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**Foreclosure Delay and U.S. Unemployment**

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# Foreclosure Delay and U.S. Unemployment\*

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## Abstract

Through a purely *positive* lens, we study and document the growing trend of mortgagors who skip mortgage payments as an extra source of “informal” unemployment insurance during the 2007 recession and the subsequent recovery. In a dynamic model, we capture this behavior by treating both delinquency and foreclosure not as one period events, but rather as protracted and potentially reversible episodes that influence job search behavior and wage acceptance decisions. With a relatively conservative parameterization, we find that the observed foreclosure delays increase the unemployment rate by an additional  $\frac{1}{3}\%$ - $\frac{1}{2}\%$  and increase the stock of delinquent loans by 8%-12%. When interpreted as an implicit line of credit, those that use their mortgage as “informal” unemployment insurance borrow at a real rate of at least 18%.

## 1 Introduction

A number of economists have suggested that chronically high unemployment may be related to the large drop in housing prices; Ohanian and Raffo (2011) document a strong relationship between labor market slumps and housing busts across OECD countries, with the highest

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unemployment and largest labor market wedges in countries with the largest declines in home prices (the U.S., Spain, and Ireland). The unique aspect of this episode is the sheer number of unemployed US mortgagors. With roughly 90 million mortgage accounts, a record 6% of mortgages ( $\approx 6\text{mm}$ ) are held by unemployed persons, which is shown in Figure 1

Figure 1: Fraction of Mortgages Held by Unemployed, 2009 PSID Supplement, Weighted, Heads of House (Source: PSID)

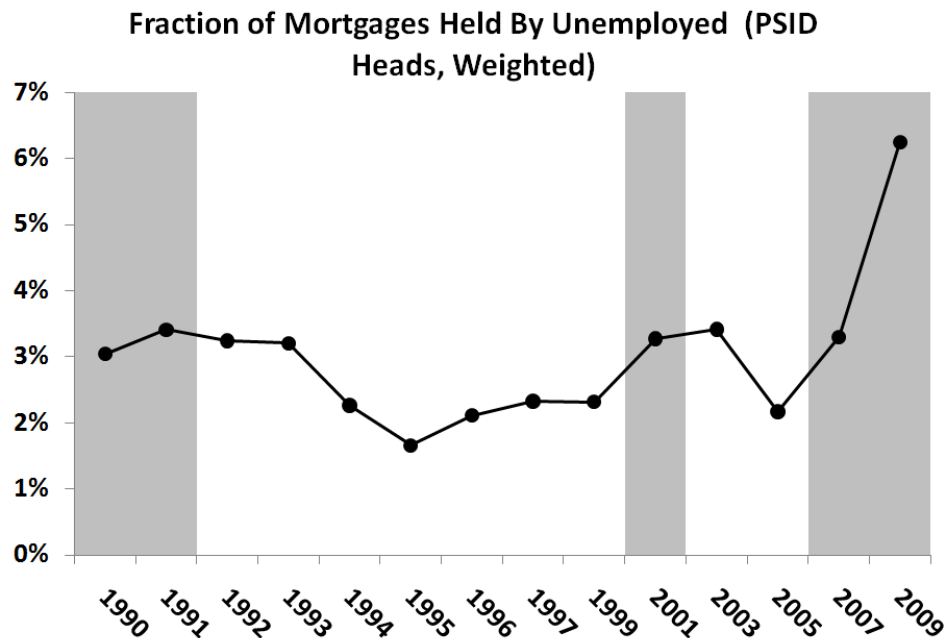
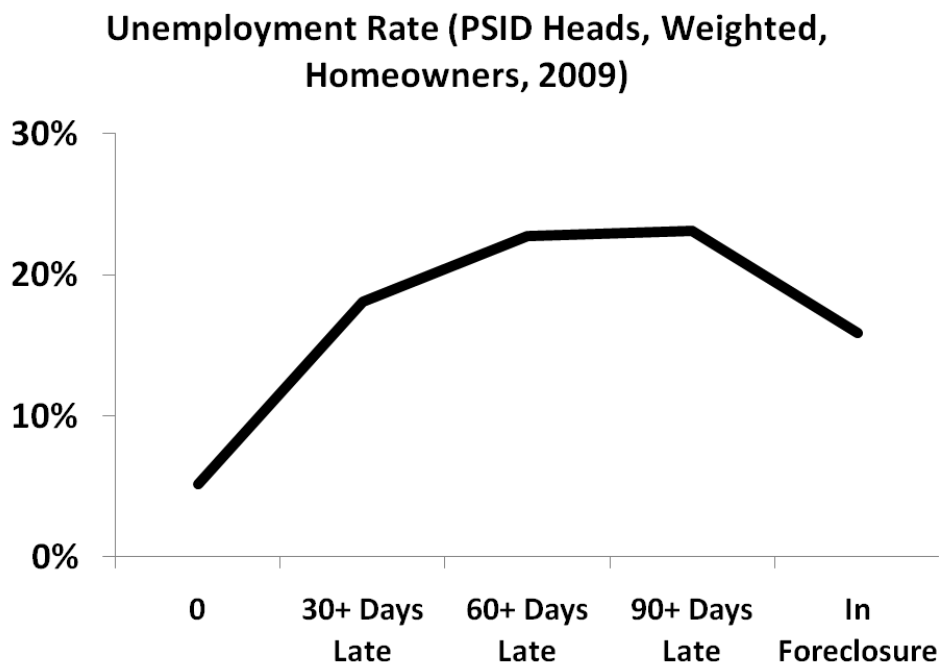


Table 1: Unemployment Rates and Unemployment Durations Among Renters/Homeowners/Delinquent Borrowers, 2009 PSID Supplement, Weighted, Heads of House (Source: PSID)

	All PSID Heads	Renters	Homeowners	30+ Days Late	60+ Days Late	90+ Days Late	In Foreclosure
Unemployment Rate	7.7%	9.5%	5.2%	18.1%	22.8%	23.2%	15.9%
Unemployment Duration	1.9	2.1	1.3	2.1	2.7	4.2	4.7

Figure 2: Unemployment Rate by Delinquency Status, 2009 PSID Supplement, Weighted, Heads of House (Source: PSID)



In a series of papers, Mulligan (2009a, 2009b, 2009c) suggests that various government housing policies, including mortgage modifications, have increased unemployment by distorting incentives to find and accept jobs. This paper analyzes the impact of foreclosure delay on unemployment. We study foreclosure delay because time to foreclosure has increased enormously since the start of the 2008-09 recession, rising from about 3 months in the early 2000s to a median time to foreclose of around 15 months today. We develop a model economy in which this large increase changes the incentive to search and accept jobs because foreclosure delay provides an implicit loan from the lender to the mortgagor which allows the mortgagor to smooth consumption and changes the opportunity cost of searching. More specifically, mortgagors will more likely choose to miss payments if the probability of foreclosure is very low, and if they can self-cure before foreclosure is imminent.

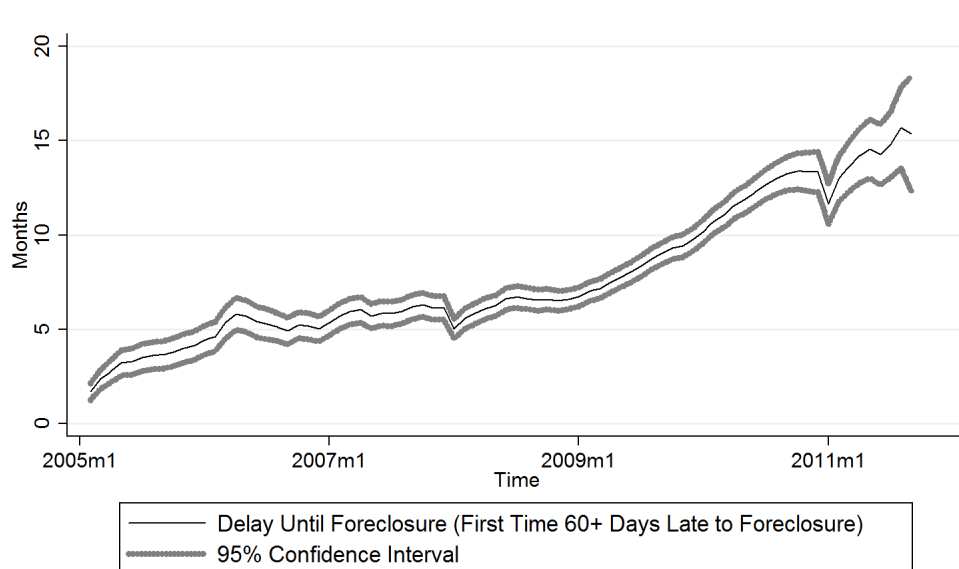
Table 1 further probes the relationship between the housing bust and unemployment, revealing that the unemployment rate amongst defaulters is 2 to 3 times the unemployment rate of the population, and the unemployment duration is particularly protracted for those in foreclosure.<sup>1</sup> Figure 2 graphically depicts the data in Table 1. The peculiar hump shape

<sup>1</sup>The PSID borrowers are well behaved, however. The delinquency rate in the PSID data is an order of magnitude smaller than that observed in a nationally representative LPS sample. This leads us to believe that the numbers stated in the table are smaller than reality. Their durations of unemployment are much

of the unemployment rate by delinquency status highlights the incentive mechanism in our model. This non-monotonicity, we will argue, has to do with the incentives to search for and subsequently accept job offers as foreclosure becomes more likely.

While the obvious implication of these pictures is that job loss causes default and foreclosure, the tougher question of how the institutional structure governing delinquent contracts affects labor supply decisions is relatively unexplored.<sup>2</sup> We argue that long foreclosure delays, as depicted in Figures 3 and 4, allow households to indefinitely skip mortgage payments when they lose their job in order to self-insure. Figure 3 shows the average time spent in delinquency until foreclosure notice is given, and Figure 4 illustrates time spent in foreclosure across the nation.<sup>3</sup> An equivalent way of interpreting this observation is that a household which consecutively skips payments is drawing on an unsolicited and undocumented *line of credit* from the servicing bank.

Figure 3: Delay from first time 60+ days late until foreclosure notice is issued (Source: LPS Loans Originated After 2004)

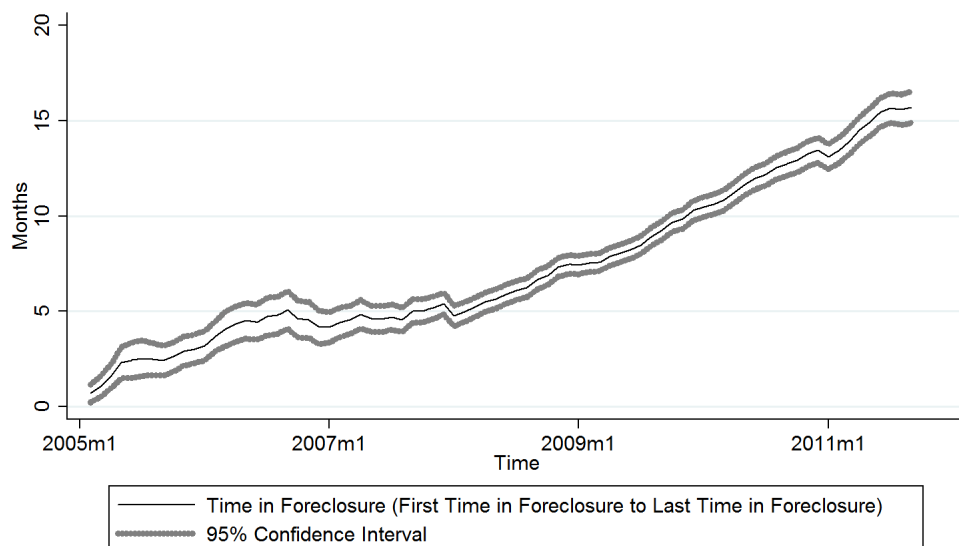


smaller, however one must remember that this is amongst *household heads*.

<sup>2</sup>See Mulligan (2009a, 2009b, 2009c) for labor supply decisions and mortgage modifications. For direct evidence that job loss causes default see Herkenhoff (2012).

<sup>3</sup>Delinquency episodes are the first time a person is 60+ days late until the last time the person is late, and foreclosure is the first time a foreclosure status is observed in the data until the last time a foreclosure state is observed. Both pictures are based on loans originated after 2004 for which foreclosure was eventually initiated. The data is explained in more detail in Appendix A, and in the next section we address the issue of censoring (i.e., since all spells must end at the last observation date regardless if they will continue for many more months, this latter observations are understating the true state of affairs). See Capozza and Thomson (2006) for a discussion of subprime foreclosure delays.

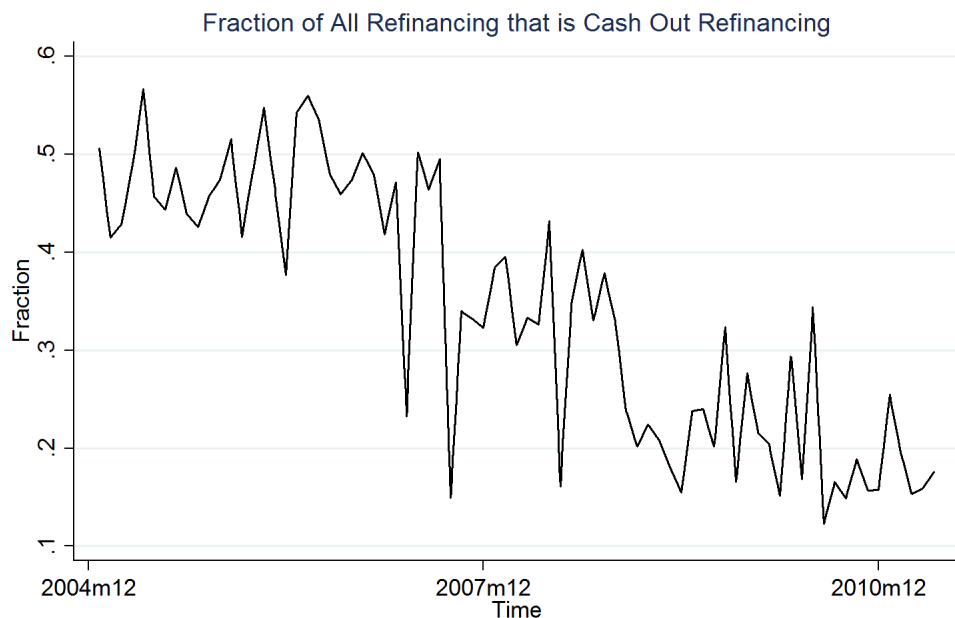
Figure 4: Time spent in foreclosure (Source: LPS Loans Originated After 2004)



We conduct a similar analysis as Hurst and Stafford (2002) who document the way unemployed persons use “cash-out” refinancing to smooth consumption when they have positive home equity, except we turn the focus on the increasingly relevant role of *prolonged default* for unemployed agents with negative equity (“underwater”) attempting to maintain their standard of living.<sup>4</sup> With the rise of underwater mortgagors, traditional “cash-out” refinancing is no longer an option as illustrated in Figure 5; instead, given the long foreclosure delays in many states, many turn to a new technology to smooth consumption, prolonged default. As observed in recent data with abnormally long foreclosure delays, many people enter deep into default without ever losing their homes; the delinquency and subsequent repayment mimic an undocumented line of credit provided by the servicing bank. Because households who are using prolonged default to smooth consumption face the risk of eviction as well as the burden of late fees which are compounded at rates as high as 5% per month, the real rate of interest on this line of credit is at least 18%. To properly tackle the question of how access to this new self-insurance technology changes job search and acceptance behavior, we structurally model the feedback loop between home mortgages and labor markets in a decision theoretic framework with realistic mortgage default decisions and endogenous search effort and reservation wage profiles. The purely *positive* goal is to disentangle the way unemployment affects long delinquency spells and, conversely, the way long delinquency spells affect subsequent labor supply decisions. This analysis contributes significantly to

<sup>4</sup>“Cash-out” refinancing refers to the process of obtaining a larger loan than the original loan, paying off the original loan and pocketing the difference. This is only feasible if there is equity in the home, which means the price is greater than the amount owed on the mortgage.

Figure 5: Refinancing Composition (Source: LPS)



our understanding of the way households self-insure and how this affects subsequent labor market outcomes.

The paper is organized as follows: Section 2 discusses the way default and foreclosure are carried out, Section 3 documents homeowner delinquency transitions and the recent rise in foreclosure delays, Section 4 describes the model, Section 5 outlines the parametrization of the model, Section 6 includes the main turbulence experiment, and Section 7 concludes.

