Essays in Consumer Finance

by

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Dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in the Department of Economics
in the Graduate School of Duke University

2012
Abstract

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Abstract

This dissertation explores issues regarding the design of consumer financial contracts and their implications for market structure and economic efficiency. These questions are important because, as the recent mortgage crisis suggests, the relationship between household financial decision making, the organization of consumer financial markets, and the optimal design of financial contracts is not well understood. Chapter 2 of the dissertation uses a structural model of housing and mortgage markets to evaluate the potential impact of mortgage designs that share house price risk between the borrower and the lender. Chapter 3 of the dissertation uses a unique identification strategy to estimate the size and sources of foreclosure externalities, and Chapter 4 of the dissertation uses a theoretical model to explore the use of health contingent surrender values in life insurance contracts. The results presented in this dissertation highlight that there is much scope for improvement in the efficiency of consumer financial markets through better contract design.
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Introduction

This dissertation explores issues regarding the design of consumer financial contracts and their implications for market structure and economic efficiency. These questions are important because, as the recent mortgage crisis suggests, the relationship between household financial decision making, the organization of consumer financial markets, and the optimal design of financial contracts is not well understood. The results presented in this dissertation highlight that there is much scope for improvement in the efficiency of consumer financial markets through better contract design.

The second chapter of the dissertation, titled Efficient Mortgage Design in an Equilibrium Model of Housing and Mortgage Markets, uses a structural empirical model of the housing and mortgage markets in L.A. from 1991 to 2009 to study the potential impact of introducing alternative mortgage designs that share house price risk between borrower and lender. The results show that mortgage designs which offer insurance against house price depreciation, but do not share the capital gains in house price appreciation between borrower and lender, force lenders to increase interest rates by 0.4 to 1 percentage points in order to compensate for the insurance. The rise in interest rates causes demand for housing to fall, so house prices decline.
by about 4 percent. Despite this, consumer welfare is still improved by an equivalent variation of about $5,500 per household per year, because households value the provided insurance. In contrast, mortgage designs which offer both loss insurance and also share the capital gains in house price appreciation allow lenders to reduce interest rates by 1.5 to 3 percentage points. Consumer welfare is improved by an equivalent variation of $7,000 per household per year, and house prices rise by about 6 percent. The results suggest that mortgages which share house price risk between borrower and lender can improve mortgage and housing market efficiency. By explicitly modeling the incentives of the lender in the mortgage market, the model also offers a general framework for studying how institutional changes in the mortgage market translate to housing market outcomes.

The third chapter of the dissertation is joint work with Elliot Anenberg and is titled *Estimates of the Size and Source of Price Declines Due to Nearby Foreclosures*. In this chapter, we present new evidence that foreclosures have a causal effect on nearby property values. Our identification strategy is more robust than those in the existing literature because we introduce a new data source on home listings which contains the precise dates that REO’s are on the market for sale. We find that sellers adjust their list prices in the exact week that an REO enters their neighborhood for sale, which is robust evidence that prices are responding to foreclosures, rather than the reverse, or to some correlated unobservable. REOs lower sale prices of homes within 0.1 miles of the REO by about 1 percent on average. This price decline occurs during the period when the REO is listed for sale, and not during the year preceding the initial list date, suggesting that it is the supply effect of the foreclosure acting as an additional competitor to nearby houses which causes price declines. We cannot, however, rule out the presence of disamenity effects generated by nearby distressed properties because we do not observe the date of mortgage delinquency. These findings are relevant because foreclosure frictions are a significant
source of economic inefficiency. Understanding the size and source of these frictions is important for assessing the impact of different policies meant to deal with the foreclosure crisis, including the alternative contract designs discussed in Chapter 2 of this dissertation.

The fourth and final chapter of the dissertation is joint work with Hanming Fang and is titled *Life Insurance and Life Settlements: The Case for Health Contingent Surrender Values*. In this chapter, we begin by asking the question of why life insurance policies in practice either do not have a cash surrender value, as in the case of Term Life policies, or surrender values that are not adjusted for health status, as in the case of Whole Life policies. We find that the addition of health contingent surrender values to a life insurance contract causes a dynamic commitment problem which makes it more costly up front for policyholders to purchase long term contracts. To the extent that life insurance buyers’ incomes are increasing over the life of the policy, buyers are not willing to accept higher ex ante costs in return for the higher liquidity provided by the surrender value. Because health contingent surrender values act in a similar way to a life settlement market, we also study the equilibrium choice of surrender values in the presence of a life settlement market. We find that optimally chosen cash surrender values can mitigate the consumer welfare loss caused by the settlement market, but only if surrender values are allowed to be contingent on health status.
2.1 Introduction

The recent implosion of U.S. housing and mortgage markets has highlighted many inadequacies in our current housing finance system. In particular, the crisis has shown that households are poorly hedged against house price risk, especially considering the large role that housing plays in most home owners’ portfolios. Due to the structure of conventional fixed and adjustable rate mortgages, where the balance of the mortgage is defined in nominal terms and does not change with house prices, the borrower is the sole bearer of almost all the house price risk.\footnote{I say almost because the lender is also indirectly exposed to the downside risk of house price depreciation through the risk of borrower default.} During the years of rapid house price appreciation in the early and mid 2000’s, this turned out to be a great boon to most homeowners. But after house prices collapsed in 2007 and 2008, many home owners found themselves underwater on their mortgages, leading to a high incidence of foreclosures. The contraction in housing wealth caused by the collapse in prices has also had a significant effect on consumer demand and on the
aggregate economy.

There are many reasons to think that overall housing and mortgage market efficiency would be improved if home owners had better tools to manage house price risk. First of all, housing constitutes such a large fraction of most home owners’ portfolios that, assuming they are risk averse, it is natural that they would benefit from diversifying some of that risk. Second, home owners are usually very exposed to local idiosyncratic risks, such as local labor market risks. House prices are correlated with local risks, so in the absence of complete markets it would be efficient for home owners to offload some of that house price risk onto a global financial market, which is less exposed to local idiosyncratic risks.

By not hedging against house price risk, home owners also run the risk of falling underwater on their mortgages, also known as having negative equity. When home owners are underwater, if they receive a shock that would force them to sell the house, they may find themselves unable to do so without defaulting on the loan. Underwater home owners also have a financial incentive to default: by walking away from the loan, the home owner essentially sells the house back to the lender for the value of the mortgage balance instead of for the value of the house, which is less. The literature on defaults and foreclosures has shown that foreclosures are costly to the lender and also exert negative externalities on neighboring properties.\(^2\) Moreover, foreclosures can lead to further price declines which in turn lead to more foreclosures, creating a vicious cycle which can severely depress house prices.\(^3\) All these costs associated with foreclosures are coming during periods of decline, when housing markets and

\(^2\) Forgey et al. (1994), Hardin and Wolverton (1996) and Pennington-Cross (2006) show that the lender typically cannot recover the full value of the house through a foreclosure sale. Lin et al. (2009), Harding et al. (2009), Campbell et al. (2011a) and Anenberg and Kung (2011) all demonstrate a negative spillover effect of foreclosures on neighboring properties.

\(^3\) Chatterjee and Eyigungor (2009) present a mechanism by which this vicious cycle can occur. In their model, a foreclosure leads the foreclosed individual to rent instead of own, and thus consume less housing space. Foreclosures thus lead to greater supply in the housing market, which depresses prices.
the economy in general are least equipped to deal with them.

