\
rel_{i,t} &= \ln(P^L_{i,t}/P^S_{i,t}) \\
\Delta^d rel_{i,t} &= rel_{i,t} - rel_{i,t-d} \\
\Delta^d relup_{i,t} &= 1_{[\Delta^d rel_{i,t}>0]} \Delta^d rel_{i,t} \\
\Delta^d reldown_{i,t} &= 1_{[\Delta^d rel_{i,t}<0]} \Delta^d rel_{i,t} \\
fico_{i,t} &= \ln(mean\ credit\ score_{i,t}) \\
lv_{i,t} &= \ln(mean\ loan\ to\ value\ ratio_{i,t}) \\
ph_{i,t} &= \ln(price\ of\ houses_{i,t}) \\
\Delta^d ph_{i,t} &= ph_{i,t} - ph_{i,t-d} \\
unem_{i,t} &= \ln(unemployment\ ratio_{i,t}),
\end{aligned}
$$

where $1_{[.]}$ is the indicator function, i identifies the state , t the time period and Δ^d is the difference between today's value and d periods ago ($\Delta^d x_{i,t} = x_{i,t} - x_{i,t-d}$).

5.2 Calibration

My objective here is to simulate the United States' economy during the recent drop on house prices. More specifically I want to use the theoretical model to calculate the following objects[6]:

$$
CDF(c) = \Pr\left(I_D = 1\ and\ \frac{P_1^L H_0^L + P_1^S H_0^S - R^f M}{P_1^L H_0^L + P_1^S H_0^S} \geq c \,\middle|\, \frac{P_1^L H_0^L + P_1^S H_0^S - R^f M}{P_1^L H_0^L + P_1^S H_0^S} \leq 0 \right)
$$

[6] For details about the numerical methods used for getting the joint distribution of the prices and labor income see the Third Appendix.

,

$$CDFUnem(c) =$$

$$\Pr\left(I_D = 1 \; and \; \frac{P_1^L H_0^L + P_1^S H_0^S - R^f M}{P_1^L H_0^L + P_1^S H_0^S} \geq c \middle| \frac{P_1^L H_0^L + P_1^S H_0^S - R^f M}{P_1^L H_0^L + P_1^S H_0^S} \leq 0 \; and \; Being \; unemployed\right)$$

and

$$CDFEm(c) =$$

$$\Pr\left(I_D = 1 \; and \; \frac{P_1^L H_0^L + P_1^S H_0^S - R^f M}{P_1^L H_0^L + P_1^S H_0^S} \geq c \middle| \frac{P_1^L H_0^L + P_1^S H_0^S - R^f M}{P_1^L H_0^L + P_1^S H_0^S} \leq 0 \; and \; Being \; employed\right).$$

Hence $CDF(c)$ is the probability of defaulting if the house equity is bigger than a certain number (c) given that the household has negative equity in his house. As an example, if $CDF(-0.1) = 0.1$ then an agent with negative equity with at most 0.1 of the value of his house has 10% probability of defaulting. $CDFUnem(c)$ and $CDFEm(c)$ translates the same probabilities as $CDF(c)$ except that in addition they are conditioned on being unemployed and employed respectively.

5.2.1 Baseline model

Table 1 contains the values of the parameters used for the benchmark model. The parameters were chosen such that the model proxies the decision made by a household who bought a house in 2005. α is the parameter of the Cobb-Douglas aggregator between consumption and housing services. δ is the minimum down payment, as a percentage of the house value, required on the initial period in order to contract a mortgage. Ψ is the maintenance cost of a house, as a percentage of the current house value, and is also equal to the rent. γ is the curvature parameter. β is the impatience rate. α, δ, Ψ, γ and β were chosen based on the literature, more specifically they were copied from Yao and Zhang (2005. μ_S, μ_L are the yearly means of the difference in logs of the prices of structure and land. σ_S^2 and σ_L^2 are the yearly variances of the variations in logs of the prices of structure and land. And ρ is the correlation between the log differences of the prices of structure and land. μ_S, μ_L, σ_S^2, σ_L^2 and ρ were set to the sample moments of the nation wide level time series data[7] available from Davis and Heathcote (2007). P_0^L and P_0^S are the prices at the first quarter of 2005 and also come from the nation wide level time series data available from Davis and Heathcote (2007). ω is set to the sample average of the ratio between the expenditures of structure and land and was also extracted from Davis and Heathcote 2007. Δ is the length of the period, its value is the average tenure time in a house in the year 2000 census. Since the mortage rates are more related to the end of the yield curve, R^f is the annual interest rate and its value is the yield

[7]Quarterly observations from $2002:q1$ to $2008:q4$.

δ	0.20
α	0.80
ω	1.33
ϵ	1.00
γ	5
β	0.96
Ψ	0.06
μ_S	0.0286
μ_L	0.0062
ρ	-0.95
$\tilde{\rho}$	0
σ_S	0.12
σ_L	0.06
R^f	1.01
P_0^L	2.12
P_0^S	1.15

Table 1: Baseline parameters

of the10 year US treasure bond at 2004. The elasticity of substitution between structure and land, ε, is set to one (the house is a Cobb-Douglas aggregator) based on Thorsnes 1997. The labor income[8] process parameters are based on Hurst 2002, the labor income $\bar{Y}$ when the agent is employed is equal to the house stock and the labor income $\underline{Y}$ when the agent is unemployed is equal to 30% of the house stock. The house stock is the value of the house stock from 2005 that comes from the data generated by Davis and Heathcote 2007. The unemployment probability was set to 6%. In the absence of reliable data on the correlation between $|\Delta \ln(P_t^L/P_t^S)|$ and the labor income, $\tilde{\rho}$, the value of $\tilde{\rho}$ was arbitrarily set to 0 on the baseline model. The robustness tests show that such choice does not change the results by much.

Table 2 has the unconditional probability of default and the probability of being in negative equity that are generated by the calibrated model. The percentage of the houses with mortgages on the United States at December of 2008 with negative equity is 20%. The percentage of mortgages in foreclosure at the last quarter of 2008 is 3.3%. If we restrict the sample to prime and subprime mortgages the numbers are 1.81% and 13.71% respectively at December 2008. So the values from the simulations are on the same order of magnitude as the values given by the data.

[8] The Third Appendix has the details about the calibration of the labor income process.