Appendix A includes the data description, Appendix B has some details on the parametrization, Appendix C includes empirical work designed to quantify the incentive effects of the delays and sort out the role of congestion versus policy induced delays, Appendix D includes the literature review.

## 2 Institutional Details of Delinquency

This section provides background information on the way mortgage default and foreclosure typically work. It is important to note that there is considerable variability across servicers and states as to how they handle foreclosure.

## 2.1 Interest on Missed Payments

Mortgage payments are usually due on the first of the month, and a late fee is assessed if the payment is not received within the first two weeks of the month. The late fee is a fraction of the payment amount. If the scheduled payment is \$1000 and the late fee is 3%, then the mortgagor must pay \$1030 in the following month. Most late fee interest rates fall in the range of 3% to 6% (see Goodman (2010)).

## 2.2 Foreclosure Process

The order of events in a foreclosure has potential to distort buyers' incentives to pay since foreclosure is a slow and relatively predictable process. The usual order of events is given below:

1. Miss payments (30+ days late)
2. Notice of Default (Enter Delinquency which is the same as Default)
3. Notice of Sale which is also called a Foreclosure Notice (Enter Foreclosure)
4. Foreclosure Auction (Sheriff Sale)
5. Eviction
6. *Potential* Deficiency Judgment if Sale Price < Remaining Mortgage Balance
7. Ineligible for government backed loans for 7 years (see Lowrey (2010)).

Legally, if a mortgagor breaks the terms of the mortgage, the bank can ask for the entire debt to be paid immediately. If the mortgagor cannot pay this entire amount, the bank can foreclose. There are two main types of foreclosures in the United States (i) judicial, and (ii) non-judicial (half of the states are non-judicial, including California). A judicial foreclosure is long and complicated. The bank that owns the mortgage must sue the person living in the home in a state court. A judge is required to rule on the case before a foreclosure sale can occur. A foreclosure sale is called a 'sheriff sale.' A non-judicial foreclosure, also known as a foreclosure by power of sale, allows the bank to sell the house without the court's approval. A notice of default is given to the person who defaulted on their payments. This explains that the bank intends to sell the property and that if the debt is not cured, there will be a public auction for the house. If the bank is unable to sell the home in a public auction, which means 'no acceptable bids are made,' the house becomes owned by the bank. The term for this is 'real estate owned' (REO).

It is possible to postpone the foreclosure process by bankruptcy (however the courts cannot modify loans) or challenging the banks' right to the property they are trying to



foreclose (see Li and White (2010)). The recent robo-signing scandal has to do with the banks’ inability to prove that they had the right of interest in the property, i.e. they do not have the correct paperwork showing that they have a mortgage on the property.

Regardless of the foreclosure procedure, each state has laws about recourse and non-recourse loans. In a state with recourse, selling a home for less than the amount due may result in a deficiency judgment. Deficiency judgments mandate the the borrower pay the difference between the sale price and the amount owed on the mortgage. Many mortgages however are non-recourse loans, meaning that the bank cannot go after the assets of the person who held the mortgage. As a result, in most cases, borrowers are exempt from deficiency judgments. In California, for instance, the first purchase-money mortgage for a residential property is a non-recourse loan (however, a little known fact is that all refinanced loans are recourse in California which makes for a nice natural experiment to test the effects of recourse status on mortgagor behavior).

There is also a chance for homeowners to ‘redeem’ their homes after foreclosure if they are able to raise enough money. These redemption periods can last up to a year and vary by state.

### 3 Default $\neq$ Foreclosure

In most standard models with limited commitment and housing, default is synonymous with leaving the home (see Garriga and Schlagenhauf (2009), Corbae and Quintin (2010), and Chatterjee and Eyigungor (2009)). This assumption makes it difficult to match the actual default rates observed in the real world.<sup>5</sup> Our earlier work found that delays played an important role in labor market outcomes through the *relocation channel*. As Herkenhoff and Ohanian (2011) find in a search economy and Chatterjee and Eyigungor (2011) find in an endowment economy, a small delay with free rent can dramatically change incentives to skip payments. On the empirical side, it is well established that default episodes are protracted and often times do not result in foreclosure (see Danis and Pennington-Cross (2010) for subprime mortgages). To our knowledge, we are the first to model the “ins” and subsequent “outs” of mortgage delinquency in a dynamic model optimization model with mortgages and labor markets.

Table 6 is a transition matrix for all possible mortgagor delinquency states. The rows are the beginning states, and the columns are the ending states. The period is 1-month, and the table includes two sets of entries: the black entries refer to the transition matrix calculated from 2009-2011 data, and the red underlined entries are for the 2001-2003 data. Table 6 succinctly establishes several stylized facts:<sup>6</sup>

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<sup>5</sup>Several authors use 2-4 year periods to make the discount rate small enough to generate default

<sup>6</sup>This is a transition matrix, so in order to read this table, the rows are the starting state at the beginning of the month and the columns are the possible states next month. For instance, in a given month the

1. [i.]
2. Default/Delinquency is often temporary, with high probabilities of transition to current or closer to being current (default is the period of time before the foreclosure notice is delivered)
3. Foreclosure is often temporary, with high probabilities of transition to current or closer to being current (foreclosure is the time between the foreclosure notice being delivered and eviction)
4. Entry into foreclosure is a slow process, most sit in the 90+ days late category for several months.
5. Conditional on reaching foreclosure, households spent significant portions of time in foreclosure.
6. The probability of remaining 90+ days late increased significantly (from 68.4% in 2001-2003 to 83.0% in 2009-2011)
7. The probability of remaining in foreclosure increased significantly (from 75.2% in 2001-2003 to 88.3% in 2009-2011)
8. The self cure probabilities fell across the board between 2001-2003 and 2009-2011 (the lower triangular entries).

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probability of moving from being current to 30 days late is 1.7% during the 2009-2011 period. See Appendix B for the strategy use to identify the modifications.

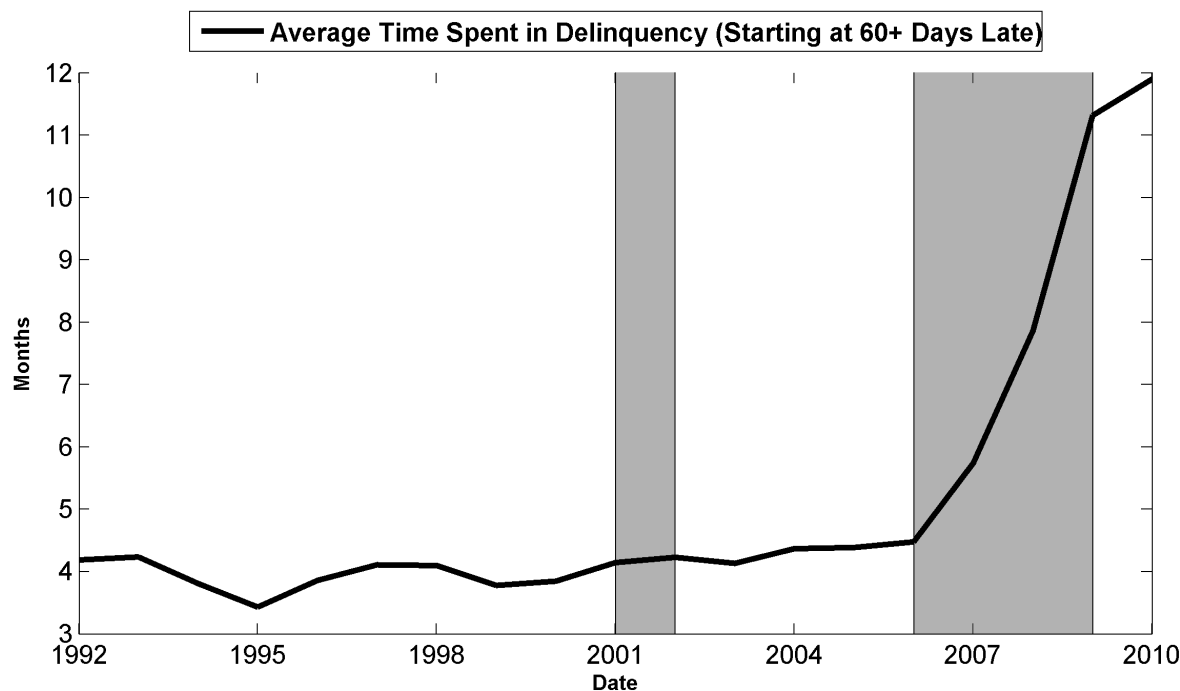
Figure 6: Homeowner Transitions 2009-2011 (Black) Homeowner Transitions 2001-2003 (Red and Underlined) (Source: LPS)

	Current	30 Days Late	60 Days Late	90+ Days Late	In Foreclosure	REO	Paid Off	Liquidated	Modified
Current	96.0	1.5	0.0	0.0	0.0	0.0	2.5	0.0	0.0
30 Days Late	41.2	38.7	15.9	0.4	0.0	0.0	3.8	0.0	0.0
60 Days Late	18.7	21.0	24.7	30.4	2.6	0.0	2.5	0.0	0.0
90+ Days Late	7.1	3.4	4.7	68.4	14.6	0.5	1.3	0.1	0.0
In Foreclosure	5.3	1.1	0.1	7.8	75.2	8.3	2.0	0.4	0.0
REO	0.0	0.1	0.0	0.8	0.6	87.3	0.1	11.1	0.0
Paid Off	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Liquidated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Modified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

### 3.1 Time Spent in Default

To handle the censoring issue in the data, we calculate the mortgage status transition matrix for each year. We then simulate the ‘ergodic distribution’ for this matrix using Monte Carlo simulation with several thousand mortgages over 35 years. Using this measure, the average time spent in default, regardless of termination type, went from roughly 4 months up to 12 months. Figure 7 shows this change with the business cycles shaded along the axis. In the next section we talk about whether or not this is a policy related delay, and this will guide the experiment below.

Figure 7: Delinquency Spells, Monte Carlo Simulations Based on LPS Transitions (Source: LPS and Author’s Calculations)



## 4 Search Model with “Ins” and “Outs” of Default

### 4.1 Overview of the Model

The model treats both delinquency and foreclosure not as one period events, but as protracted and potentially reversible episodes that influence job search behavior. It is of the same general type explored in our earlier paper, Herkenhoff and Ohanian (2011), where mortgage default does not necessarily lead to eviction. In the model below, agents are given three choices: (i) to pay their mortgage (ii) to skip payments, or (iii) to sell the house. As the time in default increases, the likelihood of eviction increases.

Agents are given access to a riskless savings technology, but for those with limited savings, agents choose to default because it is the best available technology to smooth their consumption. The typical trigger for default is unemployment or reduced wages. Aside from the initial mortgage endowment, agents are not allowed to borrow to smooth consumption. We lump credit card debt service payments into the model’s fixed mortgage payment in our parameterization, but we do note that credit card debt outstanding is 1/11th of mortgage debt outstanding and is a relatively small share of household debt. The inability to readily obtain new unsecured lines of credit is also consistent with the standard credit crunch hypotheses.<sup>7</sup> While we do not model bankruptcy, the work done by Li and White (2010) suggests that after the 2005 bankruptcy reform, households substituted away from bankruptcy into default and foreclosure.<sup>8</sup> Figure 8 documents the fact that while bankruptcies are important, they are a relatively small pandemic compared to a generic measure of delinquencies, defined by those who have skipped one or more payments.

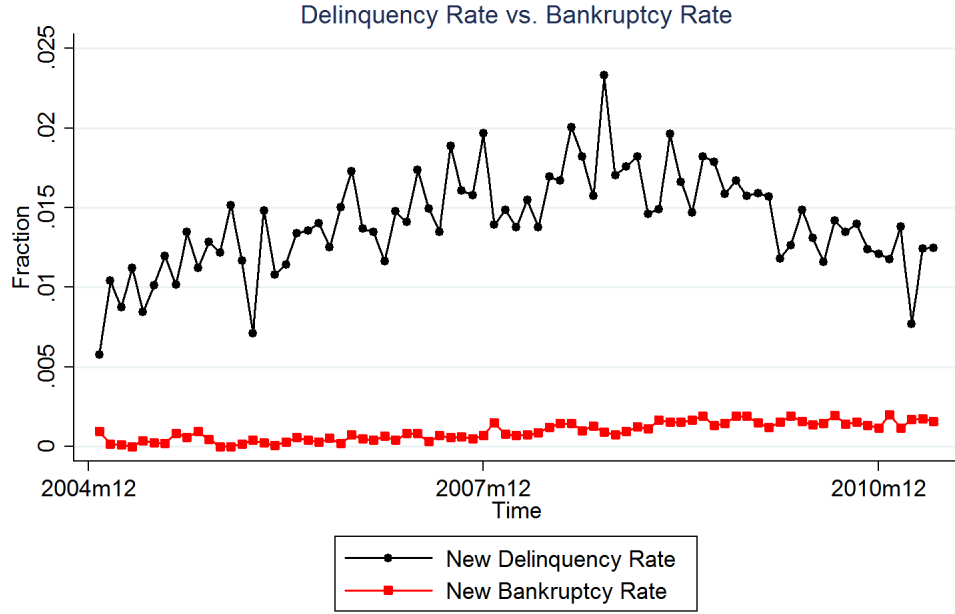
In the labor market, agents are subject to exogenous separation shocks, at which point they receive half their previous wage as an unemployment benefit. Searching for a job is costly in terms of utility, but this directly affects the probability of finding a job. Job offers are drawn from a known stationary distribution, and agents are free to turn down offers. While on the job, wages evolve stochastically, which is meant to capture wage gains from on the job search and other types of job to job transitions. The unique feature of this model is that over the course of the mortgage default episode the reservation wage and search effort of an agent change nontrivially- so much so that in some cases agents will accept any job in order to repay the amount owed the bank and in other cases agents default after turning down feasible wages. Initially, when the agent defaults, the probability of foreclosure is low so the agent economizes on search effort and turns down relatively good wage draws; in the later stage of default, eviction is imminent, and so the agent searches intensely trying to find any wage that may eventually pay the mortgage bill.

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<sup>7</sup>Mian and Sufi (2011) use Equifax data to study these regional credit crunches

<sup>8</sup>In general, they find that default and foreclosure predict bankruptcy, and vice versa. They are unable to isolate causation, but they do plot similar graphs to us that show bankruptcy applies to a small fraction of delinquent households.

Figure 8: Delinquency and Bankruptcy Rates (Source: LPS)



We run an experiment in which we follow the economy for 2 years after there is a decline in house prices and a concurrent layoff shock. We feed this same “turbulence” into two economies with varying institutional structures; one economy has a typical 3 month foreclosure delay and the other has a prolonged 12 month delay. We find that the unemployment rate increases by  $\frac{1}{3}\%$ - $\frac{1}{2}\%$  for roughly one year and that the default rate is increased by 8%-12% over the same time period.

## 4.2 Details of the Model

Consider a mortgagor that makes homeownership decisions, saving decisions, and must search for employment. Agents can save assets ( $a \geq 0$ ) to help smooth consumption at a risk free rate of  $\bar{r}$ , but they do not have access to unsecured lines of credit. Similar to Ljungqvist and Sargent’s search models (1998, 2007a, 2007b), while unemployed, agents search for a job with intensity ( $s$ ) at a weakly convex disutility ( $x(s)$ ). In the model, ( $\theta$ ) indexes the aggregate state that takes on two values, high ( $\theta_H$ ) and low ( $\theta_L$ ), and follows a 2 state Markov process. In good times the job finding probability  $\pi(s, \theta)$ , which is concave in  $s$ , improves ( $\pi(s, \theta_H) > \pi(s, \theta_L)$ ). If the agent finds a job, the wage offer is drawn from a stationary distribution  $F(w)$ . The agent is free to turn down the offer which gives rise to a reservation wage profile  $w^*(x)$ , where  $x$  is the vector state space of the agent. While

employed, there is an aggregate state contingent risk of being laid-off  $\delta(\theta)$ , such that in good times the probability of being laid off is lower than in bad times ( $\delta(\theta_H) < \delta(\theta_L)$ ). There are wage changes once employed which may be creatively interpreted as on-the-job search or skill accumulation in the case of a wage increase. In all cases considered below, the wage is weakly increasing in expectation,  $E(w' | w) \geq w$ .