In this paper, I quantify the equilibrium impact of mortgage designs which share house price risk between the borrower and the lender. These mortgage designs can be thought of as a bundle of two financial instruments: an instrument that serves the purpose of a conventional mortgage, and an instrument that is negatively correlated with house prices so as to hedge against house price risk. This type of mortgage can be achieved in many ways, for example, by indexing the value of the mortgage to local house prices, or by specifying the value of the balance to be a fixed proportion of the house’s appraisal value. These types of mortgages have been called many names, such as continuous workout mortgages, shared appreciation mortgages, or equity sharing mortgages. Although none of these mortgages exist in the current U.S. mortgage market, they have garnered some attention from economists in recent years.\footnote{Shiller (2008), Shiller (2009), Caplin et al. (2007), and Feldstein (2009) all discuss risk sharing mortgage contracts as possible solutions to the current foreclosure crisis.} All these mortgage designs share a common feature in that they try to stabilize the equity position of the homeowner by sharing the house price risk between borrower and lender. Conventional mortgages also have a form of risk sharing on the downside, via the option to default. But this is an extremely inefficient form of insurance due to frictions associated with the foreclosure process. The alternative mortgage designs circumvent the costly foreclosure process by continuously and automatically providing a “workout” of the mortgage terms in the event of house price declines.

In the paper, I focus on two specific designs which are motivated by continuous workout mortgages that index the value of the mortgage to local house prices. I will call the first type of design a partial continuous workout mortgage (PCWM). In a PCWM, the value of the mortgage balance is indexed to local house prices when local house prices fall below a prespecified limit. In this way, a PCWM provides a form of insurance to the borrower against house price depreciation. Because this
insurance is valuable to the borrower but costly to the lender, in equilibrium the lender must charge a higher interest rate on the loan to compensate. Alternatively, one can think of a mortgage design in which the mortgage balance is indexed to local house prices on both the upside and the downside. I will call such a mortgage a full continuous workout mortgage (FCWM). A FCWM provides loss insurance to the borrower against downside risk, but also shares the capital gains from house price appreciation on the upside between borrower and lender. The capital gains sharing can be used to offset the cost of the insurance being provided to the borrower, so that interest rates need not rise in equilibrium.

Using an equilibrium model of housing and mortgage markets, I study the effect of introducing these alternative mortgage designs on equilibrium house prices, mortgage interest rates, and consumer welfare. In the model, consumers take current house prices and mortgage interest rates as given and decide how much housing to purchase and how much to borrow in order to finance that purchase. In each period subsequent to the initial period, the consumers face house price risk and decide in each period whether to sell their house, default on the mortgage, or service the mortgage debt and stay in the house. Consumers care about the level of housing equity at the time of sale, so the realization of house price risk affects their propensity to sell or default.

There is a competitive lender in the model that provides mortgages to the entire market. In equilibrium, house prices and mortgage interest rates are set so that the demand for housing by consumers clears with the supply, and so that the expected return to the lender on the market’s mortgage portfolio, taking into account default and prepayment risk, is equal to the lender’s outside option. A unique feature of the model that is not captured by most others models in the housing literature is that the incentives of the consumers and lender are explicitly affected by the structure of the mortgage contract. This is what allows me to study the effect of alternative mortgage designs on equilibrium outcomes.
The model is estimated using data on home ownership histories from the Los Angeles metropolitan area from 1991 to 2008. An ownership history is an observation of a home owner from the time of purchase to the time of sale or default, or until the end of the data period. The observed default behavior in the data is used to estimate the effect of housing equity on default, and the estimated default probabilities can then be used to calculate the lender’s expected return. The model is estimated under the assumption that the mortgages observed in the data are conventional mortgages. To assess the equilibrium impact of the two CWM designs, in each period of the data, all of the mortgages are converted to the alternative mortgage design as if by surprise, and new equilibrium house prices and mortgage interest rates are computed, holding fixed the lender’s outside option at the estimated value. Consumer welfare can then be calculated under the new equilibrium.

Using this methodology, I estimate that converting to PCWMs forces lenders to increase mortgage interest rates by 0.4 to 1 percentage point, in order to compensate for the loss insurance provided to the borrowers. Despite the increase in interest rates, the loss insurance is valuable to consumers, and consumer welfare is improved by an equivalent variation of $5,500 per person per year. Because the lender in the model is competitive, this implies a total efficiency gain for both housing and mortgage markets. The results also indicate that, mostly due to the rise in interest rates, demand and thus prices fall by an average of about 4 percent. In contrast, I find that converting to FCWMs allows lenders to reduce their interest rates significantly, by 1.5 to 3 percentage points. This implies that allowing lenders to share in the capital gains from house price appreciation is more than enough to offset the cost of the insurance being provided to the borrowers on the downside. Under FCWMs, consumer welfare improves by an equivalent variation of $7,000 per person per year, and that house prices rise by an average of 6 percent. In a final bit of analysis, I decompose the consumer welfare gains under FCWMs into four separate components:
the welfare gains from eliminating foreclosure frictions, from risk sharing, from additional housing consumption, and from distributional efficiency. The welfare gains from eliminating foreclosure frictions arises because under the new mortgage designs, borrowers are never underwater and so the economic cost of default is never realized. The welfare gains from risk sharing encompass the effect of consumers passing house price risk (both upside and downside) onto the lender in return for a lower interest rate. The welfare gains from additional housing consumption comes from the fact that under FCWMs, the total amount of housing consumption increases due to higher demand. Finally, FCWMs lower interest rates which allow consumers with low income but a high preference for housing to consume more housing, leading to gains in distributional efficiency. I find that eliminating foreclosure frictions accounts for about 57 percent of the equivalent variation, risk sharing accounts for 18 percent, increased housing consumption accounts for 23 percent, and distributional efficiency contributes 2 percent.

This paper lies on the intersection between two broader strands of literature: the literature on mortgage pricing, and the literature on housing markets with incomplete financial markets. The literature on mortgage pricing concerns itself with the valuation of mortgage contracts using an option theoretic approach. Early literature in this area studied the valuation of conventional fixed and adjustable rate mortgages under the presence of prepayment and default risk, where prepayment and default are driven by both idiosyncratic shocks as well as financial considerations. Very recently, there have been a few papers that take the option theoretic approach to the pricing of continuous workout mortgages.\(^5\) In each of these papers, the house price process is taken as exogenous, so the literature is silent on how the different mortgage designs studied can have different endogenous effects on house prices. The paper presented

\(^5\) See Kau et al. (1992) for a valuation model of fixed rate mortgages, Kau et al. (1990) for a model of adjustable rate mortgages, and Ambrose and Buttiner (2010) and Shiller et al. (2011) for recent discussions about continuous workout mortgages.
here is the first to embed an option theoretic pricing model of different mortgage designs within the context of an endogenous housing market.

The literature on housing markets with incomplete financial markets has shown that incomplete markets can explain many stylized facts about housing markets, such as the relationship between price and volume, the pattern of housing consumption over life cycles, and households’ portfolio allocation between housing and other financial assets. In this literature, the incomplete markets assumption typically enters the model via a collateralized borrowing constraint, which is taken as an exogenous parameter of the model. These papers therefore do not speak to the mechanisms by which the borrowing constraint may be raised or lowered. Moreover, borrowing in these papers is typically only available through one period bonds without default risk. These models are therefore unable to speak to the impact of foreclosure frictions or to the role of dynamic contract design in the mortgage market. In the model I present here, the incomplete markets assumptions enters the model via the assumption that there is no other instrument to fully hedge against house price risk. Dynamic contract design plays a role via the long term nature of mortgage contracts, and default risk is an issue that borrowers and lenders explicitly take into account. The model implies that contract designs which share house price risk between borrower and lender can reduce the cost of credit to the consumer. In the model, the reduction in the cost of credit is reflected by lower interest rates, but in reality, lower credit costs may also be reflected by a loosening of collateral constraints. My results therefore suggest that one mechanism for lowering collateral constraints is dynamic contract designs.