$Prob.of\ default$	$Prob.of\ Neg.\ Eq.$
20%	23%

Table 2: Negative Equity and Default Probabilities

Figure 1.6 plots the $CDF(c)$ that comes from solving the baseline model and the $CDF(c)$ implied from the vanilla default model. The dot is the value of $CDF(-0.1)$ that comes from the data used by Foote, Gerardi, Willen 2008. The results from the simulated model still a bit far from the data, but they show that the customization can explain a big part of the mortgage defaults.

When the agent is unemployed he is more likely to be cash constrained. So the bigger the difference between $CDFUnem(c)$ and $CDFEm(c)$ more important the cash flow restrictions are for the default decision. Figure 1.7 show that the $CDF(c)$, $CDFUnem(c)$ and $CDFEm(c)$ are close to each other indicating that according to my model cash flow constraints are not he most important component of the mortgage defaults.

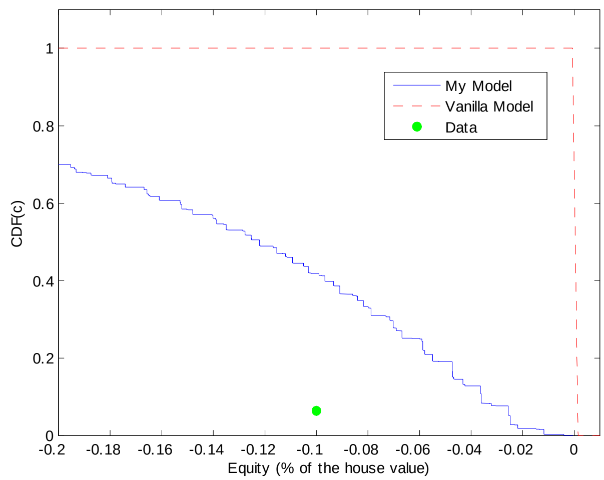

Figure 6: Baseline Model and Vanilla Model

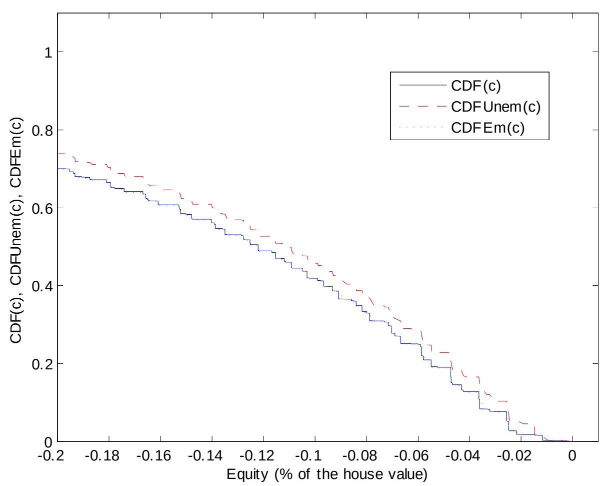

Figure 7: Cash Flow Constraints vs. Strategic default

5.2.2 Robustness tests

In the absence of reliable data on the correlation between $|\Delta \ln(P_t^L/P_t^S)|$ and the labor income, $\tilde{\rho}$, the value of $\tilde{\rho}$ was arbitrarily set to 0 on the baseline model. For that reason, I have simulated the model for three different values $(-0.34,\ 0,\ 0.34)$ while keeping the other parameters fixed. Figure 1.8 has the results for that. As expected the gap between $CDFUnem(c)$ and $CDFEm(c)$ increases as $\tilde{\rho}$ decreases, since when $\tilde{\rho}$ is negative the cost of the default is likely to be smaller if the agent is unemployed. The results are almost the same as before and the strategic defaults still are the most important component of the mortgage default decision.

I also run the baseline model with different values of the elasticity of substitution between structure and land (ϵ). The $CDF(c)$ on Figure 1.9 is below than the one on Figure 1.10. Fact that is consistent with my model. For the same variation on the relative prices between structure and land the difference between the rented houses increases as the elasticity of substitution goes up. In other words, as the degree of substitution between structure and land increases the agents wants to change bigger quantities of structure by land or vice versa when the relative prices change. Figures 1.9 and 1.10 show that the baseline model's results do not change much as ϵ moves.

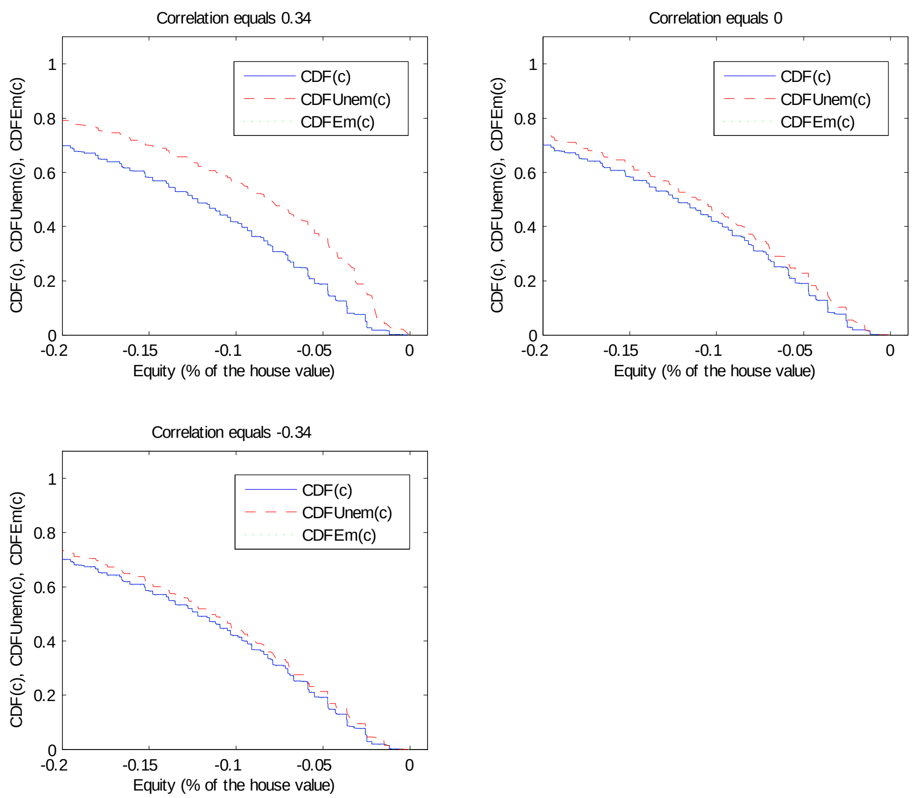

Figure 8: Effects of the Correlation between Y and $|\Delta \ln(P_t^L/P_t^S)|$.