To keep the model simple, mortgages are perpetuities and a fraction of agents are endowed with a mortgage upon entering the world. Mortgages have a constant required payment ( $c_h$ ) denoted in units of consumption, and the house price ( $p(\theta)$ ) parametrically depends on the aggregate state such that ( $p(\theta_L) < p(\theta_H)$ ). We will always assume that in good times, a homeowner can break even ( $p(\theta_H) = \frac{c_h}{r_b}$ ), where  $r_b$  is the interest rate the bank charges on loans. In bad times, the homeowner is weakly underwater ( $p(\theta_L) \leq \frac{c_h}{r_b}$ ) (see the parameterization section for more on this).

The typical mortgagor has 3 choices: (i) make payment (ii) skip payment, or (iii) sell the house. In the event of a low wage draw or unemployment shock, the mortgagor may default to smooth consumption. In this world, since default is not synonymous with eviction, households may enter and exit default as they like; however, the time spent in default ( $n$ ) increases the odds of eviction and liquidation of the house (see Figure 10 for an example of the foreclosure probability). For those who default, there is a one-time utility cost of initially entering default ( $\Delta$ ) equal to one month's utility of housing.

**[Note the modification probability ( $\lambda_m$ ) is set to zero in the experiments below]** While in default agents may qualify for a modification with probability  $\lambda_M(w, n)$ . In this context, a modification is an agreement between a bank and mortgagor to forgive the late fees and resume the normal scheduled payments. This probability depends on the wage of an agent, i.e. it must be the case that the mortgage payment to income ratio is large ( $\frac{c_h}{w} > .38$ ) as in the Home Affordable Modification Program guidelines. The probability of modification is non-monotone in  $n$ , peaking at 60 days late ( $n = 2$ ).

It is possible to stop foreclosure by paying twice, and to simplify the matter, the homeowner must pay the *two longest outstanding mortgage payments with interest* ( $(1+r_b)^{n-1}c_h + (1+r_b)^n c_h$ ), where  $r_b$  is the interest rate banks charge on late payments. This payment behavior is consistent with the transitions observed in Figure 6, where homeowners slowly transit out of delinquency, rather than curing entirely at once. Likewise, the fact that starting to self-cure stops the foreclosure process is consistent with anecdotal evidence about banks' preference to collect late fees (see Thompson 2010). In order for a homeowner to become completely current, the bank assesses a fixed late fee ( $LF$ ).

We will always assume that the mortgage payment is strictly greater than the rental payment ( $c_h > c_r$ ), but the utility flow from owning a home strictly dominates the utility flow from renting ( $z_h > z_r$ ). Rent is set such that the renter with the lowest possible unemployment benefits receives subsistence consumption,  $\bar{c}$ . Table 2 illustrates the state space of the model. It includes a tenure choice in which homeowner can leave their home to rent

( $h$ =homeowner,  $r$ =renter), but once a renter always a renter. It also includes their employment Status (E=employed, U=unemployed), their wage ( $w$ ) or benefit ( $b$ ) if unemployed, their assets ( $a$ ), their mortgage status ( $g$ =good standing,  $d$ =default [redundant]), the number of missed payments ( $n$ ), and the aggregate state ( $\theta$ ). Figure 9 explains what each of the subscripts and letters means in a typical value function. Table 3 details all of the value functions used in the paper. The leading letter  $V$  is used to denote option values; i.e.  $VE$  is the option value for an employed person  $E$  who gets to choose between defaulting, paying, or selling the house (this will be explained again below). In the text surrounding each value function below, there is a detailed explanation of what the equation is referring to.

Table 2: Typical State Space

E or U	g or d	h or r	w or b	a	n	$\theta$
Employed/ Un-employed	Current/ Defaulting [Redundant]	Homeowner/ Renter	Wages/ Benefits	Assets	Periods in Default	Aggregate State

Figure 9: Notation Explanation

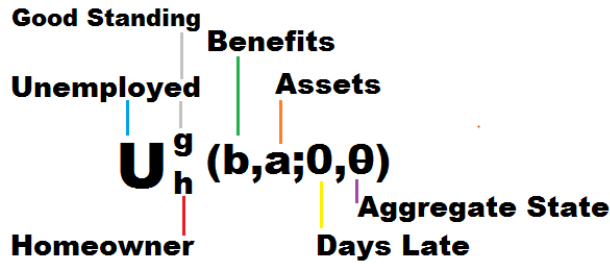




Table 3: Value Functions

Employed Decisions			
Value tion	Func-	Description	Choices
$VE_h^g$		Employed, Good Standing Homeowner Decision	Continue to Pay ( $E_h^g$ ), Default ( $E_g^d$ ), Sell ( $E_h^s$ )
$VE_h^d$		Employed, Bad Standing Homeowner (Defaulted)	Make 2 Payments ( $E_h^p$ ), Continue in Default ( $E_g^d$ ), Sell ( $E_h^s$ )
$E_h^r$		Employed, Renter	
Continuous Choice Variables Employed		Assets ( $a$ )	
Unemployed Decisions			
Value tion	Func-	Description	Choices
$VU_h^g$		Unemployed, Good Standing Homeowner Decision	Continue to Pay ( $U_h^g$ ), Default ( $U_g^d$ ), Sell ( $U_h^s$ )
$VU_h^d$		Unemployed, Bad Standing Homeowner (Defaulted)	Make 2 Payments ( $U_h^p$ ), Continue in Default ( $U_g^d$ ), Sell ( $U_h^s$ )
$U_h^r$		Unemployed, Renter	
Continuous Choice Variables Unemployed		Search Intensity ( $s$ ) and Assets ( $a$ )	

### 4.3 Employed Discrete Choices

The option value (i.e. the discrete choice) for an employed homeowner with wage  $w$ , liquid assets  $a$ , current on payments ( $n = 0$ ), and in aggregate state  $\theta$  is  $VE_h^g(w, a; 0, \theta)$  (**In general, if there is a V in front of a value function it involves a discrete choice, e.g.  $VE_h^g(w, a; 0, \theta)$  is the choice for an employed agent and  $E_h^g(w, a; 0, \theta)$  is one particular option**). An employed homeowner that is in good standing has the following set of choices: pay ( $E_h^g(w, a; 0, \theta)$ ), default at a one-time utility cost  $\Delta$  and face the risk of foreclosure ( $E_h^d(w, a; 0, \theta) - \Delta$ ), or sell ( $E_h^s(w, a; 0, \theta)$ ). Taking these options into account, the discrete choice for the employed homeowner is given below:

$$VE_h^g(w, a; 0, \theta) = \max_{Pay, Default, Sell} \{E_h^g(w, a; 0, \theta), E_h^d(w, a; 0, \theta) - \Delta, E_h^s(w, a; 0, \theta)\}$$

When  $n > 1$ , this means that the homeowner has skipped  $n$  payments and owes the lender late fees. The delinquent homeowner faces the choice of paying ( $E_h^p(w, a; n, \theta)$ ), skipping another payment which runs the risk of foreclosure,  $\lambda_F$ , or the possibility of modification,  $\lambda_M$  [**note,  $\lambda_M = 0$  for the reexperiment below**], ( $\lambda_F(n)E_h^f(w, a; n, \theta) + \lambda_M(w, n)E_h^g(w, a; 0, \theta) + (1 - \lambda_F(n) - \lambda_M(w, n))E_h^d(w, a; n, \theta)$ ), or selling the property ( $E_h^s(w, a; n, \theta)$ ):

$$VE_h^d(w, a; n, \theta) = \max_{Pay, Current, Default, Sell} \{E_h^p(w, a; n, \theta), \lambda_F(n)E_h^f(w, a; n, \theta) + \lambda_M(w, n)E_h^g(w, a; 0, \theta) + (1 - \lambda_F(n) - \lambda_M(w, n))E_h^d(w, a; n, \theta), E_h^s(w, a; n, \theta)\}$$

When  $n = 0$ , this means the borrower is current and has no outstanding payments. In this case, the value function for a defaulting homeowner is equivalent to that of a homeowner in good status  $VE_h^d(w, a; 0, \theta) = VE_h^g(w, a; 0, \theta)$  (i.e. a defaulter who has paid back the skipped payments is the same as a person in good standing).

### 4.4 Employed Value Functions

An employed renter with wage  $w$  and liquid assets  $a$  has value function  $E_r(w, a; \theta)$ . Unemployment benefits ( $b(\cdot)$ ) are weakly monotone in the past wage. Below we will allow benefits that go up to half of the mean wage,  $b(w) = \frac{1}{2} \min \{w, \frac{1}{2}(\bar{w} + \underline{w})\}$ . After benefits are initially set they decline stochastically over time in order to mimic the current tier structure of unemployment benefits in the United States.  $\delta(\theta)$  is the job destruction rate and it depends on the current aggregate state.  $z_r$  is the flow utility from renting and  $\hat{\beta}$  is the death adjusted discount factor.  $c_r$  is the rental payment, and  $\bar{r}$  is the return on savings. The renter must pick next period's liquid asset holdings  $a'$ . In case of being laid off, the unemployed renter receives unemployment benefits of  $b(w)$ .

$$E_r(w, a; \theta) = \max_{a'} u(c, z_r) + \hat{\beta}(1 - \delta(\theta))\mathbb{E}[E_r(w', a'; \theta')] + \hat{\beta}\delta(\theta)\mathbb{E}[U_r(b(w), a'; \theta')]$$

Such that

$$c + c_r + a' = w + (1 + \bar{r})a$$

An employed homeowner with wage  $w$ , liquid assets  $a$ , current payments  $n = 0$ , and aggregate state  $\theta$  that pays on time has a value function  $E_h^g(w, a; 0, \theta)$ . The mortgage payment is  $c_h$  consumption units.  $z_h$  is the flow utility from living in the house, and  $\delta(\theta)$  is the aggregate state contingent job destruction probability.

$$E_h^g(w, a; 0, \theta) = \max_{a'} u(c, z_h) + \widehat{\beta}(1 - \delta(\theta))\mathbb{E}[VE_h^g(w', a'; 0, \theta')] + \delta(\theta)\mathbb{E}[VU_h^g(b(w), a'; 0, \theta')]$$

Such that

$$c + c_h + a' = w + (1 + \bar{r})a$$

An employed homeowner in default ( $n > 0$ ) with wage  $w$  and liquid assets  $a$  that decides to make no payments solves the following problem:

$$E_h^d(w, a; n, \theta) = \max_{a'} u(c, z_h) + \widehat{\beta}(1 - \delta(\theta))\mathbb{E}[VE_h^d(w', a'; n + 1, \theta')] + \delta(\theta)\mathbb{E}[VU_h^d(b(w), a'; n + 1, \theta')]$$

Such that

$$c + 0 + a' = w + (1 + \bar{r})a$$

Notice that the delinquency indicator ticks upwards  $n' = n + 1$  and an unemployed person receives  $b(w)$  in benefits.

An employed homeowner that is in default and begins to pay current ( $E_h^p(w, a; n, \theta)$ ) is not subject to foreclosure. In this case the delinquency ticker moves down  $n' = n - 1$  and if  $n' = 0$ , the borrower is current once again; however, the bank assesses a fixed late fee  $LF$  for any default episode which reflects the additional advancement fees and servicing costs incurred by the bank. The homeowner must pay twice, and to simplify the matter, the homeowner must pay the *two longest outstanding mortgage payments with interest*  $((1 + r_b)^{n-1}c_h + (1 + r_b)^nc_h)$ . The full problem is written below:

$$E_h^p(w, a; n, \theta) = \max_{a'} u(c, z_h) + \widehat{\beta}(1 - \delta(\theta))\mathbb{E}[VE_h^d(w', a'; n - 1, \theta')] + \delta(\theta)\mathbb{E}[VU_h^d(b(w), a'; n - 1, \theta')]$$

Such that

$$c + (1 + r_b)^{n-1}c_h + (1 + r_b)^nc_h + \mathbb{I}(n = 1) \cdot LF + a' = w + (1 + \bar{r})a$$

An employed homeowner that sells has value function ( $E_h^s(w, a; n, \theta)$ ). A seller becomes a renter and must payback all late fees with interest ( $\sum_{i=1}^n (1 + r_b)^i c_h$ ) off of the top of the sale price (see Thompson (2010)); this is an accurate portrayal of the legal structure of delinquent sales.

$$E_h^s(w, a; n, \theta) = \max_{a'} u(c, z_h) + \widehat{\beta}(1 - \delta(\theta))\mathbb{E}[E_r(w', a'; \theta')] + \widehat{\beta}\delta(\theta)\mathbb{E}[U_r(b(w), a'; \theta')]$$

Such that

$$c + a' = w + (1 + \bar{r})a + S\left(p(\theta) - \frac{c_h}{r_b} - \sum_{i=1}^n (1 + r_b)^i c_h\right)$$

$S(\cdot)$  reflects the recourse status of a state (note this is different from  $G(\cdot)$  to allow for differences between forced sale and voluntary sale). For instance, in a non-recourse state  $S(\cdot) = \max\{0, \cdot\}$  and depends on the institutional details of the state in which the foreclosure occurs.

An employed homeowner that is foreclosed upon solves the following problem:

$$E_h^f(w, a; n, \theta) = \max_{a'} u(c, z_h) + \hat{\beta}(1 - \delta(\theta))\mathbb{E}[E_r(w', a'; \theta')] + \hat{\beta}\delta(\theta)\mathbb{E}[U_r(b(w), a'; \theta')]$$

Such that

$$c + a' = w + (1 + \bar{r})a + G\left(\chi(\theta)p(\theta) - \frac{c_h}{r_b} - \sum_{i=1}^n (1 + r_b)^i c_h\right)$$

As is standard in the literature,  $\chi(\theta) < 1$  is the state contingent discount on the house price  $p(\theta)$  in the event of foreclosure. Once again, late fees ( $\sum_{i=1}^n (1 + r_b)^i c_h$ ) are taken off of the top of the discounted sale price  $\chi(\theta)p(\theta)$ .  $G(\cdot)$  reflects the institutional detail of foreclosure sale/sheriff sale. This is different from  $S(\cdot)$  which illustrates a non-distressed sale.

## 4.5 Unemployed Discrete Choices

The problem of an unemployed agent closely mimics the problem of an employed agent. The main difference is in the search choice  $s$  and subsequent job finding probability  $\pi(s, \theta)$  which depends on the aggregate state  $\theta$ . An unemployed person in good standing has the following choices (pay current, default and incur one-time utility cost  $\Delta$ , or sell):

$$VU_h^g(b, a; 0, \theta) = \max_{Pay, Default, Sell} \{U_h^g(b, a; 0, \theta), U_h^d(b, a; 0, \theta) - \Delta, U_h^s(b, a; 0, \theta)\}$$

When  $n = 0$ , the borrower is current and  $VU_h^d(b, a; 0, \theta) = VU_h^g(b, a; 0, \theta)$  (i.e. a current defaulter is the same as a homeowner in good standing), but for  $n > 1$ , unemployed person in bad standing has the following choices (make two payments and work towards a cure, keep defaulting, or sell):

$$VU_h^d(b, a; n, \theta) = \max_{Pay, Current, Default, Sell} \{U_h^p(b, a; n, \theta), \lambda_F(n)U_h^f(b, a; n, \theta) + \lambda_M(b, n)U_h^g(b, a; 0, \theta) \\ + (1 - \lambda_F(n) - \lambda_M(b, n))U_h^d(b, a; n, \theta), U_h^s(b, a; n, \theta)\}$$

## 4.6 Unemployed Value Functions

An unemployed renter must pick search intensity  $s$  which comes with a weakly convex cost  $x(s)$ . The job finding probability  $\pi(s, \theta)$  is concave which ensures an interior solution to

the search choice.  $b$  is the current unemployment benefit,  $a$  is the liquid asset holding, and  $\hat{w}$  is the wage drawn from  $F(\hat{w})$ . The timing is such that the wage is drawn and then the unemployed renter can choose to accept the offer  $\hat{w}$  or reject the offer and keep benefits  $b'$  (which are stochastically declining).

$$U_r(b, a; \theta) = \max_{a', s} u(c, z_r) - x(s) + \hat{\beta} \mathbb{E} \left[ (1 - \pi(s, \theta')) U_r(b', a'; \theta') \right. \\ \left. + \pi(s, \theta') \int_{\hat{w}} \max \{ E_r(\hat{w}, a'; \theta'), U_r(b', a'; \theta') \} dF(\hat{w}) \right]$$