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6 In a seminal work, Stein (1995) develops the intuition of how “hot” and “cold” housing markets can be driven by liquidity shortages. Ortalo-Magné and Rady (2006) show that borrowing constraints, and in particular as they apply to young people, can explain patterns in life cycle housing consumption as well as the relative volatility between trade up and starter homes. In more recent work, Favilukis et al. (2010) study a setting with collateral constraints as well as foreign capital flows. They find that financial market liberalization in the form of lower collateral requirements, accompanied by larger foreign purchases of U.S. domestic bonds, causes U.S. households to shift their portfolio allocation towards housing.
that give borrowers a better instrument for hedging against house price risk. More generally, by simultaneously modeling both the housing and mortgage markets, the model I develop in this paper offers a general framework for directly studying how institutional changes in the mortgage market translate to housing market outcomes. This is an area of significant theoretical, empirical and policy interest.

This paper is also strongly related to the literature on dynamic contracts without full commitment. This literature has shown that in a dynamic contract where one side cannot commit fully to the contract terms, and there is a stochastic state variable which affects the value of the contract, then the contract can be made more efficient if the contract terms are set so that some of the risk in the stochastic variable is held by the party with commitment power.\footnote{See Hendel and Lizzeri (2003a), Daily et al. (2008a), and Fang and Kung (2010) for discussions in the context of life insurance, where the lack of commitment is the option of policyholders to lapse in their payments and the stochastic variable is the policyholder’s health.} In the context of housing, the lack of commitment is the option to default, and the stochastic variable is the price of housing. In line with the literature on dynamic contracts without full commitment, the paper shows that mortgage contracts that share the house price risk between borrower and lender are more efficient than mortgage contracts which do not.

This paper shows that mortgages which bundle a conventional mortgage with an instrument for hedging against house price risk improve efficiency relative to a world with only conventional mortgages and no way to hedge house price risk. The bundling itself does not necessarily have any intrinsic value: the same outcome could be achieved in a world with only conventional mortgages and an instrument which is perfectly correlated with the local housing market, which households are allowed to sell short, and which lenders are allowed to take if the borrower defaults on the mortgage. Given the costs, however, of administrating mortgage debt, there may be economies of scope in integrating the servicing of both the mortgage and the hedging instrument. Moreover, if one takes the view of Thaler and Sunstein (2008),
that the average household mostly follows received wisdom, making few independent economic decisions, then it may be beneficial to move to a world in which the standard mortgage contract has some risk management built into it.

Given the many efficiency benefits to risk sharing mortgages, and to instruments for hedging house price risk more generally, it is curious that markets for these instruments do not currently exist in the U.S. Shared appreciation mortgages, a particular form of risk sharing mortgage contract in which the lender is entitled to a certain percentage of the house value at the time of sale, have in fact been tried in the U.K. Unfortunately, they have not attracted must interest because, as argued in Sanders and Slawson (2005), the home owner has some control over the sale value of the house, thus creating moral hazard. The continuous workout mortgages I describe in this paper circumvent the moral hazard by indexing the value of the mortgage balance to a local house price index, rather than to the realized transaction value of the house. In the U.S. mortgage market, Caplin et al. (2008) attribute the non-existence of risk sharing mortgages to tax law impediments, but argue that these impediments are easily rectified with little consequence beyond allowing the new mortgages.

The paper is organized as follows. Section 2.2 describes the model in detail. Section 2.3 discusses the estimation and identification strategy. Section 2.4 describes the data used for estimation. Section 2.5 presents the estimation results. Section 2.6 presents the results from the counterfactual simulations using PCWMs and FCWMs. Section 2.7 concludes.

2.2 Model

In the model, I envision a local housing market populated by risk averse consumers who care about two things: consumption of a numeraire good and consumption of housing services. In an initial period, consumers decide how much housing to pur-
chase, taking as given current house prices and mortgage interest rates. The main tradeoff they face is that buying a larger house means a greater flow of housing services, but it also implies a higher per period mortgage payment, and therefore lower consumption of the numeraire good. The price of housing and mortgage interest rates affect consumers’ demand for housing through this tradeoff. In each period subsequent to the purchase, the consumer decides whether to stay in the house by paying down the mortgage, to sell the house, or to default on the mortgage. The utility to selling depends on the equity position of the consumer, so the consumer faces house price risk in making these decisions. If the consumer defaults, the lender immediately takes possession of the house and sells it for a fraction of the market value. This fraction represents friction in the foreclosure process. Because the structure of the mortgage contract can affect the consumer’s equity position, changes to the structure of the mortgage contract explicitly changes the consumer’s propensity to sell or default in each period.

Consumers have limited wealth and are unable to borrow without collateral, so in their housing purchase decision they need to borrow from a mortgage market. The lenders in the mortgage market are competitive and have access to a global financial market with many assets that are uncorrelated with the local housing market. Because of this, they act as if they are risk neutral to local house price risks. The consumers in the model do not have access to the global financial market. In equilibrium, the lenders provide mortgages to the local housing market such that the return on the local mortgage portfolio equals the return the lenders can expect to receive by participating in the outside financial market (this is the competitive assumption). Because the borrowers’ equity positions affect their propensity to default, the structure of the mortgage contract explicitly changes the lenders’ calculation of expected returns. The return the lender receives from the outside financial sector is, however, invariant to the structure of the mortgages in the local market. Changes
in the structure of the mortgage contract are therefore accompanied by changes to the mortgage interest rate that the lenders charge on the contract.

The model is designed to capture two key features—that the mortgage contract structure should affect the cost of consumer credit (the mortgage interest rate), and that house prices and the cost of consumer credit should affect consumers’ demand for housing—as simply as possible while also preserving a tight connection to the data, which I discuss in section 2.4. For expositional clarity, I present the model in two stages. First, I set out the basic structure of the model, abstracting from technical details and presenting the model in a heuristic way. After describing the basic structure of the model, I then fill in the details, including being rigorous about the state space, the error structure, and how the model can be solved.

2.2.1 Model Overview

The housing market is decentralized, and housing is a homogeneous and perfectly divisible good. The unit price of housing at time $t$ is $p_t$. In each period $t$, there is a competitive lender that provides mortgages to the entire market at a single interest rate $r_t$. The assumptions of homogenous and perfectly divisible housing and of a single interest rate keep the model simple while still preserving the feature that house prices and the cost of credit should affect consumer demand.

The competitive mortgage lender at time $t$ has an outside option given by $\Pi_t$. The outside option represents the outside value of money—the return that the lender can expect to receive by participating in an outside financial market. In equilibrium, the expected return to the lender on its market mortgage portfolio must equal its outside option. The outside option is assumed to be invariant to changes in the structure of the mortgage contract.

The lender cares about total receipts over total outlays at zero discounting. For a stream of receipts $m_t$, and an initial outlay of $L_0$, the return to the lender is
calculated as:

\[ \Pi = \sum_{t=1}^{T} \frac{m_t}{L_0} \]  

(2.1)

The baseline model assumes that all mortgages provided by the lender are all structured as \( J \)-period, fixed rate, constant amortization mortgages (FRMs). This means that for an initial loan amount of \( L \) and an interest rate of \( r \), the per-period debt service is constant at:

\[ m = \frac{r(1 + r)^J}{(1 + r)^J - 1} L \]  

(2.2)

and the remaining debt balance after \( s \) periods is:

\[ L_s = \frac{(1 + r)^J - (1 + r)^s}{(1 + r)^J - 1} L \]  

(2.3)

If the borrower sells the house after \( s \) periods, the lender receives the \( s - 1 \) payments and receives the remaining loan balance at time \( s \). The total return to the lender is thus calculated as:

\[ \Pi = \frac{m \times (s - 1) + L_s}{L} \]  

(2.4)

If the borrower defaults on the loan after \( s \) periods, the lender receives the \( s - 1 \) payments from time 1 to time \( s - 1 \), and at time \( s \) forecloses on the property, immediately selling it for \( \theta \) times the market value. \( \theta \) can be thought of as a foreclosure friction, and the literature has shown that lenders usually cannot recover the full market value for a foreclosed property. The total return to the lender in this case is calculated as:

\[ \Pi = \frac{m \times (s - 1) + \theta P_s}{L} \]  

(2.5)

where \( P_s \) is the price of the house at time \( s \).
In each period, \( N_t \) consumers are born, each of whom lives for \( J + 1 \) periods. Consumers are characterized by their per-period income, \( y_i \), which is constant, their initial wealth available for down payment, \( w_i \), and an unobserved type parameter \( \tau_i \), which can flexibly interpreted as any unobserved characteristic which would cause an individual to purchase more housing than another individual with the same observables. It can broadly be interpreted as the individual’s idiosyncratic taste for housing relative to other forms of consumption.