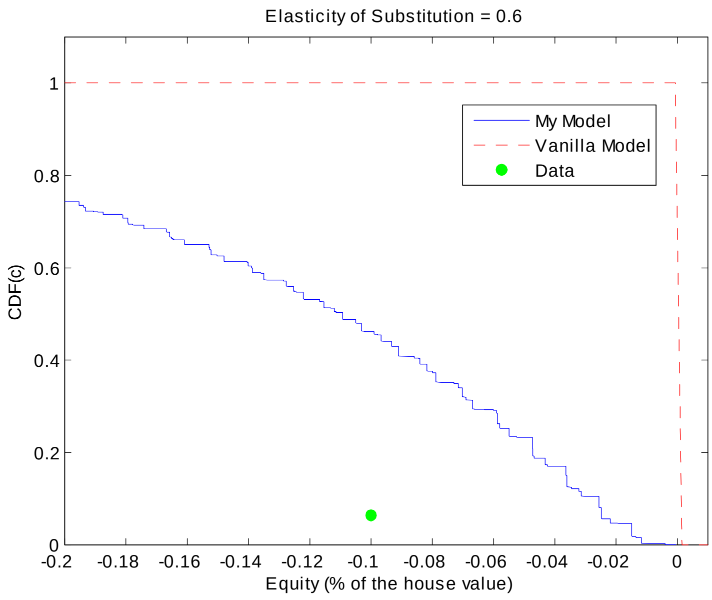

Figure 9: Results when $\epsilon = 0.6$.

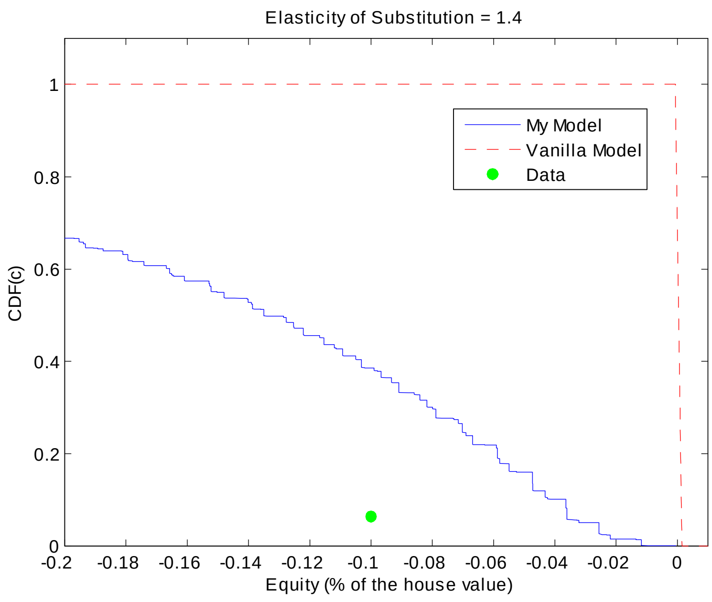

Figure 10: Results when $\epsilon = 1.4$.

5.3 Regression analysis

5.3.1 Test procedure

Let $\ln(P^L_{t+1}/P^S_{t+1}) = \ln(P^L_t/P^S_t) + \epsilon_{t+1}$. The theoretical model implies that if ϵ_{t+1} is positive then the difference between the rented and owned houses increases with ϵ_{t+1}. If ϵ_{t+1} is negative the difference increases as ϵ_{t+1} becomes more negative. Hence the model can be tested by running

$$fore_{i,t} = \alpha + |\Delta^d relup_{i,t}|\beta_1 + |\Delta^d reldown_{i,t}|\beta_2 + controls_{i,t} + u_{i,t}$$

and test whether both β_1 and β_2 are negative[9]. More specifically, I run a fixed effect state level panel regression.

5.3.2 The baseline model

The baseline testing model is

$$\begin{aligned} fore_{i,t} &= \alpha + |\Delta^d relup_{i,t}|\beta_1 + |\Delta^d reldown_{i,t}|\beta_2 + \Delta^d ph_{i,t}\beta_4 + lv_{i,t}\beta_5 \\ &\quad + fico_{i,t}\beta_6 + unem_{i,t-4}\beta_7 + u_{i,t} \end{aligned} \tag{3}$$

The dependent variable is the number of foreclosures on prime loans. A big percentage of the subprime loans might come from households that are far from the population mean of the population. (Ex.: Suppose that the average unemployment rate is 6% but the unemployment rate for the subprime households is 10%). Therefore to use mean values as regressors might not be appropriate for subprime loans. Another option would be to use the total number of foreclosures as dependent variable. However a big part of the foreclosures are from subprime loans (the number of prime loans is about 7 times bigger than the number of subprime loans, however the foreclosure rate for the subprime loans is 5 times bigger than on the prime loans).

Mortgages from different vintages, origination dates, might have very different effects over today's foreclosures. Unfortunately the available data is not disaggregated by vintages. One way to go around that problem is to include the current value of the explanatory variables and its lagged values in the same regression. If the regressor is in levels then I can add its lagged values. If the regressor is in difference then I can add differences with different lengths (d).

The correlations between variables and its lagged values (or between differences with different lengths) are very high[10]. For that reason I have decided to include only one of the lags (or length in the case of differences) of the same

[9] Let $c > 0 > f$ and $|f| < |c|$, the theoretical model does not rule out cases in which the default cost when $\Delta^d rel_{i,t} = c$ is smaller than when $\Delta^d rel_{i,t} = f$. That is why the test procedure uses $|\Delta^d relup_{i,t}|$ and $|\Delta^d reldown_{i,t}|$ as regressors instead of $|\Delta^d rel_{i,t}|$.

[10] See The Fifth Appendix for details.

regressor. In choosing which lags or lengths to include, I gave preference for the ones with higher variances[11].

The controls are the credit score, loan to value ratio, unemployment rate and variation of the house prices. The credit score proxies the damage on the reputation that happens after a default. A high credit score indicates a higher cost of defautling, since an agent with good reputation has more to loose by defaulting. The unemployment rate is related to the ability of paying the mortgage. When unemployed the household is more likely to be cash constrained and therefore have more incentives to default. The loan to value ratio and the variation of house prices control for the level of negative equity. Bigger drops in the price of housing suggests more negative equity and bigger loan to value ratio lowers the house equity. These two controls are therefore proxies of the gain of defaulting (the amount of negative equity that the agent gets hid by stopping paying his mortgage).