Such that

$$c + c_r + a' = b + (1 + \bar{r})a$$

The max operator implies a reservation wage for which an agent accepts or rejects a wage  $w_r^*(b, a'; \theta')$  (the star indicates a reservation wage, the subscript indicates the renter status). The upper bound for the support of  $w$  is  $\bar{w}$ :

$$\int_{\hat{w}} \max \{ E_r(\hat{w}, a'; \theta'), U_r(b', a'; \theta') \} dF(\hat{w}) \\ = U_r(b', a'; \theta_r^*(b', a'; \theta')) + \int_{w_r^*(b', a'; \theta')}^{\bar{w}} E_r(\hat{w}, a'; \theta') dF(\hat{w})$$

An unemployed homeowner with benefits  $b$ , liquid assets  $a$ , no late payments ( $n = 0$ ) that pays on time solves the following problem:

$$U_h^g(b, a; 0, \theta) = \max_{a', s} u(c, z_h) - x(s) + \hat{\beta} \mathbb{E} \left[ (1 - \pi(s, \theta')) VU_h^g(b', a'; 0, \theta') \right. \\ \left. + \pi(s, \theta') \int_{\hat{w}} \max \{ VE_h^g(\hat{w}, a'; 0, \theta'), VU_h^g(b', a'; 0, \theta') \} dF(\hat{w}) \right]$$

Such that

$$c + c_h + a' = b + (1 + \bar{r})a$$

An unemployed homeowner that is in default and makes no payments has their default indicator tick up  $n' = n + 1$  and engages in search just like any other agent. A defaulting non-payer solves the following problem:

$$U_h^d(b, a; n, \theta) = \max_{a', s} u(c, z_h) - x(s) + \hat{\beta} \mathbb{E} \left[ (1 - \pi(s, \theta')) VU_h^d(b', a'; n + 1, \theta') \right. \\ \left. + \pi(s, \theta') \int_{\hat{w}} \max \{ VE_h^d(\hat{w}, a'; n + 1, \theta'), VU_h^d(b', a'; n + 1, \theta') \} dF(\hat{w}) \right]$$

Such that

$$c + 0 + a' = b + (1 + \bar{r})a$$

The reservation wage  $w_d^*(b, a'; n+1, \theta')$  is the key function to characterize. The reservation wage is the point at which the value of taking a job during default is just equal to the value of continuing in default unemployed.

$$VE_h^d(w_d^*(b', a'; n+1, \theta'), a'; n+1, \theta') = VU_h^d(b', a'; n+1, \theta')$$

For a given level of assets and benefits, there are several forces at play

- As  $n$  increases, the likelihood of foreclosure goes up equally for any wage below the mortgage payment  $c_h$ .
- As  $n$  increases, the benefit of accepting any wage above  $c_h$  goes up.
- At one extreme, if foreclosure is imminent, any wage above the benefit level is accepted.
- At the other extreme, if foreclosure occurs with an extremely low probability, everyone waits to find a good paying job.

An unemployed homeowner in default that begins to pay current is not subject to foreclosure. As before, the mortgagor must pay the two longest outstanding mortgage payments  $((1+r_b)^{n-1}c_h + (1+r_b)^nc_h)$ . The value function is given below:

$$U_h^p(b, a; n, \theta) = \max_{a', s} u(c, z_h) - x(s) + \widehat{\beta} \mathbb{E} \left[ (1 - \pi(s, \theta')) VU_h^d(b', a'; n-1, \theta') \right. \\ \left. + \pi(s, \theta') \int_{\hat{w}} \max \{ VE_h^g(\hat{w}, a'; n-1, \theta'), VU_h^g(b, a'; n-1, \theta') \} dF(\hat{w}) \right]$$

Such that

$$c + (1+r_b)^{n-1}c_h + (1+r_b)^nc_h + \mathbb{I}(n=1) \cdot LF + a' = b + (1+\bar{r})a$$

An unemployed homeowner that sells solves the following problem:

$$U_h^s(b, a; n, \theta) = \max_{a', s} u(c, z_h) - x(s) + \widehat{\beta} \mathbb{E} \left[ (1 - \pi(s, \theta')) U_r(b', a'; \theta') \right. \\ \left. + \pi(s, \theta') \int_{\hat{w}} \max \{ E_r(\hat{w}, a'; \theta), U_r(b, a'; \theta') \} dF(\hat{w}) \right]$$

Such that

$$c + a' = b + (1+\bar{r})a + S \left( p(\theta) - \frac{c_h}{r_b} - \sum_{i=1}^n (1+r_b)^i c_h \right)$$

As above,  $\chi(\theta)$  is the discount on the house price  $p(\theta)$ , and  $\frac{c_h}{r_b}$  is the remaining balance on the mortgage.  $S(\cdot)$  reflects the recourse status of a state. For instance, in a non-recourse

state  $S(\cdot) = \max\{0, \cdot\}$  and depends on the institutional details of the state in which the foreclosure occurs.

An unemployed homeowner that is foreclosed upon solves the following problem:

$$U_h^f(b, a; n, \theta) = \max_{a', s} u(c, z_h) - x(s) + \widehat{\beta} \mathbb{E} \left[ (1 - \pi(s, \theta')) U_r(b', a'; \theta') \right. \\ \left. + \pi(s, \theta') \int_{\hat{w}} \max \{ E_r(\hat{w}, a'; \theta'), U_r(b, a'; \theta') \} dF(\hat{w}) \right]$$

Such that

$$c + a' = b + (1 + \bar{r})a + G \left( \chi(\theta)p(\theta) - \frac{c_h}{r_b} - \sum_{i=1}^n (1 + r_b)^i c_h \right)$$

As above,  $G(\cdot)$  reflects the institutional details of foreclosure sales. For instance, in a non-recourse state  $G(\cdot) = \max\{0, \cdot\}$ .

## 5 Simple Parameterization

We solved the above model using value function iteration over a discrete grid. The grid for search effort is evenly spaced over the interval  $[0, \frac{1}{2}]$  with 10 nodes. The asset grid is evenly spaced over the interval  $[0, 2]$  with 20 nodes (note that this is restrictive for the highest wage workers, but not for low wage defaulters). Wages are evenly spaced from  $[0, 1]$  with 20 nodes (denote  $\underline{w}$  the lower support and  $\bar{w}$  the upper support).

The wage offer distribution in the model is stationary and normal,  $F(w) \sim N(\frac{\bar{w} + \underline{w}}{2}, .1)$ , which is the same distribution used in Ljungqvist and Sargent (1998). Once employed, wages are stochastic; since we assume the flow utility from housing is constant, this wage process in combination with layoff shocks will generate default. Just like in Ljungqvist and Sargent, wages are persistent and workers move up a wage ladder in expectation. We capture this by creating a wage transition matrix in which there is a 2/3 chance the wage stays the same, a 2/9 chance it increases, and a 1/9 chance it decreases. If the agent is unemployed, benefits remain the same 2/3 of the time and move down one notch 1/3 of the time; this captures the tier structure of emergency unemployment benefit compensation. The rest of the parameters are described in Table 5. The appendix includes the regressions and transition matrix for the aggregate state.

Table 4: Parameter Values, Monthly Simulation

<b>Basic Variables</b>		
Variable	Description	Parameter Value/ Functional Form
$c$	Consumption	Choice Variable
$a$	Assets	Choice Variable
$s$	Search intensity	Choice Variable
$n$	Periods in Default (Skipped Payments)	$N = 12$ in delay model, $N = 3$ in non-delay model (calculated using LPS data in 2007 and 2001)
$b$	Benefits	$b(w) = \frac{1}{2} \min \{w, \frac{1}{2}(\bar{w} + \underline{w})\}$ (taken from Herkenhoff and Ohanian (2010))
$\hat{\beta}$	Effective Monthly Discount Rate	0.9932 (taken from Herkenhoff and Ohanian (2010))
$\bar{r}$	Risk Free Savings Rate	2% annual interest rate
$r_b$	Bank Mortgage Rate	5.95% annual interest rate (Calculated from LPS data set)
$z_h$	Flow from Housing	$z_h = 4 \cdot z_r$
$z_r$	Flow from Renting	$z_r = 1$
$c_h$	Cost of housing (mortgage payment), in consumption	.2
$c_r$	Cost of Renting	0 (Set to avoid negative consumption trap)
$p_d$	Probability of dying	42 Year Working Life, $p_d=.002$ (Ljungqvist and Sargent (1998))



Table 5: Parameter Values, Monthly Simulation

Functional Forms				
Variable	Description	Parameter	Value/	Functional Form
$x(s)$	Disutility of search	$x(s) = 3 \cdot s$	(Linear Form, Ljungqvist and Sargent (1998)) [	<b>We will later show results for <math>x(s) = c_s \cdot s^2</math> to be consistent with Kreuger and Meuller (2008)]</b>
$\pi(s, \theta)$	Job Finding Rate	$\pi(s, \theta) = s^3$	in bad times, $\pi(s, \theta) = \frac{3}{4}s^3$	in good times (Concave Form, Ljungqvist and Sargent (1998))
$\delta(\theta)$	Layoff Shock	$\delta(\theta) = 0.036$	in bad times, $\delta(\theta) = 0.018$	in good times (Employment Duration, Ljungqvist and Sargent (1998))
$p(\theta)$	Price of house	$p(\theta) = .99 \cdot \frac{c_h}{r_b}$	in bad times, $p(\theta) = \frac{c_h}{r_b}$	in good times (Requires Sensitivity Analysis)
$\chi(\theta)$	Forced sale price discount	$\chi(\theta) = .99$	in bad times, $\chi(\theta) = 1$	in good times (Requires Sensitivity Analysis)
$G(x)$	Deficiency Enforcement if Sheriff Sale	$\frac{1}{2}x\mathbb{I}(x < 0) + x\mathbb{I}(x > 0)$	(Requires Sensitivity Analysis)	
$S(x)$	Deficiency Enforcement if Voluntary Sale	$\frac{1}{2}x\mathbb{I}(x < 0) + x\mathbb{I}(x > 0)$	(Requires Sensitivity Analysis)	
$\lambda_F(n)$	Foreclosure probability after skipping $n$ payments	Linear and increasing after month 3, everyone evicted after <b>month 12</b> in delay economy everyone evicted after <b>month 3</b> in no delay economy (Calculated from LPS data)		
$\lambda_M(w, n)$	**Set to zero for the experiment below, in general linear and increasing (Calculated from LPS data)			

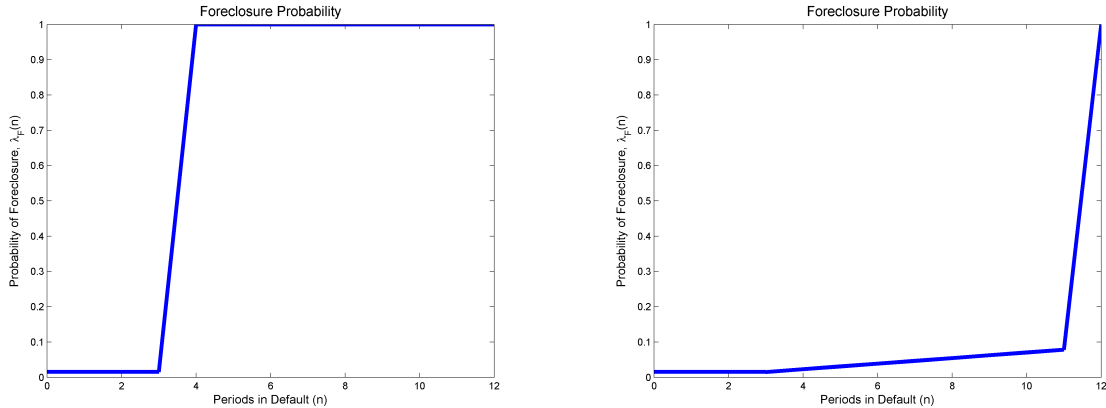
## 6 Turbulence Experiment

We ran the following turbulence experiment in an economy with foreclosure delays and an economy without foreclosure delays:

- Date 0: The economy is in the good state with initial assets, initial wages, and homeownership set to approximate the peak 70% homeownership rate and the observed distribution of liquid assets and back end DTIs in the 2007 PSID.<sup>9</sup>
- Date 1: The job destruction rate triples for one month
- Dates 2-6: The economy is in the bad state (job destruction still twice what it is in the good state)
- The economy then begins to recover after month 6 by entering the good state.

Figure 10 has the foreclosure probabilities whose slopes were based on the data. In both economies, during months 1-3, there is a constant foreclosure rate of 1.5%. In the no delay economy, there is certain eviction in month 4 ( $N = 3$  with the assumed grid structure). In the delay economy, this rate gradually increases after becoming 90+ days late until there is certain eviction in month 13 ( $N = 12$ ). See the Appendix for more information.

Figure 10: Foreclosure Probability  $\lambda_f(n)$



<sup>9</sup>The liquid asset distribution is approximated as truncated normal over  $\mathbb{R}_+$ , mean 0 and variance .1, and the back end DTI distribution is approximated as normal over  $\mathbb{R}_+$ , mean .5 and variance .1.

Figure 11: Model Homeowner Transitions, (No Delay Economy=Red Underlined Entries, Delay Economy= Black Entries), Conservative Parametrization

	Current	30 Days Late	60 Days Late	90+ Days Late	Renter
<b>Current</b>	<u>99.2</u> 99.1	<u>0.8</u> 0.9	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>0.0</u> 0.0
<b>30 Days Late</b>	<u>22.7</u> 30.7	<u>0.0</u> 0.0	<u>76.2</u> 68.3	<u>0.0</u> 0.0	<u>1.1</u> 1.0
<b>60 Days Late</b>	<u>0.0</u> 0.0	<u>24.7</u> 29.1	<u>0.0</u> 0.0	<u>74.4</u> 70.0	<u>0.9</u> 0.9
<b>90+ Days Late</b>	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>17.8</u> 7.3	<u>54.0</u> 87.6	<u>28.2</u> 5.1
<b>Renter</b>	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>100.0</u> 100.0

## 6.1 Transition Matrices

The transition matrices generated from both the 12-period delay and 3-period delay economies are overlaid and shown below in Table 11. The model does well in matching flows into and out of default. By picking  $\Delta$ , the model matches the approximate 1% flow into default and by picking  $LF$ , the model matches the approximate 25% flow back into becoming current. The remaining transitions are engogenous to the model. It does well at matching the cure rate of mortgages that are 60+ days late, and the cure rate of mortgages that are 90+ days. The main difference between the model results and the data results is that there are more cures with delays; agents are more likely to keep their home in the delay economy and thus eventually cure, even though default episodes are longer and the job finding rate is smaller. This difference may merely be due to the censoring issues, since in the LPS data we have not yet observed the majority of outcomes for loans sitting in foreclosure (perhaps many will eventually cure as the model suggests). The transition probability out of 90+ days late into rentership is also relatively high in the no-delay economy, but this merely reflects the simplified states space.

## 6.2 Aggregates

Figures 12 to 15 show how the aggregate economy responds to the shock for a state with the typical number of defaults. First and foremost, Figure 12 illustrates the 1/3% gap in the unemployment rate; this difference in unemployment rates is economically significant, corresponding to 600,000 unemployed workers, and the gap persists for at least 12 months. Given the 1-time nature of the shock, this is likely an underestimate of the effects of prolonged default on unemployment. What causes this persistent gap is the reduced search effort of defaulters and the higher default rate in the delay economy. What closes the gap after 1 year is that those who defaulted anticipating a 12-month delay run up against the deadline and begin to search intensely.

Figure 13 shows that people use this margin for protracted periods of time, nearly 7 months on average in the delay economy. Figure 14 illustrates the sheer number of people that use this mode of consumption smoothing. These levels of default are moderate compared to what is in the data (see Figure 23). This defaulter gap reaches a difference of as much as 8 %, and the two economies remain divergent for the entire simulation. What generates this difference in delinquency stocks is the institutional delay in combination with the slow cure process.

Figure 15 shows that homeownership falls as people leave their homes. Homeownership falls by as much as 6-8%, but this large drop in ownership is due to the modeling assumption that there are no repeat homeowners, i.e. people cannot default and then eventually become a homeowner again.