In the first period of life, each consumer decides how much housing \( h \) to purchase, and equivalently, how much to borrow in order to finance that purchase. The amount of downpayment \( w_i \) is assumed to be exogenous, so that \( h \) is the only choice variable. This simplifies the consumer’s initial housing decision into a one-dimensional choice problem that still fully captures the effect of house prices and cost of credit on housing demand. The amount of borrowing required to finance a purchase of \( h \) units is \( L = p_t h - w_i \). In each period subsequent to the purchase, the consumer either pays down the mortgage and stays in the house, or sells the house, or defaults on the mortgage, in which case the house is put into foreclosure. Selling and defaulting are treated as terminal actions, with the utility to selling being modeled as a reduced form utility that depends on your housing equity at the time of sale, and with the utility to defaulting being normalized to zero. Consumers are assumed to sell their property with probability 1 in the last period of life, age \( J + 1 \). The stay/sell/default decisions are the only decisions that the consumers make subsequent to their initial purchase. The model thereby abstracts from the optimal savings decisions of the consumers, and does not allow consumers to adjust the quantity of housing owned.\(^8\)

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\(^8\) These assumptions are due to data limitations which I discuss in section 2.4. The savings decisions and wealth level of consumers is not observed, and the home owner is only observed from the time of purchase to the time of sale or default. It is not known what happens to them afterwards. These are additional margins through which consumers may respond to changes in the mortgage market. I argue in section 2.6.3 that not modeling these margins would actually lead the model to understate the welfare results, at least in a partial equilibrium sense.
The consumer’s decision problem is therefore an optimal stopping problem coupled with a continuous choice problem in the initial period.

Consumers care about two things: consumption of a numeraire good and consumption of housing services. The quantity of housing services consumed each period is simply equal to the quantity of housing owned, \( h \). Suppose a consumer owns a quantity \( h \) of housing and sells the house at time \( T \). Let \( c_t \) be the path of consumption from \( t = 1 \) to \( t = T - 1 \) and let \( e_T = p_T h - L_T \) be the amount of equity owned at the time of sale. The consumer’s time-separable utility over this outcome is given by:

\[
U_i = \sum_{t=1}^{T-1} \delta^{t-1} u_i(c_t, h) + \delta^T v_i(e_T)
\]

(2.6)

where \( u(c_t, h) \) is the flow utility from consumption and housing services, and \( v(e_t) \) is a reduced form model of the utility to selling with equity \( e_T \).

If the consumer instead defaults at time \( t = T \), he would value this path of outcomes according to:

\[
U_i = \sum_{t=0}^{T-1} \delta^{t-1} u_i(c_t, h) + 0
\]

(2.7)

In the first period of life, the consumer therefore chooses \( h \) to maximize the following:

\[
h_i^* = \arg \max_h E \left[ \sum_{t=1}^{T-1} \delta^{t-1} u_i(c_t, h) + \delta^T \max \{ v_i(e_T), 0 \} \right]
\]

(2.8)

where the expectation is taken both over the termination period \( T \) (which is actually an endogenous policy response function), and the equity position at the termination date \( e_T \). Equation (2.8) illustrates the main tradeoff that consumers face. A higher choice of \( h \) means more borrowing, and hence less consumption of the numeraire good, but a higher flow of housing services in each period. Note that the amount
of borrowing required depends on current prices, and that the per-period mortgage payment which helps determine consumption depends on the current interest rate. Therefore, the optimal choice of $h^*_t$ depends on both $p_t$ and $r_t$. For simplicity, I write $h^*_t(p_t, r_t)$.

Because in the data income is only observed at the time of purchase, the consumer’s income is assumed to be constant and deterministic over time. In the baseline model the per-period mortgage payment is constant as well. The only relevant stochastic variable then is the evolution of house prices $p_t$, which determines the consumer’s equity position. Consumers and lenders forecast future price appreciation based on lagged appreciation, according to the following forecasting rule:

$$
\log \left( \frac{p_{t+1}}{p_t} \right) = \beta_1 + \beta_2 \log \left( \frac{p_t}{p_{t-1}} \right) + \beta_3 \log \left( \frac{p_{t-1}}{p_{t-2}} \right) + \sigma_p \mathcal{N}(0, 1) \tag{2.9}
$$

This specification of the forecasting rule is motivated by three considerations. First, such a forecasting rule is consistent with survey evidence in Case et al. (2003) that home buyers indeed forecast future appreciation based on recent experience of a few years (and the period in the model is a year). Second, allowing expectations to depend only on lagged appreciation simplifies the computational tractability of the model by reducing the size of the state space that consumers must keep track of. Third, two lags were chosen because house price appreciation has historically shown both positive short run persistence as well as long run mean reversion. For the rest of the paper, the forecasting rule is taken to be exogenous, and the coefficients are estimated in a first step from realized price appreciation.\(^{10}\)

Under these assumptions, we can write the expected return to the lender for a

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\(^9\) Of course, the optimal choice of $h$ may depend on other variable, such as lagged prices which are used to forecast future prices. I leave those other variables out here for notational simplicity. In the section on implementation I will give a more rigorous description of the model.

\(^{10}\) In a rational expectations model, the agents in the economy would forecast future prices based on the evolution of underlying fundamentals, such as the expected number of new buyers and the distribution of their characteristics, and the evolution of the lenders’ outside options. This makes the equilibrium pricing kernel a high dimensional object that is very difficult to solve. The
given mortgage contract as:

\[ \Pi_i^*(p_t, r_t) = E \left[ \frac{m \times (T - 1) + (d = 0)L_T + (d = 1)\theta p_T h}{L_i} \right] \]  

(2.10)

where \( d = 0 \) indicates that the contract ends with a sale and \( d = 1 \) indicates that the contract ends with a default. The expectations here are over \( p_T, d \) and \( T \).

In equilibrium, the house price \( p_t \) and mortgage interest rate \( r_t \) are set so that the demand for housing clears with the supply and so that the expected return to the lender on the market’s mortgage portfolio is equal to its outside option. The housing supply function is modeled as a constant price elasticity of supply function given by \( H(p_t) \).\(^{11}\) The housing market clearing condition can therefore be written as:

\[ \sum_{i=1}^{N} h_i^*(p_t, r_t) = H(p_t) \]  

(2.11)

and the competitive lender condition is written as:

\[ \frac{1}{N} \sum_{i=1}^{N} \Pi_i^*(p_t, r_t) = \Pi_t \]  

(2.12)

2.2.2 Implementation Details

Having described the model in broad terms, I can now fill in the details regarding implementation. First, some notation. Let:

\[ \omega_{it} = (p_t, p_{t-1}, p_{t-2}, y_i, w_i, \tau_i, h_i, s_i, r_i^0, p_i^0) \]

model presented here can approximate a rational expectations equilibrium with a specific functional form for the forecasting rule by choosing the coefficients on the forecasting rule such that they are consistent with realized price paths. I discuss this more in section 2.6.3.