Table 3 has the estimates of (3). The results validate my model. Both the estimated coefficients of $|\Delta^d relup_{i,t}|$ and $|\Delta^d reldown_{i,t}|$ are negative and statistically significant. The unemployment coefficient is positive but staticaly insignificant. Which is similar to the calibrated model's results where unemployment has a positive but small effect over the default probability. Moreover, the possibility of customization seems to have an importat role when compared with the other default components represented by the controls, since the absolute variations on the relative prices explain the variation of foreclosures by the same order of magnitude as the other controls. The credit score has a negative and statistically significant coefficient as expected. The loan to value ratio and the variation of house prices have respectively positive and negative statisticaly significant coefficients.

5.3.3 The effect of future house prices

One of the reasons why mortgagers who have negative equity in their homes do not default is the potential appreciation of their houses. As a matter of fact, a big deal of the strategic default literature is about analyzing the effect of future house over the default decision. In order to compare that effect with the one produced by house customization, I have included the forecasts of the variation on house prices among the regressors in (3). The correlation between forecasts with different values of d is high. For that reason I have not included forecasts with different ds in the same regression. That yielded the following regression

$$\begin{aligned} fore_{i,t} &= \alpha + |\Delta^d relup_{i,t}|\beta_1 + |\Delta^d reldown_{i,t}|\beta_2 + \Delta^d ph_{i,t}\beta_4 + lv_{i,t}\beta_5 \\ &\quad + fico_{i,t}\beta_6 + unem_{i,t-4}\beta_7 + \mathbb{E}_t[\Delta^d ph_{i,t+d}]\beta_8 + u_{i,t}, \end{aligned} \tag{4}$$

where $\mathbb{E}_t[\Delta^d ph_{i,t+d}]$ is the prediction of the change of the house price in d periods given today's available information[12].

[11] See The Fifth Appendix for details.

[12] For details about the forecast construction see Appendix 4.

The results (Table 4) show that the estimates of the regressors that are present in both (3) and (4) are almost the same regardless the forecast is included. So if the product between the estimated coefficient and the regressor's variance is much bigger than the same product for the forecasts, it is fine to say that the other regressor explain better the variation of the foreclosures when compared to the forecasts. By using that reasoning the numbers on Table 4 show that the effect of customization is much bigger than the one from the expected change on house prices[13].

The basic intuition is that the estimate of the forecast's coefficient should be negative. However its estimate on Table 4 is positive and at a 10% level of significance is significantly different from zero. If the household impatience rate is high, future house prices's predictions of periods that are further in the future should affect much less the default decision than the predictions of periods closer to the present. For that reason it is interesting to run (4) using the one year ahead ($d = 4$) forecast instead. The results for that are in Table 5. The forecasts' coefficients now have point estimates that are negative. The other regressors have estimated coefficients that are extremely similar to the ones from (3).

5.3.4 Robustness tests

As a robustness test (specially in what regards $|\Delta^d relup_{i,t}|$ and $|\Delta^d reldown_{i,t}|$), I run (3) using foreclosures of subprime mortgages as dependent variable instead of prime mortgages ' foreclosures. Hence (3) becomes:

$$\begin{aligned} sub\_fore_{i,t} &= \alpha + |\Delta^d relup_{i,t}|\beta_1 + |\Delta^d reldown_{i,t}|\beta_2 + rel_{i,t-d}\beta_3 + \Delta^d ph_{i,t}\beta_4 \\ &\quad + lv_{i,t}\beta_5 + fico_{i,t}\beta_6 + unem_{i,t-4}\beta_7 + u_{i,t} \end{aligned} \tag{5}$$

Table 6 contains the estimates of (5). The estimates of the coefficients associated with house customization still negative and significantly non-zero. However their effect seems to be stronger. The estimated coefficient of the credit score is negative but statistically insignificant. The biggest change is on the unemployment coefficient which is negative and statistivcally significant. Since programs as HAMP benefit households who are cash constrained, it is possible that a big part of the agents with subprime loans remain unemployed so that they can face lower mortgage payments. If that is true then the rates of foreclosure and unemployment may have negative correlation.

The following regression is the same as (4) but using default rates of subprime as dependent variable and its results are in Table 7 .

[13] $var(|\Delta^d relup_{i,t}|)\beta_1 + var(|\Delta^d reldown_{i,t}|)\beta_2$ is considerably bigger than $var(\mathbb{E}_t[\Delta^d ph_{i,t+d}])\beta_8$.

	$d=16$ (4 *years*)		$d=12$ (3 *years*)	
	coef.	$p-value$	*coef.*	$p-value$
$\|\Delta^d relup_{i,t}\|$	-0.038 (0.008)	0.000	-0.026 (0.008)	0.001
$\|\Delta^d reldown_{i,t}\|$	-0.128 (0.043)	0.004	-0.140 (0.058)	0.017
$\Delta^d ph_{i,t}$	-1.706 (0.118)	0.000	-2.227 (0.114)	0.000
$lv_{i,t}$	2.245 (0.126)	0.000	2.250 (0.125)	0.000
$fico_{i,t}$	-12.389 (2.606)	0.000	-7.772 (2.418)	0.000
$unem_{i,t-4}$	0.014 (0.012)	0.232	0.006 (0.010)	0.516

Standard deviations are in parenthesis.

Table 3: Results using prime mortgages

$$\begin{aligned} sub\_fore_{i,t} &= \alpha + |\Delta^d relup_{i,t}|\beta_1 + |\Delta^d reldown_{i,t}|\beta_2 + \Delta^d ph_{i,t}\beta_4 + lv_{i,t}\beta_5 \\ &\quad + fico_{i,t}\beta_6 + unem_{i,t-4}\beta_7 + \mathbb{E}_t[\Delta^d ph_{i,t+d}]\beta_8 + u_{i,t}, \end{aligned} \tag{6}$$

Tables 7 and 8 results are akin to those on Table 6. House customization still seems to play an important role. The only estimate that has significant differences is the one associated with the credit score.The conclusions about the effect of future house prices are the same as in Tables 5 and 6 .