Figure 12: Turbulence Experiment: Difference in Unemployment Rates Across Economies, Conservative Parameterization

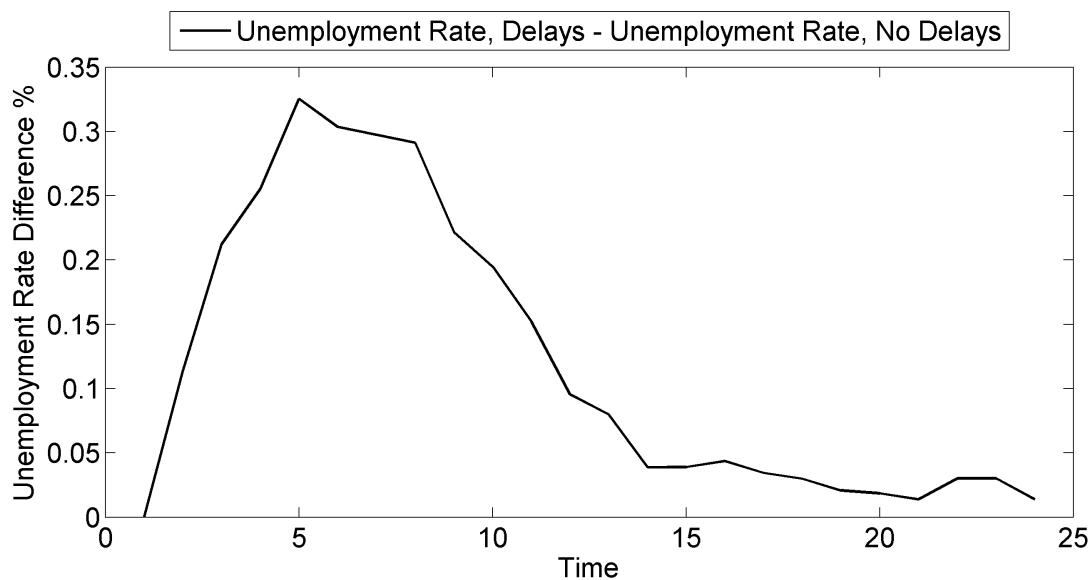


Figure 13: Turbulence Experiment: Length of Delinquency Spells, Conservative Parameterization

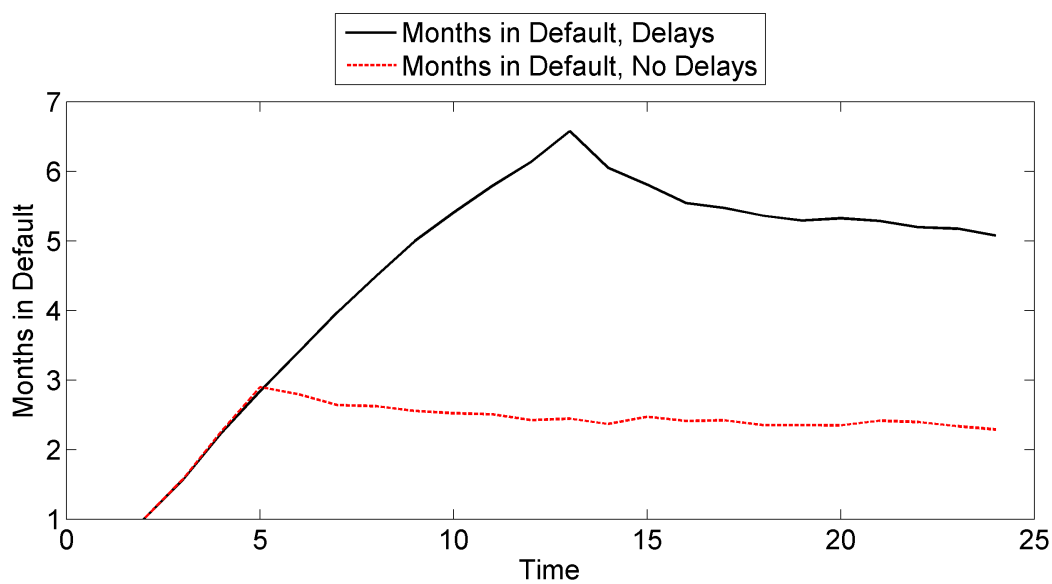


Figure 14: Turbulence Experiment: Delinquency Stock, Conservative Parameterization

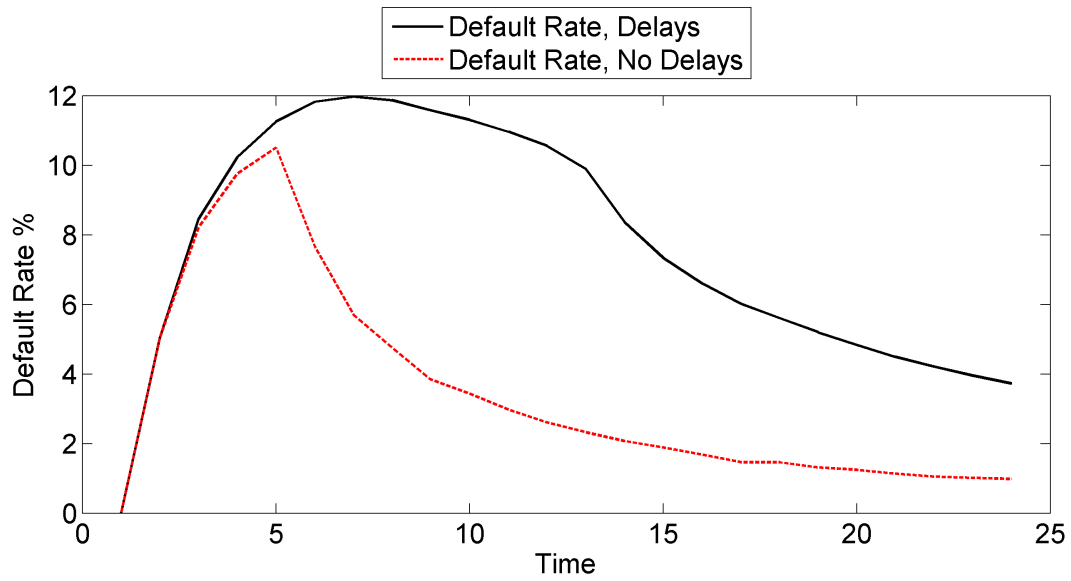
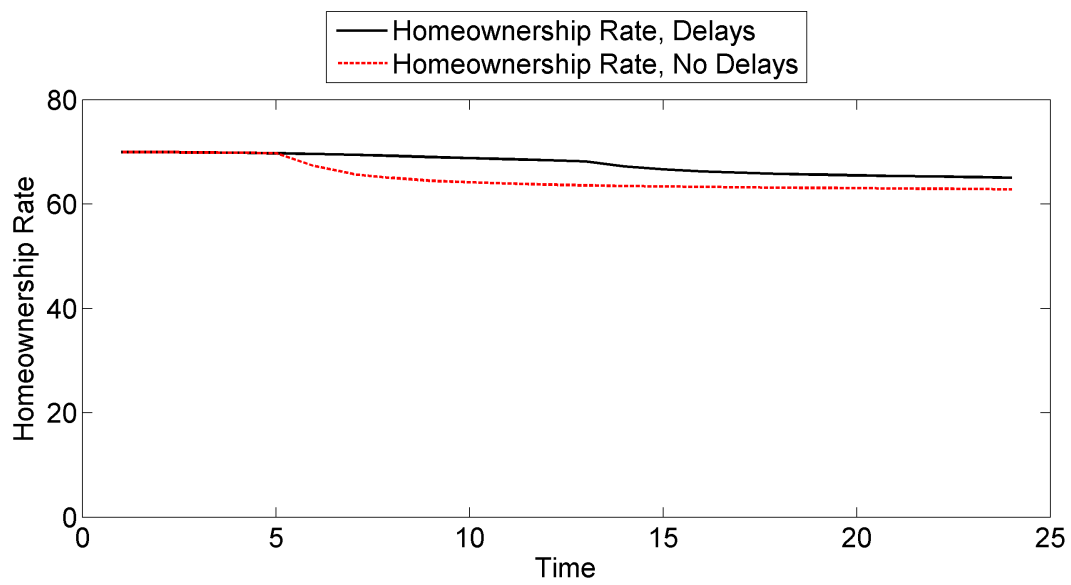


Figure 15: Turbulence Experiment: Homeownership, Conservative Parameterization



### 6.3 Real Rate of Interest

A skipped payment is nothing more than a line of credit by the bank to the mortgagor. We define the real rate of interest on the “skipped payment loan” as the potential payment in consumption terms, which is a foreclosure-probability-weighted summation of the late payment and the consumption equivalent to the utility loss of foreclosure, over the loan amount ( $c_h$ ). In symbols, the real rate of interest is given as a function of skipped payments ( $n$ ):

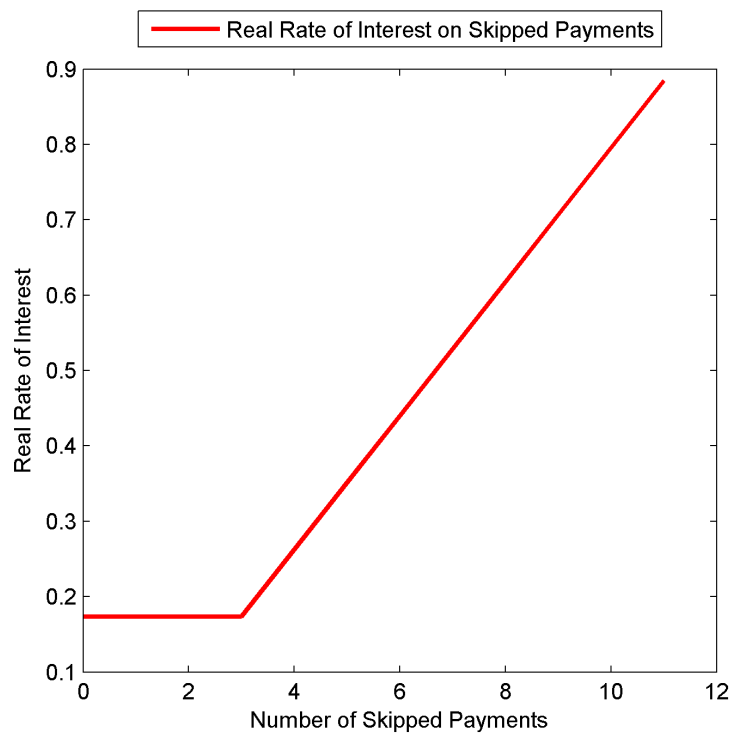
$$\hat{r}(n) = \frac{\lambda_f(n)\tilde{c} + (1 - \lambda_f(n))(1 + r_b)c_h}{c_h} - 1$$

Such that

$$\tilde{c} = e^{\left\{ \frac{r_b + p_d}{1 + r_b} (E_h - E_r) \right\}}$$

The notation is the same as in the model where  $r_b$  is the late interest rate on the payment,  $p_d$  is the death probability,  $(E_h - E_r)$  is the utility cost of becoming a renter if foreclosure happens, and  $\lambda_f(n)$  is the chance of being foreclosed upon after having skipped  $n$  payments. Figure 16 plots this real rate for an unemployed person with low assets and medium unemployment benefits during good times; the real rate peaks above 85% per month which points to an efficiency argument in the way these ‘informal unemployment benefits’ are funded; when the government can borrow with a 2-3% annual rate, there is no reason to finance consumption at a monthly interest rate of 18-85%.

Figure 16: Real Rate of Interest





## 6.4 Quadratic Search Costs and Greater Indebtedness (Benchmark)

In the economy above with linear search disutility, the majority of unemployed persons search at the maximum intensity possible, which is inconsistent with the evidence in Kreuger and Mueller (2008) who find that the average laid-off person searches for a job for only 41 minutes a day. To obtain a more empirically plausible search intensity, we increase the convexity of the search cost from a linear specification to a quadratic specification:

$$x(s) = c_s s^2$$

Where  $c_s = 15$  which enables this specification to be consistent with an observed ergodic unemployment rate of 6%, given the job finding probability  $\pi(\theta, s)$  remains the same.<sup>10</sup>

For this portion of the paper, we use a less conservative distribution of initial DTIs to capture the severe indebtedness of households which is documented in Herkenhoff and Ohanian (2011), and we let job destruction quadruple in the first month, rather than triple, in order to get the same observed unemployment level of 9.5%.<sup>11</sup> They find that the median distressed homeowner has a debt to income ratios of almost 80%. Figures 17 through 20 illustrate the results in this economy.

Figures 22 and 23 illustrate the stock of delinquent mortgagors by days late and by region. Our above parameterization had limited defaults (12% delinquent mortgage stock). According to the national average in 22, this is the correct magnitude of defaults. However, each state had a much different experience as evidenced by Figure 23 which shows delinquent mortgage stocks in excess of 30% of existing loans. Unpublished preliminary results indicate that the unemployment rate difference reaches  $\frac{2}{3}\%$  in the states that have 30% delinquent stocks, such as Florida.

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<sup>10</sup>This function actually lies below the original linear disutility function at most points on the grid  $[0, .5]$  so we must increase the job destruction rate

<sup>11</sup>Now the distribution is truncated with a lower mean and higher variance, i.e. initial wages  $\sim N(.15, .5)$ , which corresponds to a mean wage of .44. Recall the mortgage payment is set to .2.

Figure 17: Turbulence Experiment: Difference in Unemployment Rates Across Economies, Benchmark Parameterization

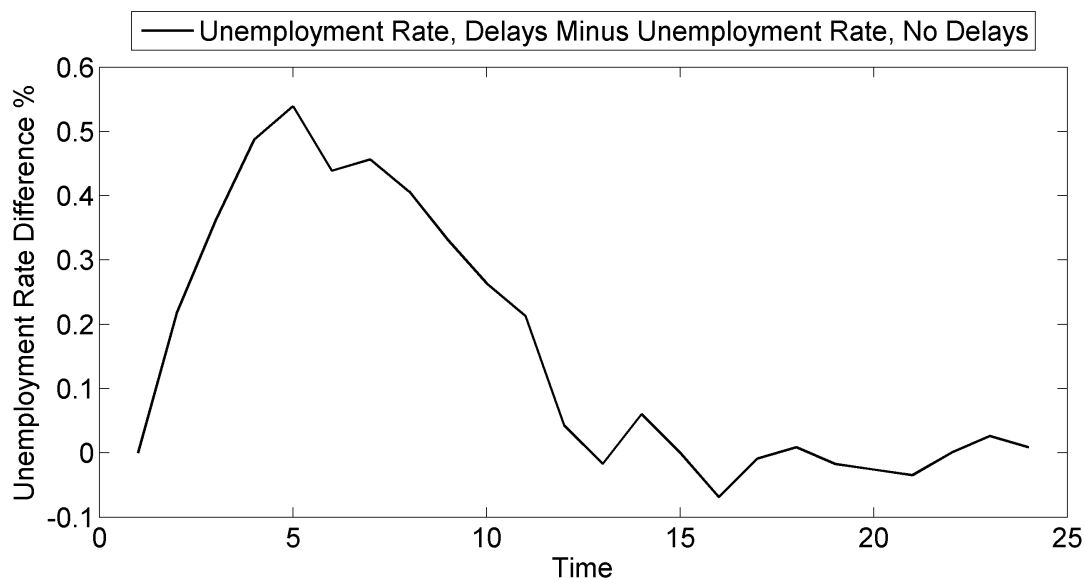


Figure 18: Turbulence Experiment: Length of Delinquency Spells, Benchmark Parameterization