\(^{11}\) The implicit assumption here is that the supply of housing on the market is dominated by new constructions. This assumption is made due to data limitations in which the entire stock of owners is never observed. Because the stock of owners is not observed, it is difficult to model existing home sales. The model itself, however, is robust enough to model existing sales if the appropriate data were available. I discuss this more in sections 2.4 and 2.6.3.
denote the full vector of state variables that are relevant to the consumer’s optimal stopping problem. The \( p_t \)'s are the current price and two lagged prices which are used to calculate expectations. \( y_i, w_i, \) and \( \tau_i \) are the fixed characteristics of the individual, their income, initial down payment, and type parameter. \( h_i \) is the quantity of housing owned, and \( s_{it} \) is the number of periods since the house was purchased. \( r_i^0 \) and \( p_i^0 \) are the mortgage interest rate and house price at the time of purchase.

From these, the initial loan amount can be derived as:

\[
L_0^i = p_i^0 h_i - w_i
\]

and the per period mortgage payment \( m_i \) and the current loan balance \( L_{it} \) can be derived as:

\[
m_i = \frac{r_i^0 (1 + r_i^0)^J}{(1 + r_i^0)^J - 1} L_i^0
\]

and

\[
L_{it} = \frac{(1 + r_i^0)^J - (1 + r_i^0)^{s_{it}}}{(1 + r_i^0)^J - 1} L_i^0
\]

The equity position of the consumer at time \( t \) is therefore given by

\[
e_{it} = p_t h_i - L_{it}
\]

The only stochastic variables in the state vector are the \( p_t \)'s, and they are forecast according to the rule given in (2.9).

In addition to the state variables \( \omega_{it} \), let \( \epsilon_{it} = (\epsilon_{1it}, \epsilon_{2it}, \epsilon_{3it}) \) be a vector of idiosyncratic taste shocks which affect the consumer’s propensity to stay, sell, or default. The \( \epsilon_{it} \)'s are independently and identically distributed according to the type 1 extreme value distribution. Let \( u^{\text{stay}}(\omega_{it}, \epsilon_{it}) \) denote the flow utility from staying in the house (consuming the numeraire good and housing service flows), let \( u^{\text{sell}}(\omega_{it}, \epsilon_{it}) \) denote the flow utility from selling, and let \( u^{\text{def}}(\omega_{it}, \epsilon_{it}) \) denote the flow utility from
defaulting. I specify these functions in the following way:

\[ u^{\text{stay}}(\omega_{it}, \epsilon_{it}) = \alpha_1 + \alpha_2(y_i - m_i) + \tau_i \log h_i + \epsilon_{1it} \]  
\[ = \hat{u}^{\text{stay}}(\omega_{it}) + \epsilon_{1it} \]  
\[ u^{\text{sell}}(\omega_{it}, \epsilon_{it}) = \alpha_3 + \alpha_4 \log(1 + \epsilon_t)(\epsilon_t \geq 0) + \alpha_5(\epsilon_t < 0) + \epsilon_{2it} \]  
\[ = \hat{u}^{\text{sell}}(\omega_{it}) + \epsilon_{2it} \]  
\[ u^{\text{def}}(\omega_{it}, \epsilon_{it}) = \epsilon_{3it} \]  

(2.13) (2.14) (2.15)

There are some key features of this specification of consumer utility that are worth mentioning. First, the inclusion of idiosyncratic error terms implies that there is always a positive probability for any of the three actions to be chosen by the consumer. This assumption properly reflects the data, as we can see borrowers default who are not underwater, and we can see borrowers who are underwater sell their houses without defaulting. Second, this specification implies a strictly positive bliss point for housing consumption, because the marginal benefit of housing services is infinite at zero housing services, and approaches zero as housing services increase to infinity. Third, all other things being equal, a consumer with a higher type parameter \( \tau_i \) will demand more housing. Finally, the specification implies that the consumers are risk averse over their terminal wealth but risk neutral over their consumption of the numeraire good. The linearity in the consumer’s utility over consumption was chosen for computational tractability. Recall that the consumer solves a continuous choice problem in the initial period of his or her life. Assuming linear utility in consumption simplifies the computation of the consumer’s first order conditions. Although somewhat non-standard in risk sharing models, assuming linearity in consumption does not change the interpretation of the model because consumers are still risk averse over their terminal wealth. Consumers may be risk averse over their terminal wealth because they have non-linear utility over a bequest motive, and also because they have non-linear utility over housing service flows.
An additional implication of this utility specification is that it does not matter to the consumer how far underwater he or she is, only that he or she is underwater. This assumption was chosen because it better fits the data, and in many cases it is actually possible for the lender and an underwater borrower to come to an agreement in which the house is sold for less than the remaining balance of the loan, and the borrower pays back only what he was able to sell the house for, without going through the foreclosure process.

I am now in a position to describe the consumer’s decision problem in terms of Bellman equations. Let $V_a(\omega_{it}, \epsilon_{it})$ denote the ex ante expected present value of utility flows to a consumer who enters period $t$ at age $a$. We can define $V_a$ in terms of a recursive Bellman equation:

$$V_a(\omega_{it}, \epsilon_{it}) = \max \left\{ \hat{u}^{\text{stay}}(\omega_{it}) + \epsilon_{1it} + \delta E\left[V_{a+1}(\omega_{i,t+1}, \epsilon_{i,t+1}) \mid \omega_{it}\right], \hat{u}^{\text{sell}}(\omega_{it}) + \epsilon_{2it}, \epsilon_{3it} \right\}$$

(2.16)

The first term is the expected present value to staying, the second term is the expected present value to selling, and the third term is the expected present value to defaulting. Starting from the assumption that age $J+1$ consumers sell with probability 1, and so

$$V_{J+1}(\omega_{it}) = u^{\text{sell}}(\omega_{it})$$

(2.17)

we can solve for $V_a(\omega_{it}, \epsilon_{it})$ at each $a$ via backward recursion.

It is assumed that at $a = 1$, the time when the loan is originated, that the borrower immediately begins making mortgage payments in the same period, and that payment is made with probability 1 (sell and default decisions don’t begin until age 2). The expected present value to owning $h_i$ units of housing from age 1 is therefore equal to

$$V_1(\omega_{it}) = \hat{u}^{\text{stay}}(\omega_{it}) + \delta E\left[V_2(\omega_{i,t+1}, \epsilon_{i,t+1} \mid \omega_{it}\right]$$

(2.18)
and the optimal choice of housing from a new buyer is given by solving:

\[ h^*(\omega_{it}|h_i) = \max_{h_i} V_1(\omega_{it}) \]  

(2.19)

where \( \omega_{it}|h_i \) is simply the vector of state variables minus \( h_i \).

Now let us write

\[ \hat{V}^{stay}_{a}(\omega_{it}) = \hat{u}^{stay}(\omega_{it}) + \delta E[V_{a+1}(\omega_{i,t+1}, \epsilon_{i,t+1})| \omega_{it}] \]  

(2.20)

Due to the type 1 extreme value assumption, we can now write the probability of staying, selling, and defaulting as:

\[ P^{stay}_a(\omega_{it}) = \frac{e^{V^{stay}(\omega_{it})}}{e^{V^{stay}(\omega_{it})} + e^{\hat{u}^{sell}(\omega_{it})} + 1} \]  

(2.21)

\[ P^{sell}_a(\omega_{it}) = \frac{e^{\hat{u}^{sell}(\omega_{it})}}{e^{V^{stay}(\omega_{it})} + e^{\hat{u}^{sell}(\omega_{it})} + 1} \]  

(2.22)

\[ P^{def}_a(\omega_{it}) = \frac{1}{e^{V^{stay}(\omega_{it})} + e^{\hat{u}^{sell}(\omega_{it})} + 1} \]  

(2.23)

where the probabilities are taken over the distribution of \( \epsilon_{it} \). Using these choice probabilities, the expected lender returns can be calculated recursively. Define \( \pi_a(\omega_{it}) \) as the expected present value of lender receipts for a contract held by a borrower of age \( a \) entering period \( t \). We can define \( \pi_a \) recursively as:

\[ \pi_a(\omega_{it}) = P^{stay}_a(\omega_{it})(m_i + E[\pi_{a+1}(\omega_{i,t+1})| \omega_{it}]) + P^{sell}_a(\omega_{it})L_{it} + P^{def}_a(\omega_{it})\theta p_t h_i \]  