	$d = 16$ (4 *years*)		$d = 12$ (3 *years*)	
	coef.	$p - value$	*coef.*	$p - value$
$\mathbb{E}_t[\Delta^d ph_{i,t+d}]$	0.004 (0.002)	0.070	0.013 (0.005)	0.016
$\|\Delta^d relup_{i,t}\|$	−0.039 (0.008)	0.000	−0.028 (0.008)	0.000
$\|\Delta^d reldown_{i,t}\|$	−0.131 (0.043)	0.003	−0.146 (0.058)	0.013
$\Delta^d ph_{i,t}$	−1.711 (0.118)	0.000	−2.251 (0.114)	0.000
$lv_{i,t}$	2.272 (0.126)	0.000	1.766 (0.117)	0.000
$fico_{i,t}$	−13.304 (2.651)	0.000	−9.013 (2.465)	0.000
$unem_{i,t-4}$	0.015 (0.012)	0.203	0.007 (0.010)	0.490
Standard deviations are in parenthesis.				

Table 4: Results using prime mortgages when $E_t[\Delta^d ph_{i,t+d}]$ is included

	$d = 16$ (4 *years*)		$d = 12$ (3 *years*)	
	coef.	$p - value$	*coef.*	$p - value$
$\mathbb{E}_t[\Delta^4 ph_{i,t+4}]$	−0.368 (0.082)	0.000	−0.043 (0.080)	0.585
$\|\Delta^d relup_{i,t}\|$	−0.028 (0.008)	0.001	−0.025 (0.008)	0.002
$\|\Delta^d reldown_{i,t}\|$	−0.119 (0.043)	0.006	−0.137 (0.059)	0.021
$\Delta^d ph_{i,t}$	−1.547 (0.122)	0.000	−2.201 (0.124)	0.000
$lv_{i,t}$	2.123 (0.127)	0.000	1.727 (0.110)	0.000
$fico_{i,t}$	−10.879 (2.597)	0.000	−7.645 (2.431)	0.002
$unem_{i,t-4}$	0.025 (0.012)	0.038	0.008 (0.011)	0.449
Standard deviations are in parenthesis.				

Table 5: Results using prime mortgages when $E_t[\Delta^4 ph_{i,t+4}]$ is included

	$d = 16$ (4 *years*)		$d = 12$ (3 *years*)	
	coef.	$p-value$	*coef.*	$p-value$
$\|\Delta^d relup_{i,t}\|$	−0.048 (0.008)	0.000	−0.034 (0.008)	0.000
$\|\Delta^d reldown_{i,t}\|$	−0.312 (0.044)	0.000	−0.484 (0.059)	0.000
$\Delta^d ph_{i,t}$	−1.483 (0.121)	0.000	−1.936 (0.116)	0.000
$lv_{i,t}$	1.873 (0.128)	0.000	1.447 (0.119)	0.000
$fico_{i,t}$	−3.615 (2.657)	0.174	0.156 (2.459)	0.949
$unem_{i,t-4}$	−0.131 (0.012)	0.000	−0.148 (0.010)	0.000
Standard deviations are in parenthesis.				

Table 6: Results using subprime mortgages

	$d = 16$ (4 *years*)		$d = 12$ (3 *years*)	
	coef.	$p-value$	*coef.*	$p-value$
$\mathbb{E}_t[\Delta^d ph_{i,t+d}]$	0.001 (0.002)	0.434	0.007 (0.005)	0.188
$\|\Delta^d relup_{i,t}\|$	−0.048 (0.008)	0.000	−0.035 (0.008)	0.000
$\|\Delta^d reldown_{i,t}\|$	−0.314 (0.044)	0.000	−0.487 (0.059)	0.000
$\Delta^d ph_{i,t}$	−1.486 (0.121)	0.000	−1.950 (0.116)	0.000
$lv_{i,t}$	1.885 (0.129)	0.000	1.466 (0.120)	0.000
$fico_{i,t}$	−4.019 (2.708)	0.138	−0.532 (2.513)	0.000
$unem_{i,t-4}$	−0.131 (0.012)	0.000	−0.148 (0.010)	0.000
Standard deviations are in parenthesis.				

Table 7: Results using subprime mortgages when $E_t[\Delta^d ph_{i,t+d}]$ is included

	$d = 16$ (4 $years$)		$d = 12$ (3 $years$)	
	$coef.$	$p - value$	$coef.$	$p - value$
$\mathbb{E}_t[\Delta^4 ph_{i,t+4}]$	−0.433 (0.083)	0.000	−0.095 (0.081)	0.240
$\|\Delta^d relup_{i,t}\|$	−0.037 (0.008)	0.000	−0.031 (0.008)	0.000
$\|\Delta^d reldown_{i,t}\|$	−0.303 (0.044)	0.000	−0.477 (0.060)	0.000
$\Delta^d ph_{i,t}$	−1.297 (0.124)	0.000	−1.878 (0.126)	0.000
$lv_{i,t}$	1.730 (0.129)	0.000	1.435 (0.119)	0.000
$fico_{i,t}$	−1.842 (2.638)	0.485	0.433 (2.470)	0.861
$unem_{i,t-4}$	−0.118 (0.012)	0.000	−0.145 (0.011)	0.000
Standard deviations are in parenthesis.				

Table 8: Results using subprime mortgages when $E_t[\Delta^4 ph_{i,t+4}]$ is included

6 Conclusion

This paper proposes a new testable channel that explain strategic mortgage defaults. The house owners can customize their houses whereas the renters cannot. Because of that the agents loose utility by moving from his own house to a rented one. After defaulting the household no longer has access to the credit market and cannot afford to buy a house. Hence a household who has negative equity in his house only defaults if the gain of stopping paying his mortgage overweights the cost of moving to a rented house.

My model defines house customization as the ability of adjusting the ratio between structure and land in the house, so when there is a big a change on the relative price of structure and land the agent has a bigger desire of modifying his house. Hence more volatility on the relative price between structure and land implies a bigger cost of defaulting. So the model can be tested by running a regression of foreclosure rates against the variation on the relative prices of structure and land and testing if the estimated coefficients are negative.

The presence of stochastic labor income makes it possible to see how important cash flow constraints are for the default decision. When an agent is unemployed he is more likely to be facing liquidity restrictions. Hence if the probability of defaulting when employed is not very different when the agent is unemployed then cash flow restrictions are not very relevant for the default decision.

The model simulations using parameters that replicate the U.S. economy during the recent drop on the house prices shows that house customization can alone explain a big part of the default decision. Moreover the simulations show that cash flow constraints are not determinant for the defaults associated with houses that have negative equity.

The regression analysis ratifies my model and shows that the customization channel might have an important role in the default decisions. Akin the simulation results, labor income does not seem to be very important for the default decision. The conclusions in what regards the house customization channel are the same as when the forecast of the future changes in the house prices is included in the empirical analysis.