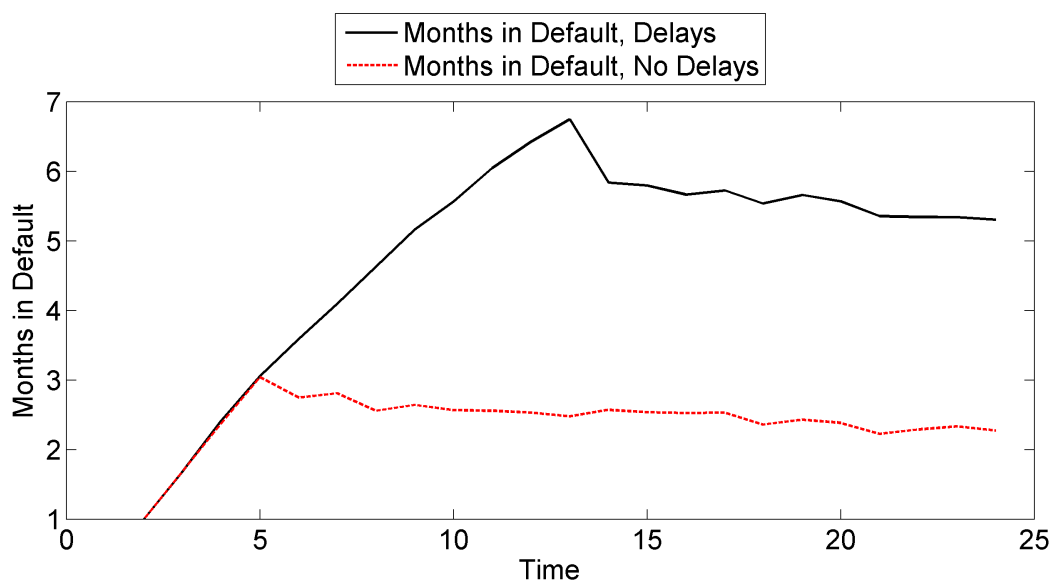


Figure 19: Turbulence Experiment: Delinquency Stock, Benchmark Parameterization

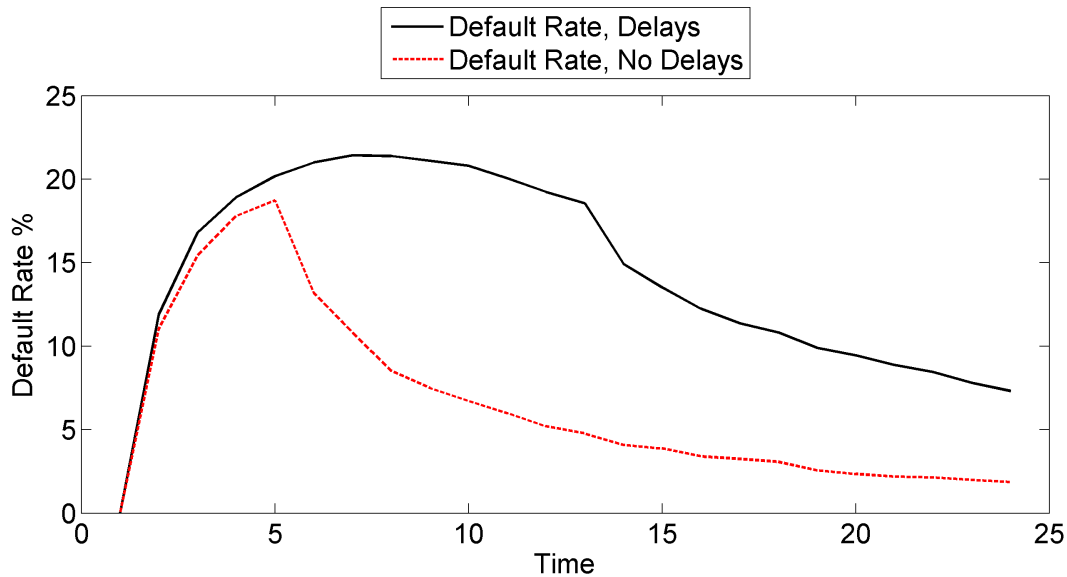


Figure 20: Turbulence Experiment: Homeownership, Benchmark Parameterization

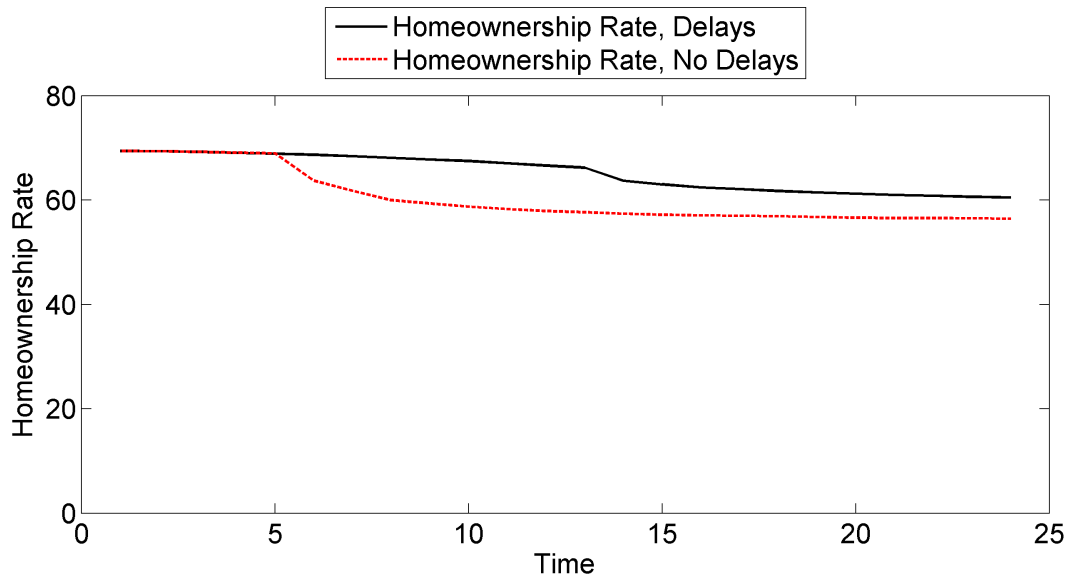


Figure 21: Model Homeowner Transitions, (No Delay Economy=Red Underlined Entries, Delay Economy= Black Entries), Benchmark Parameterization

	Current	30 Days Late	60 Days Late	90+ Days Late	Renter
Current	<u>98.5</u> 98.4	<u>1.5</u> 1.6	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>0.0</u> 0.0
30 Days Late	<u>19.0</u> 25.4	<u>0.0</u> 0.0	<u>79.8</u> 73.5	<u>0.0</u> 0.0	<u>1.3</u> 1.1
60 Days Late	<u>0.0</u> 0.0	<u>22.3</u> 25.0	<u>0.0</u> 0.0	<u>76.8</u> 74.0	<u>1.0</u> 1.1
90+ Days Late	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>18.3</u> 6.8	<u>54.1</u> 88.2	<u>27.7</u> 5.0
Renter	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>0.0</u> 0.0	<u>100.0</u> 100.0

Figure 22: Delinquency Stock and Foreclosure Stock (Source: LPS)

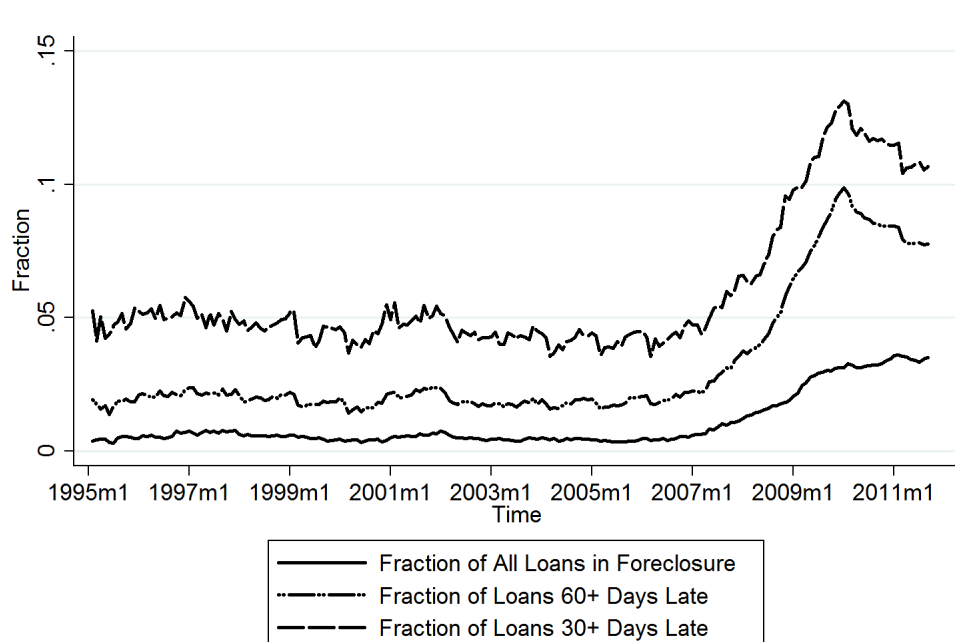
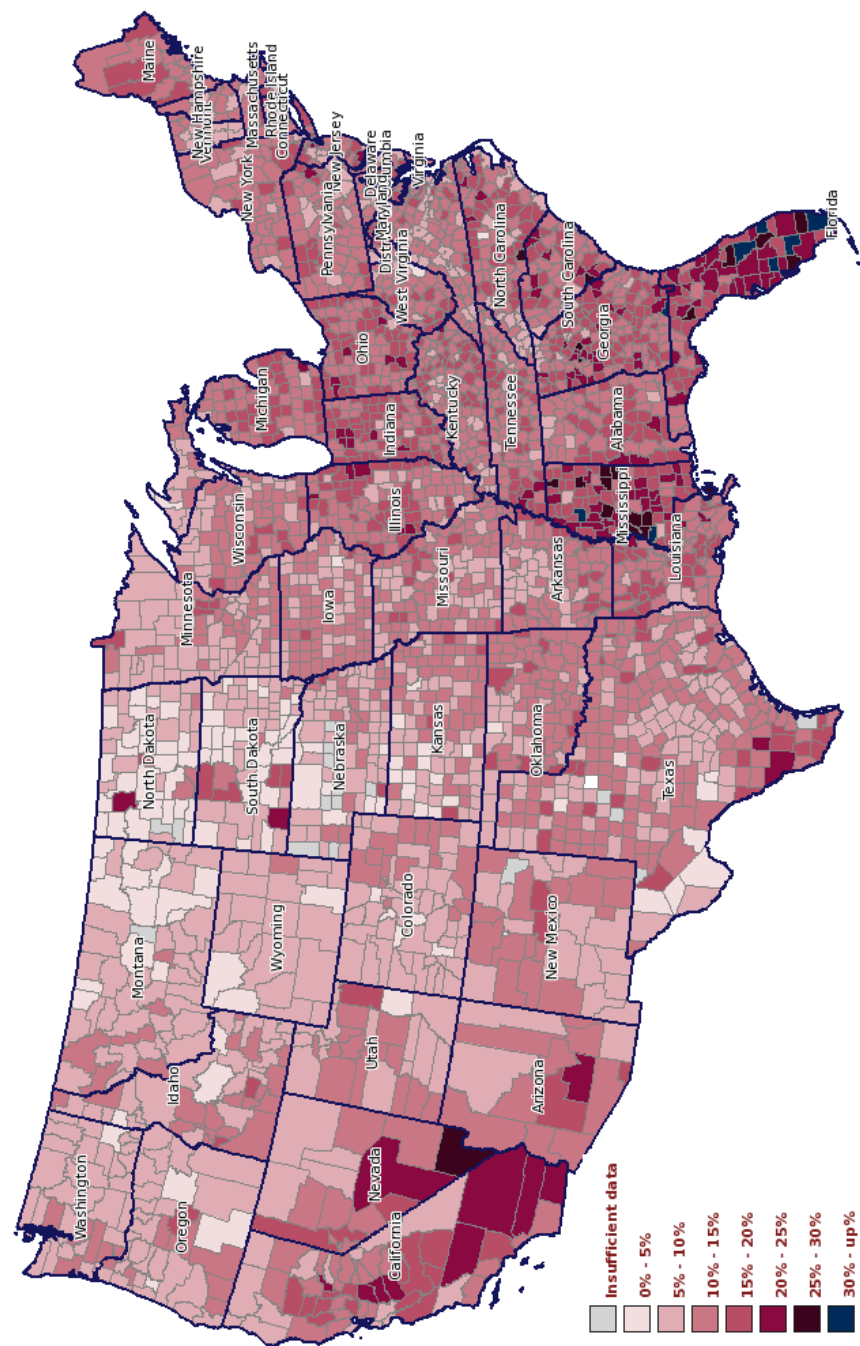


Figure 23: Fraction Delinquent (30+ Days Late, Compare to Model) (Source: LPS)



## 6.5 Mechanisms in the Model and the Data

The two main mechanisms generating the differences between the economies are the search effort and reservation wage of defaulters. In the delayed foreclosure case, defaulters have higher reservation wages since they have time to find a better paying job, rather than accepting lower offers and working their way up the wage ladder. The reservation wage declines as foreclosure gets closer since foreclosure will potentially leave them with low consumption, and the curvature of the utility function means they will have a near infinite marginal utility of consumption if this scenario is realized. Thus they lower their reservation wage to just above the minimum amount necessary to cover their mortgage payments. This behavior is illustrated in Figure 24 which is the reservation wage profile in good times ( $\theta = \theta_H$ ) for a given level of assets ( $a$ ); just as described above, as foreclosure becomes a higher probability event, the reservation wage falls dramatically. Moreover, the reservation wage always remains above the required mortgage payment ( $c_h$ ). The shorter delay economy merely compresses the time it takes to for this process to occur.

Figure 25 shows how the search intensity changes over the default episode. Initially the search intensity is quite low as agents do not have strong incentives to find a job; they are still receiving the same flow utility from housing as well as a 50% replacement rate of their last wage which gives them an effective income that is in some cases greater than their effective income while working and making payments on the mortgage. In terms of the model, because the utility function is concave and these defaulting agents have the same effective consumption as before, their marginal utility of consumption is still relatively low, and thus the agents are not incentivized to find a job immediately. As the foreclosure probability increases, the search intensity dramatically rises because there is now a risk that the agent will potentially go through a costly foreclosure and lose the flow utility from housing.

Figure 26 shows the unemployment rate by delinquency status.<sup>12</sup> Due to the way the incentives to find a job increase as the foreclosure probability rises, the model generates a hump shaped unemployment rate by delinquency status, just as in Figure 2.

Figures 27 and 28 are the 3 dimensional versions of the reservation wage profiles and search intensity profiles for the delay economy versus the no delay economy at initial default. Figure 27 shows that the entire reservation wage policy shifts down in the no delay economy since foreclosure is imminent. At the same time, Figure 28 shows that the entire search intensity profile shifts up as agents face a higher probability of foreclosure. As mentioned above, agents in this model try to avoid foreclosure since it will potentially leave them with very little consumption, and the curvature of the utility function means they will have a near infinite marginal utility of consumption if this occurs.

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<sup>12</sup>The unemployment rate by delinquency status is relatively low since it is calculated over the entire 2 year period, and there are many employed homeowners who are curing and thus counted as an employed delinquent homeowner.

Figure 24: Difference in Reservation Wages Between Economies

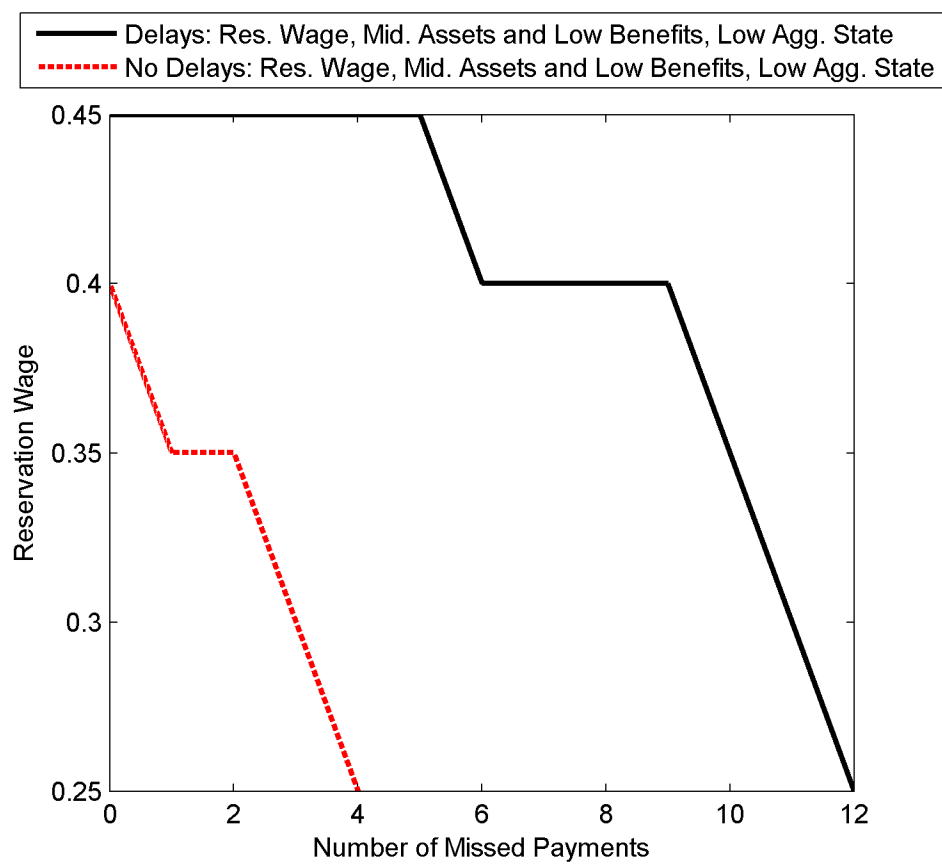


Figure 25: Difference in Search Effort Between Economies

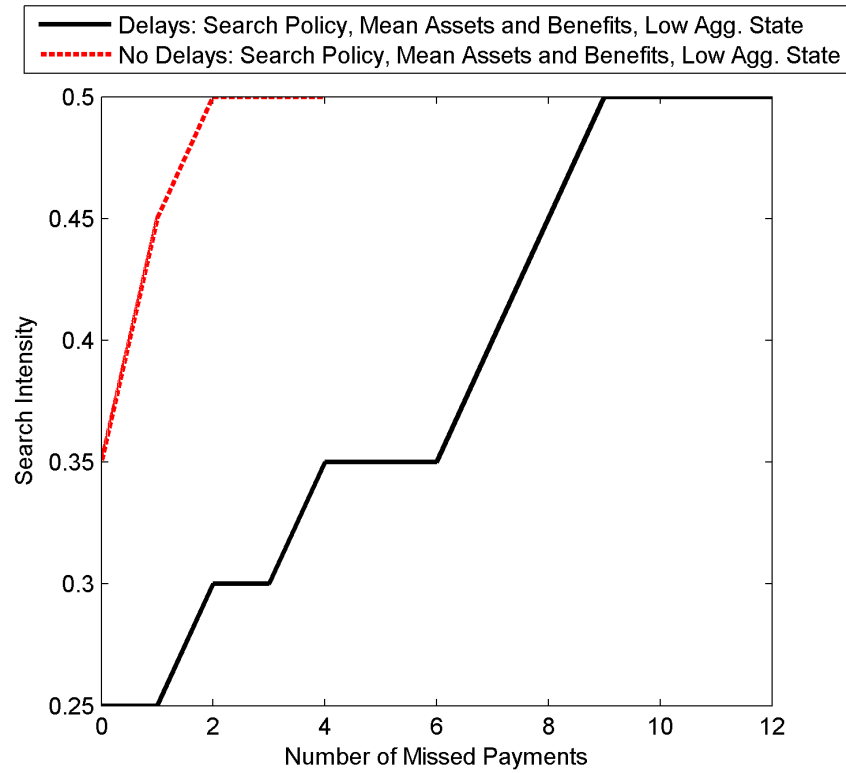


Figure 26: Unemployment Rate by Delinquency Status (Model)