(2.24)

Because selling occurs at age \( J + 1 \) with probability 1, and the loan will always be fully paid off at age \( J + 1 \), we can write

\[ \pi_{J+1}(\omega_{it}) = 0 \]  

(2.25)

Finally, because payment occurs with probability 1 at \( a = 1 \), we can write:

\[ \pi_1(\omega_{it}) = m_i + E[\pi_2(\omega_{i,t+1})| \omega_{it}] \]  

(2.26)
The equilibrium conditions are therefore given by:

\[ \sum_{i=1}^{N_t} h^*(\omega_{it} \mid h_i) = H(p_t) \]  \hspace{1cm} (2.27)

and

\[ \frac{1}{N_t} \sum_{i=1}^{N_t} \pi_1(\omega_{it}) = \Pi_t \]  \hspace{1cm} (2.28)

Equations (2.27) and (2.28) are two equations in two unknowns that can be used to solve for price and interest rate \((p_t, r_t)\) in any given period \(t\), conditional on the housing supply function and the lender outside option, and on the set of age 1 consumers at time \(t\).

2.3 Identification and Estimation

The parameters to be estimated are the vector \(\alpha\), the individual type parameters \(\tau_i\), and the outside options \(\Pi_t\) of the lender, from periods \(t = 1\) to \(t = T\). Roughly speaking, the individual type parameters \(\tau_i\) are identified off variation in the housing choices of observably identical individuals, and the utility parameters \(\alpha\) are identified off the discrete stay/sell/default decisions of the observed owners. Once the parameters \(\alpha\) and \(\tau_i\) are recovered, the lender’s outside options \(\Pi_t\) can be calculated directly from the estimated choice probabilities. Two parameters that are not estimated are the consumers’ discount factor \(\delta\), which is set to 0.95, and the foreclosure friction \(\theta\), which is set to 0.78.\(^{12}\) The housing supply function is also taken from outside the model. The housing supply elasticity is set to 3, in accordance with metropolitan specific supply elasticity estimates measured in Green et al. (2005).

The data available are a sequence of house prices and interest rates from periods \(t = -2\) to \(t = T\) (with \(t = 1\) being the first decision period in the data and \(t = T\)

\(^{12}\) A friction of 0.78 was chosen in accordance with previous literature which estimates that foreclosures sales result in prices that are about 22% below non-foreclosure sales. See Forgey et al. (1994), Hardin and Wolverton (1996), and Pennington-Cross (2006).
being the last). Denote this sequence as \( \{(p_t, r_t)\}_{t=-2}^{T} \). I also observe a set of \( N \) ownership histories given by \( \{y_i, w_i, h_i, t^0_i, t_i, d_i\}_{i=1}^{N} \). An ownership history follows a single home owner from the time of purchase to the time of sale or default, or until the end of the data period. \( y_i \) is the observed per-period income of the owner. \( w_i \) is the observed down payment, and \( h_i \) is the amount of housing the owner chose to purchase initially. \( t^0_i \) is the period in which the house was bought, and \( t_i \) is the date in which the ownership ended, either through sale or default, or the end of the data period. For each \( i \), \( d_i = d_{i,t_0}, \ldots, d_{i,t_i} \) is the sequence of stay/sell/default decisions from period \( t^0_i \) to period \( t_i \). \( d_{it} = 0 \) indicates that owner \( i \) stayed in his house in period \( t \). \( d_{it} = 1 \) indicates sale and \( d_{it} = 2 \) indicates default.

Crucially, the type parameters \( \tau_i \) for each owner is not observed. Instead, it will be inferred from the owner’s initial purchase decision. Recall that the owner’s optimal choice of housing is given by \( h^*(\omega_{it} \mid h_i) \). For any guess of \( \alpha \), the function \( h^* \) can be computed. The observed housing choice \( h_i \) must be optimal, and therefore must satisfy:

\[
h^*(\omega_{it} \mid h_i) = h_i \quad (2.29)
\]

Now note that holding everything else fixed, \( h^* \) is monotonic in \( \tau_i \). The function \( h^* \) is therefore invertible in \( \tau_i \). We can therefore solve for \( \tau_i \) using the relation

\[
\tau_i = h^{*-1}(\omega_{it} \mid \tau_i) \quad (2.30)
\]

Thus, for any guess of \( \alpha \), the individual type parameters \( \tau_i \) are point identified.

The \( \alpha \)'s themselves can then be estimated by maximum likelihood, using the consumer’s discrete choice data. The log likelihood for a particular owner \( i \) is written:

\[
\sum_{t=t^0_i}^{t_i} (d_{it} = 0) \log P_a^{\text{stay}}(\omega_{it}) + (d_{it} = 1) \log P_a^{\text{sell}}(\omega_{it}) + (d_{it} = 2) \log P_a^{\text{def}}(\omega_{it}) \quad (2.31)
\]

An important point to note thus far is that, conditional on observing interest rates, none of the consumer’s decisions depend on the lender’s outside options \( \Pi_t \).
Therefore, $\tau_i$ and $\alpha$ are estimated without knowing $\Pi_t$. Once $\alpha$ and $\tau_i$ are estimated, $\Pi_t$ can be computed directly using equations (2.24)-(2.26) and (2.28).

The full estimation procedure is described as follows.

1. For each guess of the parameters $\alpha$:
   
   (a) Solve the model via backward recursion and numerically approximate the housing demand function, $h^*(\omega_{it} \mid h_i)$, and the inverse of it, $h^{*-1}(\omega_{it} \mid \tau_i)$.
   
   (b) Assign to each individual $i$, $\tau_i = h^{*-1}(\omega_{it} \mid \tau_i)$, using the observed values in $\omega_{it}$.
   
   (c) Calculate the log likelihood of the observed stay, sell, and default decisions using the assigned $\tau_i$’s and equation (2.31).

2. Estimate $\alpha$ by maximizing the log likelihood.

3. Re-solve the model at the estimated $\alpha$, and numerically approximate the lender profit function using equations (2.24)-(2.26). Then compute $\Pi_{it}$ at each $t$ in the data, using equation (2.28).

Because of the large size of the state space, the backward recursion procedure requires the use of function interpolation in order to approximate the value functions, as in Keane and Wolpin (1994).

2.4 Data

The data used for estimation is a random sample of 70,219 ownership histories from the Los Angeles metropolitan area, in which the house was initially purchased between 1991 and 2008. The period of the model is a year, and the decision horizon of the consumers is assumed to be 30 years from the date of initial purchase.

The data on ownership histories comes primarily from the database on housing transactions provided by DataQuick, a real estate information company. The
DataQuick data that I have available is a comprehensive register of all real estate transactions which occurred in Los Angeles from 1988 through 2009. The main variables of interest are the transaction price, down payment, and loan amount. A key advantage of the DataQuick data is that all liens against the property are recorded, so one can observe second and third mortgages. This is important in order to get a complete picture of the borrowing done by a purchaser, especially in the mid 2000’s, where a large fraction of purchases were financed by multiple mortgages. A second key feature of the DataQuick data is that in every transaction, the name of the buyer(s) and seller(s) are recorded. The names of the parties in the transaction are crucial for me to identify the difference between a sale and a foreclosure.

In order to construct an ownership history, the owner of a housing transaction is followed from the time of initial purchase to the time of sale, foreclosure, or to the end of the data period (2009). A sale is identified if a second transaction on the property occurs in which the buyer in the second transaction is identified as an individual. A foreclosure is identified if a second transaction on the property occurs in which the buyer is identified as a bank or a mortgage servicer. In some cases, the second transaction following an initial purchase is a sale to an individual by a bank or servicer, even though the initial purchase was bought by an individual. In such instances, the second transaction is again identified as a foreclosure. Table 2.1 shows the distribution of outcomes by initial purchase date, and Table 2.2 shows the distribution of outcomes by end date.