In terms of policy implications, my results suggest that the government should not try to lower the number of foreclosures by focusing on households' cash flow problems ignoring the negative equity problem. One way to do so is to facilitate the renegotiation of the terms of the mortgages so that the troubled houseowners have a lower amount of negative equity.

The First Appendix

Proof of why $\frac{V^{ND}}{V^{D}}$ goes up as $|\theta-\theta^{*}|$ increases.

Lets look at the simpler problem:

$$\max_{C,H^L,H^S} C^{\alpha}\left[\left[(H^L)^{\frac{\varepsilon-1}{\varepsilon}}+\omega(H^S)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}\right]^{1-\alpha}$$
$$s.t.\begin{cases} W+Y=C+\Psi(P^LH^L+P^SH^S) \\ H^S=\theta H^L \end{cases}.$$

By plugging the last restriction into the objective function and into the budget constraint we get

$$\max_{C,H^L} C^{\alpha}(H^L)^{1-\alpha}\left[\left[1+\omega(\theta)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}\right]^{1-\alpha}$$
$$s.t.\left\{W+Y=C+H^L\Psi(P^L+P^S\theta)\right. .$$

The value function of that problem is given by

$$\alpha^{\alpha}(1-\alpha)^{1-\alpha}W\left[\frac{\left[1+\omega(\theta)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L+P^S\theta)}\right]^{1-\alpha}.$$

Now returning to the original problem and defining V^D and V^{ND} as the value functions for the default and non default cases respectively we have that

$$V^D = \alpha^{\alpha}(1-\alpha)^{1-\alpha}\left[\frac{\left[1+\omega(\theta)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L+P^S\theta)}\right]^{1-\alpha}(W+Y)$$
$$V^{ND} = \alpha^{\alpha}(1-\alpha)^{1-\alpha}\left[\frac{\left[1+\omega(\theta^*)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L+P^S\theta^*)}\right]^{1-\alpha}(W+Y+P^LH_0^L+P^SH_0^S-M)$$

then

$$\frac{V^{ND}}{V^D}=\frac{\left[\frac{\left[1+\omega(\theta^*)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L+P^S\theta^*)}\right]^{1-\alpha}}{\left[\frac{\left[1+\omega(\theta)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L+P^S\theta)}\right]^{1-\alpha}}\frac{W+Y+P^LH_0^L+P^SH_0^S-M}{W+Y}.$$

Thus the agent default if and only if $\frac{V^{ND}}{V^D}<1$. Since we are focusing on the case of negative equity, we can define $\frac{W}{W+P^LH_0^L+P^SH_0^S-M}$ as the monetary gain of defaulting and $\frac{\left[\frac{\left[1+\omega(\theta^*)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L+P^S\bar{\theta})}\right]^{1-\alpha}}{\left[\frac{\left[1+\omega(\theta)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L+P^S\theta)}\right]^{1-\alpha}}$ as the utility cost of defaulting.

Proposition 1 *The utility cost of defaulting increases as increases as* $|\theta - \theta^*|$.

Proof. The function

$$g(\theta) = \frac{\left[1 + \omega(\theta)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}}{\Psi(P^L + P^S\theta)}$$

is concave with maximum at

$$\left(\omega \frac{P_1^L}{P_1^S}\right)^{\epsilon} = \theta^*.$$

Hence by keeping every thing fixed but θ the utility cost of defaulting increases as $|\theta - \theta^*|$ increases. ■

Let $\ln(\theta) = \ln(\theta^*) + \epsilon$. Hence if ϵ is positive then an increase in ϵ increases the utility cost of defaulting. And if ϵ is negative then a decrease in ϵ increases the utility cost of defaulting.

The Second Appendix

This appendix summarizes how Davis and Heathcote 2007 have obtained the series of land and structure prices.

The market value of the house is given by:

$$p_t^h h_t = p_t^l l_t + p_t^s s_t,$$

where p_t^h, p_t^l and p_t^s are respectively the prices of the houses, h_t, l_t and s_t are respectively the quantities of house, structure and land. If the quantities between dates are fixed then

$$\frac{p_{t+1}^l}{p_t^l} = \frac{1}{\omega_t^l}\left[\frac{p_{t+1}^h}{p_t^h} - (1-\omega_t^l)\frac{p_{t+1}^s}{p_t^s}\right],$$

where $\omega_t^l = \frac{p_t^l l_t}{p_t^h h_t}$.

The prices of structures (p_t^s) were extracted from the price index for gross investment in new residential structures produced by the Bureau of Economic Analysis (BEA) within the National Income and Product Accounts (NIPA). Notice that the NIPA definition of new residential structures includes gross investment in newly built housing units as well as improvements to existing units.

The price of houses (p_t^h) is the repeat-sales-based index produced by the Office of Federal Housing Enterprise Oversight (OFHEO) (1975-now).

The replacement cost of residential structures published by the BEA is the basis for the value of structures ($p_t^s s_t$). That series is converted from annual to quarterly frequency by using investment data and a perpetual inventory account system.

A series of the market value of housing ($p_t^h h_t$) plus the three previous series give the means to generate a series for the price of land. Since Davis and Heathcote were not able to find a reliable series with that information, they constructed it by using data from the Census Bureau and the NIPA tables.

Since

$$p_{t+1}^h h_{t+1} = \frac{p_{t+1}^h}{p_t^h} p_t^h h_t + p_{t+1}^h \Delta h_{t+1},$$

given the value of $p_t^h h_t$ at one period and a time series of $p_t^h \Delta h_t$ it is possible to generate a time series of $p_t^h h_t$. The second term of the above equation is the nominal net new additions to the stock of housing which can be decomposed as

$$p_{t+1}^h \Delta h_{t+1} = p_{t+1}^s \Delta s_{t+1} + p_{t+1}^l \Delta l_{t+1}.$$

The first term is the new additions to the stock of structures and the second is the new additions to the stock of land. $p^s_{t+1}\Delta s_{t+1}$ is directly observed through the NIPA's nominal net investment in residential structures. The second term is not directly observed but the census provides a series of new residential structures put in place. The CENSUS bureau does not directly observe that series. Instead they observe the value of the house sales and assume that the value of the structures is a constant fraction of the value of the house. According to the Census methodology the value of the house is split in the following way: 84.2% are structures put in place, 10.6% are raw land and the remaining is from other non-structure costs. Therefore a series of new additions to the stock of land can be obtained by multiplying the series of new residential structures put in place by 10.6/84.2. In order to choose a benchmark for $p^h_t h_t$ they use data of February 2000 that comes from the microdata in the 2000 Decenial Census of Housing (DCH) and the 2001 Residential Finance Survey (RFS).