Figure 27: Reservation Wages Over Default Episode (Delay Economy, BT)

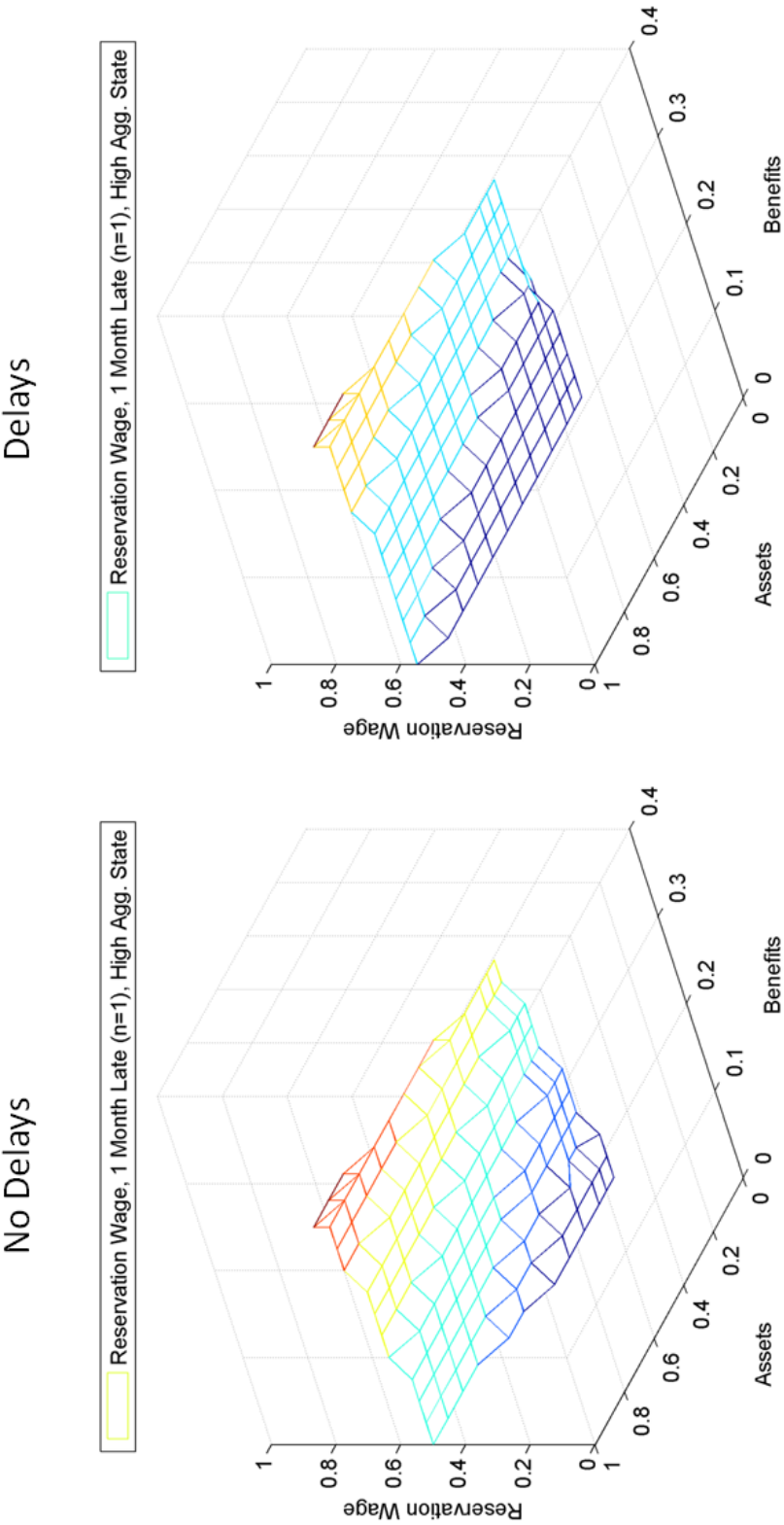
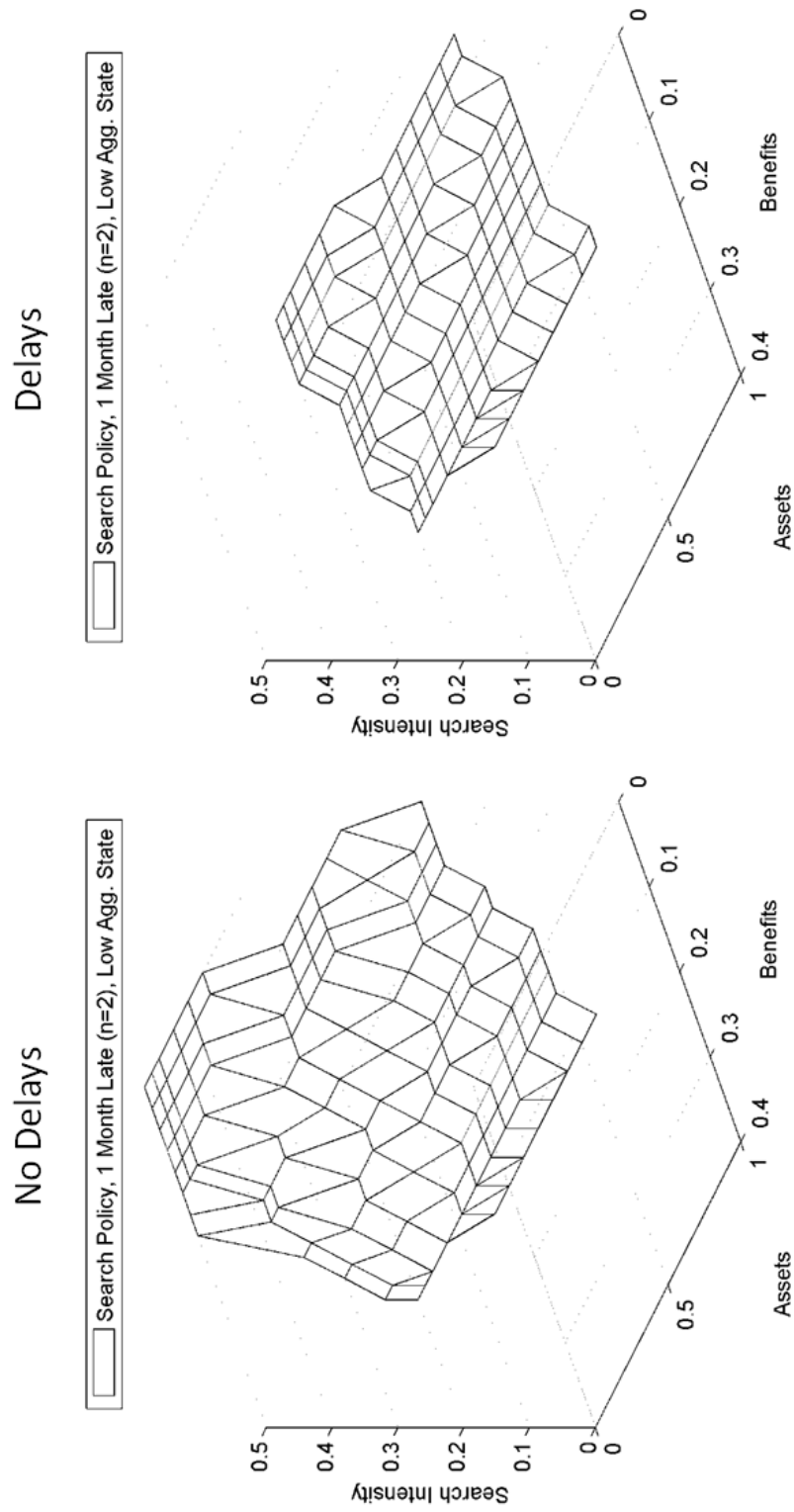


Figure 28: Search Intensity over Default Episode (Delay Economy, BT)



## 7 Conclusion

To our knowledge, we are the first to capture the “ins” and “outs” of default in a quantitative model, and the first to empirically show this relationship in a simple transition matrix. The model introduces the new mechanism of prolonged default and allows us to consider how it interacts with job search and wage acceptance decisions. By allowing for differing degrees of default, we are able to capture the feedback effects between mortgage default and unemployment. With plausible turbulence, we find significant and persistent effect from the foreclosure delays on the unemployment rate that reaches  $\frac{1}{3}\%$ - $\frac{1}{2}\%$  and a difference in delinquency stocks that peaks at 8%-12%. We find that defaulters borrow at extraordinarily high interest rates, and we show that the behavior in our model is consistent with observed facts from the data. While our analysis is entirely positive, it gives future researchers the opportunity to use the data in this paper to analyze the normative implications of foreclosure delay including whether or not this is the most efficient way to provide unemployment benefits.

In related work, Herkenhoff and Ohanian (2012) suggest that more permanent aid to unemployed homeowners such as retraining subsidies and scholarships for secondary education will stem defaults more permanently and allow the housing market to recover. Delaying foreclosure is temporary relief, but helping workers obtain the skills required to find a job will provide them with the income necessary to be homeowners in the long run.

## References

- [1] Adelino, M., K. Gerardi, and P. Willen. ‘Why Don’t Lenders Renegotiate More Home Mortgages? Redefaults, Self-Cures and Securitization.’ NBER Working Paper, 2009.
- [2] Ambrose, B., R. Buttimer, and C. Capone. 1997. “Pricing Mortgage Default and Foreclosure Delay.” *Journal of Money Credit and Banking*.
- [3] Benjamin, D. and X. Mateos-Planas. 2011. “Formal and Informal Default in Consumer Credit.” Manuscript.
- [4] Benjamin, D. and M.L.J. Wright. 2008. “Recovery before redemption: A theory of delays in sovereign debt renegotiations.” NBER Working Paper.
- [5] Calomiris, C. and E. Higgins, 2010. “Policy Briefing: Are Delays to the Foreclosure Process a Good Thing?” Manuscript.
- [6] Calomiris, C.W., S.D. Longhofer, and W. Miles. 2008. “The Foreclosure-House Price Nexus: Lessons from the 2007-2008 Housing Turmoil.” NBER Working Paper.

- [7] Capozza, D. and T. Thomson, 2006. ‘Subprime Transitions: Lingering or Malingering in Default?’, *The Journal of Real Estate Finance and Economics*, Springer, vol. 33(3), pages 241-258, November.
- [8] Chatterjee, S. 2010. “An Equilibrium Model of the Timing of Bankruptcy Filings.” Manuscript.
- [9] Chatterjee, S. and B. Eyigungor. 2011. “A Quantitative Analysis of the US Housing and Mortgage Markets and the Foreclosure Crisis.” Federal Reserve Bank of St. Louis, Working Paper.
- [10] Chatterjee, S. and Eyigungor, B. 2009. ‘Foreclosures and house price dynamics: a quantitative analysis of the mortgage crisis and the foreclosure prevention policy.’ Federal Reserve Bank of St. Louis, Working Paper.
- [11] Corbae, D. and E. Quintin. ‘Mortgage Innovation and the Foreclosure Boom.’ June 2010.
- [12] Dawsey, A.E. and L.M. Ausubel. 2004. “Informal Default.” Manuscript.
- [13] Farber, H. 2010. “Job Loss and Unemployment in the 21st Century: The Great Recession in Labor Market Perspective.” Manuscript.
- [14] Garriga, C., and D.E. Schlagenhauf. 2009. “Home Equity, Foreclosures, and Bail-outs.” Manuscript.
- [15] Gerardi, K., P. Willen, L. Lambie-Hansen. 2011. “Do Foreclosure Delays Improve Borrower Outcomes?” Manuscript.
- [16] Goodman, P.S. 2009. “Lucrative Fees May Deter Efforts to Alter Loans.” *New York Times*.
- [17] Hatchondo, J.C., L. Martinez, and J.M. Sanchez. 2011 “Mortgage Defaults.” Federal Reserve Bank of Richmond, Working Paper.
- [18] Head, A. and H. Lloyd-Ellis. ‘Housing Liquidity, Mobility, and the Labor Market.’ Queen’s University Working Paper, 2008.
- [19] Hedlund, A. 2011. “Illiquidity and Foreclosures in a Directed Search Model of the Housing Market.” Manuscript.
- [20] Herkenhoff, K.F., and L.E. Ohanian. 2012. “Why the U.S. Economy Has Failed to Recover and What Policies Will Promote Growth.” Forthcoming, *Restoring Robust Growth*, edited by John B. Taylor.
- [21] Herkenhoff, K.F., L.E. Ohanian, and J.M. Sanchez. 2011. “Informal Default and Mortgage Delinquency.” Manuscript.

- [22] Karahan, R. and S. Rhee. 2011. "Housing and the Labor Market: The Role of Migration on Aggregate Unemployment." Manuscript.
- [23] Krueger, Alan B. and Andreas Mueller. 2008. "Job Search and Unemployment Insurance: New Evidence from Time Use Data." Manuscript.
- [24] Li, W. and M.J. White. 2010. "Mortgage Default, Foreclosures and Bankruptcy." Manuscript.
- [25] Ljunqvist, L. and T. Sargent. 'The European unemployment dilemma.' *Journal of Political Economy*, 1998.
- [26] Lowrey, A. 2010. "Strategic Default Penalties Threaten Struggling Homeowners." *Washington Independent*.
- [27] Mian, A. and A. Sufi. "What Explains High Unemployment? The Aggregate Demand Channel." Manuscript.
- [28] Mulligan, C.B. 2009. "Means-Tested Subsidies and Economic Performance Since 2007." NBER Working Paper 17445.
- [29] Mulligan, C.B. 2009. "A Depressing Scenario: Mortgage Debt becomes Unemployment Insurance." NBER Working Paper 14514.
- [30] Mulligan, C.B. 2009. "Aggregate Implications of Labor Market Distortions: The Recession of 2008-9 and Beyond." Manuscript.
- [31] Ohanian, L.E. 2010. "The Economic Crisis from a Neoclassical Perspective." *Journal of Economic Perspectives*. Volume 24, Number 4.
- [32] Ohanian, L.E. and A. Raffo. 2011. 'Hours Worked over the Business Cycle in OECD Countries, 1960-2010.' Manuscript.
- [33] Pace R.K. and S. Zhu. 2011. "The Influence of Foreclosure Delays on Borrower's Default Behavior." Manuscript.
- [34] Pennington-Cross, A. 2010. "The Duration of Foreclosures in the Subprime Mortgage Market: A Competing Risks Model with Mixing" *Journal of Real Estate Finance and Economics*, Volume 40, No. 2.
- [35] Sahin, A., J. Song, G. Topa, G.L. Violante. 2011. "Measuring Mismatch in the U.S. Labor Market." Federal Reserve Bank of New York Working Paper.
- [36] Thompson, Diane E. 2010. "Problems in Mortgage Servicing From Modification to Foreclosure." Manuscript.
- [37] Van Nieuwerburgh, S. and P.O. Weill. 2010. "Why Has House Price Dispersion Gone Up?" *Review of Economic Studies*.