DataQuick does not include information about the purchaser’s income, or about the interest rate on the loan. To observe the purchaser’s income, DataQuick transactions were merged with data from HMDA (Home Mortgage Disclosure Act), which is a publicly available database of loan applications. HMDA’s loan application register contains data on the annual income of mortgage applicants. The matching variables used were the loan amount, lender name, date of transaction, and the ge-
ographic location of the property. Table 2.3 summarizes the owner and transaction characteristics for each ownership history in the data, for each initial purchase year.

In order to get per unit housing prices, a repeat sales regression was performed on the entire sample of DataQuick transactions from 1988 to 2009. The estimated price indices are shown in Table 2.4, and are comparable to the S&P Case-Shiller price indices for the L.A. metro area. The quantity of housing $h_i$ owned by individual $i$ is computed by deflating the total transaction price by the price index:

$$\log h_i = \log P_i - \log p_t$$

The house price indices are then used to estimate the coefficients $\beta$, using the forecasting rule (2.9) as the regression equation.

Data on mortgage interest rates comes from the Freddie Mac Primary Mortgage Market Survey. Only the contract rate on mortgages is used because it is the appropriate interest rate to use when determining the annual mortgage payment and the evolution of the mortgage balance, which are the variables of primary importance in the model. All mortgages in the data are assumed to be 30-year fixed rate mortgages. Although adjustable rate mortgages were also popular during the data period, fluctuations in the equity position due to an adjustable interest rate tend to be drowned out by much larger changes in house prices over this period. One may be concerned that the popularity of 2/28 and 3/27 mortgages with teaser rates may confound my estimates of the effect of negative equity on foreclosures, but Foote et al. (2008) argue that teaser rates cannot explain the sharp rise in mortgage defaults in 2007 and 2008.

In addition to the variables discussed in section 2.2, the unemployment rate in L.A. from the BLS was also included as a state variable affecting the consumers’ propensity to default. Because I do not directly observe income and employment shocks to the owners in the data (income is only observed at the time of purchase), I
use the unemployment rate to proxy for the effect such shocks may have on the time series variation in aggregate default rates. Table 2.4 shows prices, interest rates, and unemployment rates in L.A. for the data period.

2.5 Estimation Results and Model Fit

Table 2.5 reports the maximum likelihood estimation results for the structural parameters described in section 2.2, as well as the estimates for the forecasting rule in equation (2.9). The results imply that a 10% increase in housing service flows is equivalent to about $2,300 in consumption of the numeraire good for the average consumer in the data. The results also imply that negative equity has a large impact on the propensity to default. For example, an owner who is 20% underwater has approximately twice the chance of defaulting as an owner with zero home equity.

To get a sense of how well the model is fitting the data, Table 2.6 shows actual vs. simulated decisions in each period of the data. The model does a good job of fitting the aggregate decision probabilities.

Table 2.7 shows the estimated expected returns to the lender each year. It is presented in two forms: expected total returns calculated as expected receipts over outlays, and the equivalent 10-year T-bill rate. The equivalent 10-year T-bill rate is the interest rate on a 10-year Treasury bill that would generate an equivalent total return. Column 4 of Table 2.7 shows the actual 10-year T-bill rate over this period, and column 5 plots the difference. The estimated returns to the lender turn out to be quite close to the actual 10-year T-bill rates. Interestingly, the difference between the estimated returns and the returns on a 10-year T-bill starts off high, but then falls during the mid 2000’s. This is consistent with the interpretation that mortgage lending standards declined during this period. The fact that the estimated lender returns work out to be quite close to the 10-year T-bill rate is a reassuring indication that the model is giving sensible results, because there is nothing in the estimation
procedure which forces the estimated lender returns to match any kind of market interest rate.

Table 2.7 also shows the mean of the estimated type parameters by year. We see that the type parameter is relatively stable across the years, but that it increases somewhat during the mid 2000’s. The type parameter captures residual heterogeneity in housing demand that is not explained by observable characteristics. Some portion of \( \tau_i \) reflects the heterogeneity in the consumers’ preferences for housing services relative to consumption of the numeraire good, and it is conceivable that the average home buyer’s taste for housing went up during the mid 2000’s. Another interpretation is that the increase in \( \tau_i \) over this period is capturing a relaxation in mortgage lending standards. Relaxation of lending standards can come in many forms, including lower interest rates, but also in a loosening of down payment requirements or the extension of credit to previously un-creditworthy individuals. If there was a subset of the population who were unable to obtain high LTV loans in the late 90’s, but became eligible for high LTV loans in the mid 2000’s, this would show up in the model as a higher average preference for housing in the mid 2000’s. Unfortunately, there is no way to determine who is credit constrained in the data.

2.6 Continuous Workout Mortgages

In this section, I study the equilibrium impact of PCWMs and FCWMs on house prices, mortgage interest rates, and consumer welfare. The counterfactual simulation is performed by replacing all the mortgages in the model in a given period with the mortgage design in question. The incentives of the consumers are changed under the new mortgage design, as are the lenders’ calculation of expected returns, so the value functions in the model have to be re-solved by backward recursion. Under the new demand function and lender expected return function, the equilibrium price and interest rate are computed by equating housing supply with housing demand, and
by equating the expected lender returns to their estimated outside option, which is held fixed in the counterfactual.

2.6.1 Partial Continuous Workout Mortgage

I use a particular simple PCWM design in which the mortgage payment and the mortgage balance are computed in exactly the same way as in a fixed rate mortgage, except that both are indexed to house prices whenever cumulative appreciation has gone down since the time of origination. The mortgage payment at time $t$ is therefore given by:

$$m_{it} = \frac{r(1 + r)^J}{(1 + r)^J - 1} L \min \left\{ 1, \frac{p_t}{p_0} \right\}$$

(2.32)

and the mortgage balance after $s$ periods is given by:

$$L_{it} = \frac{(1 + r)^J - (1 + r)^s}{(1 + r)^J - 1} L \min \left\{ 1, \frac{p_t}{p_0} \right\}$$

(2.33)

Figure 2.1 plots the mortgage payment as a function of cumulative appreciation for a conventional FRM on the blue line and for a PCWM on the red line. Figure 2.2 plots the debt-to-value ratio after 3 years as a function of cumulative appreciation. In both graphs, the wedge between the blue line and the red line represents loss insurance, which is valuable to the borrower but costly to the lender. Because a PCWM bundles costly loss insurance into the contract, the lender will have to charge a higher interest in equilibrium in order to compensate for this insurance.

Table 2.8 shows the effects of introducing PCWMs, holding fixed house prices, interest rates, and the initial purchase decisions. Columns 1-3 of Table 2.8 show that even if consumers’ housing decisions are held fixed, the introduction of PCWMs still improves consumer welfare, because loss insurance is valuable to the consumer. The value of the loss insurance is particularly high when house prices are expected to decline. Columns 4-6 of the table show that if interest rates are not allowed to adjust,
the introduction of PCWMs is costly to the lender, and is more costly during periods in which house prices are expected to decline. The message of Table 2.8 is that if prices and interest rates are not allowed to adjust, then the introduction of PCWMs is beneficial to consumers but costly to lenders. What, then, is the equilibrium effect of PCWMs, when prices and interest rates are allowed to adjust?