Davis and Heathcote argue that the assumption used by the Census Bureau that the production function of new homes is Cobb-Douglas is consistent with Thorsnes(1997). Moreover since the Census use the same method as here any series of the market value of the houses generated by the Census Bureau is going to be consistent with theirs.

The Third Appendix

This appendix contains the details about the calibration of the joint distribution of P_t^S, P_t^L and Y.

The uncertainty over P_t^S and P_t^L is described by the following process:

$$\begin{array}{c}\Delta\ln(P_t^S)\\ \Delta\ln(P_t^L)\end{array} \sim N\left[\left(\begin{array}{c}\mu_S\\ \mu_L\end{array}\right),\left(\begin{array}{cc}\sigma_S^2 & \rho\sigma_S\sigma_L\\ \rho\sigma_S\sigma_L & \sigma_L^2\end{array}\right)\right].$$

And in the simulations is approximated using Hermit quadrature.

The labor income can assume two values $\bar{Y}$ when the agent is employed and $\underline{Y}$ when he is unemployed, where $\bar{Y} > \underline{Y}$, the unconditional unemployment probability is given by u. Conditional on $|\Delta\ln(P_t^L/P_t^S)|$ being below its mean (μ^Δ) the unemployment probability is given by $\underline{u}$. Conditional on $|\Delta\ln(P_t^L/P_t^S)|$ being above its mean (μ^Δ) the unemployment probability is given by $\bar{u}$. Given that $|\Delta\ln(P_t^L/P_t^S)| \leq \mu^\Delta$ the distribution of $|\Delta\ln(P_t^L/P_t^S)|$ and Y are independent. The same goes when we are conditioning on $|\Delta\ln(P_t^L/P_t^S)| > \mu^\Delta$. Hence the probability density of $|\Delta\ln(P_t^L/P_t^S)|$ plus the parameters $\bar{Y}$, $\underline{Y}$, $\bar{u}$ and $\underline{u}$ completely characterize the joint distribution of $|\Delta\ln(P_t^L/P_t^S)|$ and Y.

Therefore $\bar{u}$ and $\underline{u}$ and the values of u and $cov(|\Delta\ln(P_t^L/P_t^S)|, Y)$ are related in the following way

$$u = \bar{u}\Pr(|\Delta\ln(P_t^L/P_t^S)| > \mu^\Delta) + \underline{u}Pr(|\Delta\ln(P_t^L/P_t^S)| \leq \mu^\Delta)$$

and

$$cov(|\Delta\ln(P_t^L/P_t^S)|, Y) = (\underline{u}-\bar{u})\Pr(|\Delta\ln(P_t^L/P_t^S)| > \mu^\Delta)\mathbb{E}[(|\Delta\ln(P_t^L/P_t^S)| - \mu^\Delta)|(|\Delta\ln(P_t^L/P_t^S)| > \mu^\Delta)].$$

Hence given $\bar{Y}$, $\underline{Y}$ and the probability density of $|\Delta\ln(P_t^L/P_t^S)|$, $\bar{u}$ and $\underline{u}$ can be obtained from the values of u and $cov(|\Delta\ln(P_t^L/P_t^S)|, Y)$. The method for calibrating the labor income process consists of getting values for u and $cov(|\Delta\ln(P_t^L/P_t^S)|, Y)$ and from them obtain $\bar{u}$ and $\underline{u}$.

The Fourth Appendix

This appendix details the construction of the house prices' forecast used during the regression analysis.

The dynamics of the house price change ($\Delta^d ph_{i,t}$) is assumed to follow the vector auto-regressive model

$$\begin{pmatrix} \Delta^d ph_{i,t} \\ \Delta^d rel_{i,t} \\ \Delta^d r_{i,t} \end{pmatrix} = c + \Phi_1 \begin{pmatrix} \Delta^d ph_{i,t-1} \\ \Delta^d rel_{i,t-1} \\ \Delta^d r_{i,t-1} \end{pmatrix} + ... + \Phi_l \begin{pmatrix} \Delta^d ph_{i,t-l} \\ \Delta^d rel_{i,t-l} \\ \Delta^d r_{i,t-l} \end{pmatrix} + \varepsilon_{i,t},$$

where c is a constant vector, l is the number of lags, $\Phi_1 ... \Phi_l$ are constant real matrices, $\varepsilon_{i,t}$ is a vector with the shocks, $r_{i,t}$ is the return of the ten year treasury bonds.

The change on the relative prices of structure and land is included to see how customization affects the house prices. The interest rates' change translates the opportunity cost of investing in housing instead of treasuries. The choice of the 10 year bonds was based on the fact that mortage rates are fixed income instruments with long duration. I decided to be parsimonious and chose the number of lags to be 1.

The series of future house prices expectations was generated based on the above VAR and ranges from the first quarter of 2005 to the last quarter of 2008. The forecasts were calculate separately for each state. For each date the VAR parameters were estimated from the first quarter of 1996 to the current date. Then they were used to calculate $\mathbb{E}_t[\Delta^d ph_{i,t+d}]$.

	$\|\Delta^4 relup_{i,t}\|$	$\|\Delta^8 relup_{i,t}\|$	$\|\Delta^{12} relup_{i,t}\|$	$\|\Delta^{16} relup_{i,t}\|$
$\|\Delta^4 relup_{i,t}\|$	1	.	.	.
$\|\Delta^8 relup_{i,t}\|$	0.95	1	.	.
$\|\Delta^{12} relup_{i,t}\|$	0.90	0.97	1	.
$\|\Delta^{16} relup_{i,t}\|$	0.86	0.93	0.98	1

Table 9: Correlation matrix of $|\Delta^d relup_{i,t}|$

	$\|\Delta^4 reldown_{i,t}\|$	$\|\Delta^8 reldown_{i,t}\|$	$\|\Delta^{12} reldown_{i,t}\|$	$\|\Delta^{16} reldown_{i,t}\|$
$\|\Delta^4 reldown_{i,t}\|$	1	.	.	.
$\|\Delta^8 reldown_{i,t}\|$	0.90	1	.	.
$\|\Delta^{12} reldown_{i,t}\|$	0.79	0.92	1	.
$\|\Delta^{16} reldown_{i,t}\|$	0.66	0.81	0.92	1

Table 10: Correlation matrix of $|\Delta^d reldown_{i,t}|$

The Fifth Appendix

This appendix lists some descriptive statistics of the explanatory variables used for the regression analysis.