[38] <http://www.bloomberg.com/news/2011-06-22/u-s-shadow-inventory-shrinks-as-foreclosed.html> <http://www.housingwire.com/2011/03/29/foreclosure-inventory-volume-outpacing-ac>  
<http://www.foreclosureradar.com/california-foreclosures> <http://www.smithavenue.com/blog/> <http://www.areuea.org/conferences/papers/details.phtml?id=300>

## A Data

The mortgage data is randomly sampled from the Lender Processing Services (LPS) McDash database and is nationally representative. All regressions using LPS data are thus unweighted. The database extends back to 1992:Q2 and covers roughly 2/3 of all mortgage until the present.

The wealth, wage, and asset data is taken from the Panel Study of Income Dynamics (PSID), and only household heads are considered. The PSID data is a survey, and thus the statistics are weighted by the survey weights provided.

## B Parameterization Regressions and Aggregate State Transition Matrix

For non-censored observations, we estimated a few simple linear hazard regressions. In Table 6 the dependent variable is an indicator that takes the value 1 when the person is asked to leave the house.<sup>13</sup> Our estimates look at the probability of being asked to leave the home conditional on being 90+ days late.

This table says, that for each missed payment after having already skipped 3 payments,

Table 6: Estimation results : Dependent variable is indicator of eviction  $\mathbb{I}(Eviction\ Occured)$ , sample is conditional on being 90 days late (Source: LPS)

Variable	Coefficient	(Std. Err.)
Time Since 90 Days Late	0.00797	(0.00028)
Intercept	0.07992	(0.00563)

the probability of eviction goes up by .797%.

Table 7 shows the estimates for how likely it is to be modified as a function of skipped payments. These hazards are easy to interpret, which is the reason we used this simple setup

<sup>13</sup>The “paid-off” state can indicate many outcomes, but we count all of those outcomes as evictions- if this were not the case, and if we took into account censoring, the delay periods would look much longer

for our preliminary results. In later versions we will use Cox proportional hazard models that can correct for censoring.

Table 7: Dependent variable is indicator of modification  $\mathbb{I}(\textit{Modification Occured})$ , sample conditional on being 30+ days late (Source: LPS)

Variable	Coefficient	(Std. Err.)
Time Since 30 Days Late	-0.00002	(0.00004)
Intercept	0.00556	(0.00058)

We also constructed the monthly good-times-bad-times transition matrix from business cycle data on the NBER webpage; the probability of transiting from good times to bad times is .0146 and the probability of staying in good times is .9854:

$$\theta_{Transition} = \begin{bmatrix} 0.9854 & 0.0146 \\ 0.0833 & 0.9167 \end{bmatrix}.$$

## C Congestion or Policy Driven Foreclosure Delay and Its Impact on Default Decisions

The anecdotal evidence of foreclosure delay is widespread. Take for instance this excerpt from a write up that was based on an interview with Shaun Donovan, the director of the Department of Housing and Urban development (HUD)

*Housing and Urban Development chief Shaun Donovan stopped by the [Wall Street] Journal's editorial page Thursday to answer that question and others about the [robo-signing] settlement, and it was a revealing chat... Mr. Donovan had a harder time answering questions about who's getting the [robo-signing settlement money], and why. He emphasized, for instance, that it was right to reward delinquent borrowers with cash payouts because banks charged those borrowers fees they shouldn't have and didn't always adequately inform them of government programs to help them avoid foreclosure. **But how many borrowers current on their mortgage were booted out of their homes?** Mr. Donovan couldn't provide a number but estimated it would be a "tiny fraction" of robo-signed foreclosures. That's a remarkable admission given that HUD, the Department of Justice, state attorneys general and others spent 18 months pressuring banks to strike a deal. What the HUD secretary revealed is that the government did all that work*

- *which delayed foreclosures and prevented the market from clearing*
  - *largely to protect homeowners who weren't even paying their bills.*
- (Mary Kissel, WSJ, Feb. 17, 2012 )

Table 8 explains the variables used in this empirical portion of the paper. The robo-signing indicator, which takes a value of 1 after October 2010, is the first variable of interest.<sup>14</sup> To see what the effects were of foreclosure delay, we use a natural experiment to conduct an event study by looking at loans in the foreclosure process between 2009 and 2011, and comparing their chances of being foreclosed upon before and after the robo-signing lawsuit was initiated. Figure 29 shows the break in the series, plotted quarterly; clearly after the robo-signing lawsuit, the probability of being foreclosed upon fell substantially (where “foreclosed upon” means liquidated via foreclosure sale). To formalize this event study, we regress an indicator of whether or not a loan was foreclosed (either successful or unsuccessful foreclosure sale) on the robo signing indicator, as well as a host of other controls. Panel (A) of Table 9 shows that the probability of being foreclosed in any given month declined by roughly 2.41% after the robo-signing lawsuit was passed. To put this in perspective, this is equivalent to an additional six month delay (simply take the ratio of the months in foreclosure and robo-signing coefficients  $6.67 = .0036 / .0241$ ). This is only one of many events that impacted the ability of banks to foreclose, and thus represents a potentially small part of the issue at hand. We therefore conclude that policy interventions have caused a decent portion of the foreclosure delays. The role of congestion is also important; one percent more loans in foreclosure in the given state decreases the probability of being foreclosed upon by .92%.

Panel (B) of Table 9 shows the effect of general foreclosure delay on the decision to default. To capture this effect, we regress an indicator that equals one when the loan first becomes 60+ days late on the relevant state’s foreclosure delay along with other covariates. Even after controlling for a time trend, foreclosure delay impacts the decision to default, increases the probability of default by about .1-.2% at roughly 1 year’s worth of delays ( $.0013 \times 12 - .0001 \times 12^2$ ). To put this into perspective, the foreclosure delay effect on the hazard of defaulting is about 1/15th-1/10th as important as being 30% underwater (being underwater by 30% or more increases chances of defaulting by 1.52%).

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<sup>14</sup>The robo-signing lawsuit was originally given to the 5 largest services on this date; these servicers handle a disproportionate share of loans, so we treat this as a national event.



Figure 29: Foreclosure Completion Rate, Event Study (Robo Signing Date, Vertical Line)  
(Source: LPS)

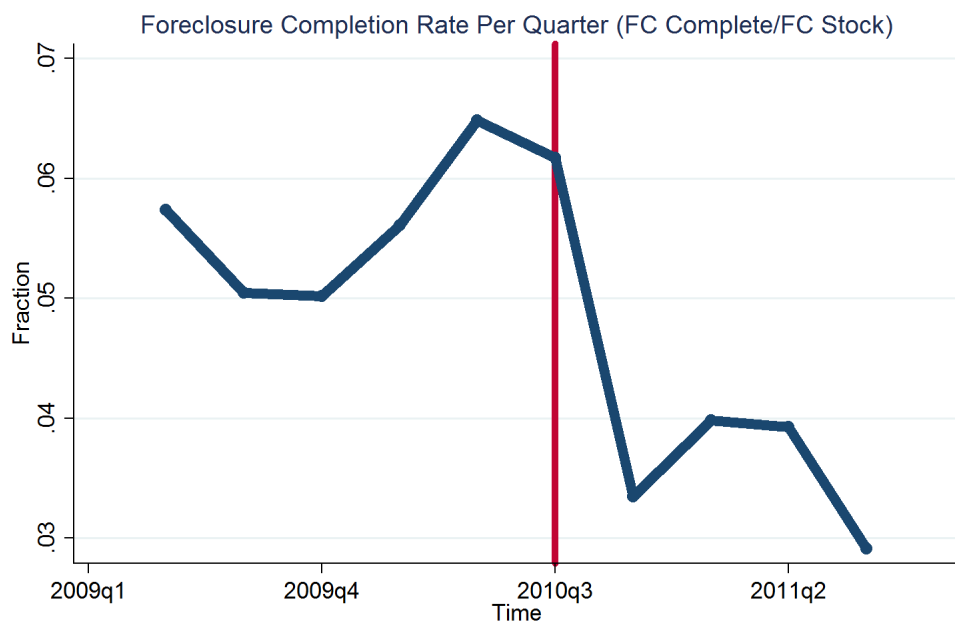


Table 8: Definitions (Source: LPS)

Variable	Description
Robo	Indicator=1 if Date > October 2010
Months in Foreclosure	Months spent in foreclosure, by month and by loan
Percent of Loans in Foreclosure, by State	Fraction of all loans in foreclosure proceedings, by month and by state
Principal Remaining in 10,000s	Principal Remaining in \$ 10,000s
Foreclosure Delay, by State	Average time spent in foreclosure proceedings, by month and by state
(Foreclosure Delay) <sup>2</sup> , By State	
1.1 $\geq$ Current LTV> 1	Principal Remaining/Current Home Value (Estimated using OFHEO All Transactions Index)
1.2 $\geq$ Current LTV> 1.1	
1.3 $\geq$ Current LTV> 1.2	
Current LTV> 1.3	
Mortgage Characteristics	FICO, DTI, Interest Rate, Mortgage Type, Loan Type, Investor Type, Document Type, Purpose Type

Table 9: Linear Probability Model (Source: LPS)

<b>Panel (A)</b>		<b>Panel (B)</b>	
Dependent Variable:	<b>Foreclosed Indicator</b>	Dependent Variable:	<b>60 Days Late Indicator</b>
Robo	-0.0241** (0.0104)		
Principal Remaining in 10,000s	-0.0064*** (0.0006)	Principal Remaining in 10,000s	0.0001** (0.0000)
Months in Foreclosure	0.0036*** (0.0005)	Foreclosure Delay	0.0013*** (0.0005)
Percent of Loans in Foreclosure, by State	-0.0092** (0.0046)	(Foreclosure Delay) <sup>2</sup>	-0.0001*** (0.0000)
1.1 $\geq$ Current LTV > 1	-0.0140 (0.0186)	1.1 $\geq$ Current LTV > 1	0.0087*** (0.0028)
1.2 $\geq$ Current LTV > 1.1	-0.0156 (0.0225)	1.2 $\geq$ Current LTV > 1.1	0.0138*** (0.0047)
1.3 $\geq$ Current LTV > 1.2	-0.0051 (0.0274)	1.3 $\geq$ Current LTV > 1.2	0.0182*** (0.0070)
Current LTV > 1.3	-0.0079 (0.0309)	Current LTV > 1.3	0.0152** (0.0068)
Mortgage Characteristics	Yes	Mortgage Characteristics	Yes
State Fixed Effects	Yes	State Fixed Effects	Yes
Time Trend	Yes	Time Trend	Yes
State Unemployment Rate	Yes	State Unemployment Rate	Yes
Observations	3792	Observations	98590
Standard errors in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			

## D Literature Review

We find similar behavioral effects as Mulligan (2009a, 2009b, 2009c) who looks at means-tested subsidies, including mortgage modifications, and their role in slowing employment growth.<sup>15</sup> Our paper also builds on our earlier work, Herkenhoff and Ohanian (2011), where we explored the interaction between labor markets and housing markets in a partial equilibrium setting with frictional employment, skill loss and means-tested mortgage subsidies.<sup>16</sup> The model predicts agents use the modification “option” at the last possible moment to lock-in low payments and potentially avoid eviction. In order to qualify for a modification, agents must become at least 1 month delinquent; the novelty of that model was that the initial delinquency did not result in foreclosure- instead the agent had free rent for one period. This changes the model economic agents’ incentives to relocate to relatively better labor markets, and as a result, unemployment reaches .5% higher in the world with modifications. This moderate *relocation distortion* has been verified by others including Head and Lloyd-Ellis (2008) and Karahan and Rhee (2011). Our work is also related to Mulligan (2008, 2011) who considers the impact of mortgage modifications and means testing on labor supply decisions. Mulligan shows that the replacement rate of income has increased substantially since the onset of the recession and that this replacement rate manifests itself as a labor wedge. This is consistent with the diagnosis in Mulligan (2007) and Ohanian (2010).

On the empirical side of the literature, Gerardi, Willen, and Lambie-Hansen (2011) consider whether or not foreclosure delay actually helps a borrower; they find that foreclosure delay merely stalls the ultimate outcome of eviction. Pace and Zhu (2010) find that borrowers are more likely to default if there is a longer period of free rent during foreclosure delay. They find that an additional 3 month delay increases the default hazard by 30%, for a subset of loans. Calomiris and Higgins (2010) provide some thought experiments on foreclosure delay. They walk through the costs of the delays including (i) bank lending reduction, (ii) uncertain and transitory affect on income, (iii) less housing construction, (iv) neighborhood blight and the benefit of (i) stabilizing house prices, and (ii) keeping people in their homes. Calomiris, Higgins, and Mason (2011) apply a similar thought experiment to the mortgage servicer settlement that mandates modifications; similar to Herkenhoff and Ohanian (2010), these authors argue that modifications are merely another foreclosure delay that slows down the economy. While not modeled endogenously in our exercise, the price effects from actual foreclosures which are carefully documented in Calomiris, Longhofer, and Miles (2008).

On the structural real estate economics side, the norm in the literature is to model default and foreclosure as immediate eviction, and in general this allows authors to focus

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<sup>15</sup>Mulligan’s models were the first to look at the incentive effects of mortgage modifications in a creative principal agent setting, and his subsequent work is in an RBC model which has voluntary unemployment due to increased payments to non-employed household members.

<sup>16</sup>In that model, agents were living hand-to-mouth and given one tool to keep their home, mortgage modification (for a general equilibrium treatment of modifications in an endowment economy see Chatterjee and Eyigungor (2009) and for empirical facts of modifications see Adelino, Gerardi, and Willen (2009)).

on the mechanism of interest. Examples include Garriga and Shlagenhaut (2009), Corabe and Quintin (2010), Hatchondo, Martinez, and Sanchez (2011) and Campbell and Cocco (2011); each of these papers contributes substantially to the work on mortgage innovation, but omits the role of protracted default and foreclosure. Chatterjee and Eyigungor (2011) use an endowment economy to model the effect of the construction boom on home prices and foreclosure. As a subsection of their paper, they look at foreclosure delay which is modeled as a one period delay between default and foreclosure. In essence, a homeowner picks between paying, inviting eviction (with 1 period of free rent), or selling. They find that this one period delay is important in generating a large incidence of foreclosure (it also allows them to keep the discount factor lower). However, they find that this has no impact on house prices. Herkenhoff and Ohanian (2011) include a similar foreclosure delay in which agents skip one payment before either modifying a loan or being foreclosed upon, and in related work, Herkenhoff, Ohanian, and Sanchez (2011) consider the delinquency interactions across unsecured debt and secured debt, including long term contracts, in a life-cycle consumption smoothing model. The idea of delays in defaultable debt models is not new, however. Benjamin and Wright (2008) were the first to model protracted sovereign default episodes for nations using renegotiation delays and Benjamin and Mateos-Planas (2011) apply the same structure as Benjamin and Wright to look at protracted renegotiation over unsecured consumer credit in an endowment economy where agents have the option to file for bankruptcy.

In terms of labor and housing, Head and Lloyd-Ellis (2008) were one of the first to consider housing markets, labor markets, and mobility in a general equilibrium matching model. Their focus is on the relocation effect, similar to Herkenhoff and Ohanian (2010). They find that there are important interactions between the labor market and the housing market, but that the effects are a wash in aggregate. There are several recent papers that have built on Head and Lloyd-Ellis' work such as Karahan and Rhee (2011) and Hedlund (2011).

As mentioned above, this paper contributes along a data dimension and modeling dimensions. The model allows households to enter and exit default regularly in times of crises in order to smooth consumption. With frictional employment, these ins and out of default correspond to unemployment spells. On the data side, we find similar behavior. Default episodes are often times serially correlated, and often times do not result in eviction (the sheriff sale of foreclosure).