Note that $\Delta^d x_{i,t} = x_{i,t} - x_{i,t-d}$. Since the data is quarterly, Δ^4, Δ^8, Δ^{12} and Δ^{16} refer to the differences between today's value of the variable and its value 1 year ago, 2 years ago, 3 years ago and 4 years ago respectively.

	$fico_{i,t}$	$fico_{i,t-4}$	$fico_{i,t-12}$	$fico_{i,t-16}$
$fico_{i,t}$	1	.	.	.
$fico_{i,t-4}$	0.98	1	.	.
$fico_{i,t-12}$	0.95	0.95	1	.
$fico_{i,t-16}$	0.92	0.98	0.93	1

Table 11: Correlation matrix of $fico_{i,t}$

	$\mathbb{E}_t[\Delta^4 ph_{i,t+4}]$	$\mathbb{E}_t[\Delta^8 ph_{i,t+8}]$	$\mathbb{E}_t[\Delta^{12} ph_{i,t+12}]$	$\mathbb{E}_t[\Delta^{16} ph_{i,t+16}]$
$\mathbb{E}_t[\Delta^4 ph_{i,t+4}]$	1	.	.	.
$\mathbb{E}_t[\Delta^8 ph_{i,t+8}]$	0.904	1	.	.
$\mathbb{E}_t[\Delta^{12} ph_{i,t+12}]$	0.763	0.947	1	.
$\mathbb{E}_t[\Delta^{16} ph_{i,t+16}]$	0.675	0.896	0.955	1

Table 12: Correlation matrix of $E_t[\Delta^d ph_{i,t+d}]$

$\Delta^4 ph_{i,t}$	0.054
$\Delta^8 ph_{i,t}$	0.099
$\Delta^{12} ph_{i,t}$	0.134
$\Delta^{16} ph_{i,t}$	0.162

Table 13: Standard deviations of $\Delta^d ph_{i,t}$

$\|\Delta^4 relup_{i,t}\|$	0.120
$\|\Delta^8 relup_{i,t}\|$	0.190
$\|\Delta^{12} relup_{i,t}\|$	0.241
$\|\Delta^{16} relup_{i,t}\|$	0.266

Table 14: Standard deviations of $|\Delta^d relup_{i,t}|$

$\|\Delta^4 reldown_{i,t}\|$	0.079
$\|\Delta^8 reldown_{i,t}\|$	0.275
$\|\Delta^{12} reldown_{i,t}\|$	0.539
$\|\Delta^{16} reldown_{i,t}\|$	0.833

Table 15: Standard deviations of $|\Delta^d reldown_{i,t}|$

$fico_{i,t}$	0.025
$unem_{i,t}$	0.34
$lv_{i,t}$	0.36

Table 16: Standard deviations of $fico_{i,t}$, $unem_{i,t}$ and $lv_{i,t}$

$\mathbb{E}_t[\Delta^4 ph_{i,t+4}]$	0.031
$\mathbb{E}_t[\Delta^8 ph_{i,t+8}]$	0.100
$\mathbb{E}_t[\Delta^{12} ph_{i,t+12}]$	0.291
$\mathbb{E}_t[\Delta^{16} ph_{i,t+16}]$	0.714

Table 17: Standard deviations of $E_t[\Delta^d ph_{i,t+d}]$

References

[1] Campbell, J. Y. ; Cocco, J. F., 2003, "Household Risk Management and Optimal Mortgage Choice", The Quarterly Journal of Economics, Vol. 118, No. 4 , pp. 1449-1494

[2] Cocco, J. F., 2004, "Portfolio Choice in the Presence of Housing", The Review of Financial Studies Vol. 18, No. 2 pp 535-567

[3] Cocco, J. F.; Gomes, F. J.; Maenhout, P. J., 2005, "Consumption and Portfolio Choice over the Life Cycle", The Review of Financial Studies Vol. 18, No. 2, pp. 491-533

[4] Damgaard, A.; Fuglsbjerg, B.; Munk, C., 2003, "Optimal Consumption and Investment Strategies with a Perishable and an Indivisible Durable Consumption Good", Journal of Economic Dynamics and Control, 28, 209–253.

[5] Davis, M.; Heathcote, J., 2007, "The price and quantity of residential land in the United States", Journal of Monetary Economics 54, pp. 2595–2620

[6] Dynan, K. E.; Skinner, J.; Zeldes, S. P., 2002, "The Importance of Bequests and Life-Cycle Saving in Capital Accumulation: A New Answer", The American Economic Review, Vol. 92, No. 2, pp 274-278

[7] Foote, C. L.; Gerardi, K.;Willen , P. S., 2008, "Negative equity and foreclosure: Theory and evidence", Journal of Urban Economics 64, pp. 234–245.

[8] Grossman, S. J.; Laroque, G., 1990, "Asset Pricing and Optimal Portfolio Choice in the Presence of Illiquid Durable Consumption Goods", Econometrica, 58, 25–51.

[9] Guiso, L.; Sapienza, P.; Zingales, L., 2009, "Moral and Social Constraints to Strategic Default on Mortgages"

[10] Himmelberg, C.; Mayer, C.; Sinai, T., 2005, "Assessing High House Prices: Bubbles, Fundamentals, and Misperceptions", Federal Reserve Bank of New York Staff Reports, no. 218

[11] Hurst, E.; Stafford, F. , 2002, "Home is Where the Equity Is: Mortgage Refinancing and Household Consumption"

[12] Kau, J.; Keenan, D.; Kim, T., 1994, "Default probabilities for mortgages", Journal of Urban Economics 35, pp. 278–296.

[13] Portov, B. A.; Odish, Y.; Fleishman, L., 2005, "Factors Affecting Housing Modifications and Housing Pricing: A Case Study of Four Residential Neighborhoods in Haifa, Israel", J R E R Vol. 17 Number 4

[14] Sinai, T; Souleles, N., 2005, "Owner-occupied Housing as a Hedge Against Rent Risk", Quarterly Journal of Economics

[15] Thorsnes, P., 1997, "Consistent estimates of the elasticity of substitution between land and non-land inputs in the production of housing", Journal of Urban Economics 42, 98–108.

[16] Yao, R.; Zhang, H., 2004, "Optimal Consumption and Portfolio Choices with Risky Housing and Borrowing Constraints", The Review of Financial Studies Vol. 18, No. 1 pp 197-239.

[17] Yao, R.; Zhang, H., 2006, "Optimal Life-Cycle Asset allocation with Housing as a Collateral," working paper