Table 2.9 shows the effect of introducing PCWMs, allowing prices and interest rates to adjust to a new equilibrium. Columns 4-6 show that, as expected, equilibrium interest rates go up in order to compensate for the loss insurance being provided to the borrowers, and that interest rates go up more when house prices are expected to decline. Consumer welfare also increases, by an average equivalent variation of about $5,500 per consumer per year. Note that equivalent variation is especially high in 2007 and 2008, reaching as high as $15,000 per consumer per year in 2008. This is partially due to the fact that the PCWM protects the consumer from equity loss, which after 3 years under a FRM would have totaled $200,000 in expected losses for the average buyer in 2008. If the expected equity losses are subtracted from the equivalent variation, then the equivalent variation in 2007 and 2008 are about $5,000, in line with the average welfare gains in the other years. The effect of PCWMs on prices is mostly negative, but interestingly it is positive in 2008. The reason that the effect of PCWMs on prices is ambiguous is because there are two effects at play. The first effect, which seems to dominate, is that interest rates go up in equilibrium, which means a given quantity of borrowing requires a greater mortgage payment, and this reduces demand for housing. The second effect, which dominates in 2008, is the insurance effect. Because borrowers are insured against downside risk, they are more willing to leverage against their property. Consumers in 2008 expect house prices to drop sharply, so the net effect of PCWMs in 2008 is actually to increased demand for housing, even though interest rates are higher. The takeaway from Table 2.9 is that it is efficient for lenders to provide loss insurance to borrowers. Even though lenders
have to charge a higher interest rate in order to provide that insurance, borrowers are strictly better off by making that trade.

2.6.2 Full Continuous Workout Mortgage

The FCWM design that I use is identical to the PCWM design, except that the mortgage balance is indexed to house prices regardless of whether appreciation has gone up or down. The mortgage payment is still indexed to prices only on the downside. The reason for this is that we know wages are sticky, and it would be undesirable if the mortgage payment becomes a disproportionate burden on income simply because house prices grew at a much faster rate than income. The mortgage payment at time \( t \) is given by:

\[
m_{it} = \frac{r(1 + r)^J}{(1 + r)^J - 1} L \min \left\{ 1, \frac{p_t}{p_0} \right\}
\]

and the mortgage balance after \( s \) periods is given by:

\[
L_{it} = \frac{(1 + r)^J - (1 + r)^s}{(1 + r)^J - 1} L \frac{p_t}{p_0}
\]

The plot of the mortgage payment as a function of cumulative appreciation is the same as for a PCWM, and is shown in Figure 2.1. Figure 2.3 plots the debt-to-value ratio after 3 years as a function of cumulative appreciation. In Figure 2.3, the wedge between the blue line and the red line on the left side represents loss insurance, whereas the wedge between the blue line and the red line on the right side represents capital gains sharing. The loss insurance is valuable to the borrower, but costly to the lender, while the capital gains sharing is valuable to the lender but costly to the borrower. A key empirical question is whether the capital gains sharing can be used to offset loss insurance, so that interest rates do not have to go up in equilibrium.

Table 2.10 shows the effects of introducing FCWMs, holding fixed prices, interest rates, and the consumers’ initial purchase decisions. Columns 1-3 of Table 2.10 show
that, similar to the PCWM case, consumer welfare is improved by the introduction of FCWMs, even when holding the consumers’ decisions fixed. It is worth pointing out that, when prices and interest rates are held fixed, consumer welfare is higher under PCWMs than FCWMS. This is naturally the case because, given the same interest rate, PCWMs and FCWMs are equivalent on the downside, but FCWMs are worse for the consumers on the upside. Columns 4-6 of Table 2.10 shows that if interest rates are held fixed, then the introduction of FCWMs is extremely beneficial to lenders.

Table 2.11 shows the effect of introducing FCWMs on equilibrium prices, interest rates, and consumer welfare. Columns 4-6 show that converting to FCWMs allow lenders to reduce interest rates by 1.5 to 3.5 percentage points, a significant decrease. The reduction in interest rates, coupled with the loss insurance effect, increases demand in all periods and hence increases house prices. Consumer welfare is increased by an average equivalent variation of about $7,000 per person per year.

Table 2.12 compares the equilibrium outcomes under PCWMs and under FCWMs. The table shows that equilibrium prices are higher (on the order of 10%) under FCWMs than under PCWMs, and that interest rates are significantly lower (from 2 to 4 percentage points). The reduction in interest rates is economically very significant. For $400,000 in borrowing, the difference in annual payments between a PCWM and a FCWM is on the order of $10,000. Consumer welfare is also higher in every period under FCWMs than under PCWMs. Because the lender’s expected returns are held fixed across each regime, all of the gains from the alternative mortgage designs are going to the consumers. We can therefore conclude that in the context of the model, FCWMs are a more efficient mortgage instrument than PCWMs.
Disentangling the sources of welfare gains

In a final bit of analysis, I decompose the welfare gains due to FCWMs into four components. The first component is the elimination of foreclosure frictions, which occurs because borrowers no longer fall underwater on their loans. The second source of welfare gains is from risk sharing, in which the borrower sells some of the risk in house price appreciation (both upside and downside) to the lender in return for a lower interest rate. The third component is from the additional consumption of housing services which occurs in the new equilibrium. The fourth source of welfare gains is distributional efficiency. Because interest rates go down in equilibrium, it is possible for individuals with low income but high preference for housing to consume more housing. To disentangle the contribution of the four sources, I simulate the equilibrium outcomes under four regimes:

A. Fixed rate mortgages, fixed housing consumption, type parameters \( \tau \) set at population average, no foreclosure frictions \((\theta = 1, \alpha_5=0)\)

B. FCWMs, fixed housing consumption, type parameters \( \tau \) set at population average

C. FCWMs, endogenous housing consumption, type parameters \( \tau \) set at population average

D. FCWMs, endogenous housing consumption, type parameters \( \tau \) set at estimated values

In regime A, the mortgages used are fixed rate mortgages, so there is no sharing of house price risk. Each household’s housing consumption is fixed at baseline levels, and each household’s type parameter \( \tau \) is set to the population average. The welfare gains associated with risk sharing, additional housing consumption, and distributional efficiency are shut down, so the difference in consumer surplus between
regime A and the baseline model gives us a measure of the contribution of eliminating foreclosure frictions. In regime B, the gains from risk sharing are allowed, and foreclosure frictions are also eliminated due to the usage of FCWMs. However, housing consumption is still fixed at baseline levels, and there is still no heterogeneity in housing preferences. The difference in consumer surplus between regime B and regime A gives us the contribution of risk sharing. In regime C, consumers are allowed to adjust their housing consumption, but their type parameters are held fixed at the population average. The difference in consumer surplus between regime C and regime B gives us the contribution of additional housing consumption. Finally, regime D is identical to the main counterfactual, and the difference between regime D and regime C gives the contribution of distributional efficiency. Table 2.13 reports the results from these exercises for each year of the data. On average, eliminating foreclosure frictions accounts for 57% of the total equivalent variation, risk sharing accounts for about 18%, additional housing consumption accounts for 23%, and distributional efficiency accounts for 2%.

2.6.3 Discussion

There are a number of issues that could cause problems for the interpretation of the results. In this section, I discuss some of these issues and argue that they do not invalidate the qualitative nature of my results.

The first broad set of issues are related to decision margins that are not modeled. For example, the consumer’s optimal savings decisions is modeled, nor is the consumer’s optimal down payment decision. The timing of the consumers’ purchases is also not modeled; for example, the conversion to a new mortgage model may incentivize consumers to purchase earlier than they otherwise would have. Each of these decision margins are additional dimensions to which the consumers may respond to any changes to the mortgage market institutional structure. By assuming
them away, the model essentially shuts down a dimension in which consumers may respond. Since consumers will only change their behavior when it is optimal for them to do so, shutting down decision margins should cause the model to understate the welfare results, at least in a partial equilibrium sense.

The second issue is that the model only captures the intensive margin of how much housing buyers choose to purchase, but does not capture the extensive margin of whether potential buyers choose to participate in the housing market or not. The main reason that the extensive margin is not modeled is due to data issues: from the data one can only observe individuals who actually purchased a house; one cannot observe the entire set of potential buyers. The model, however, still pick up some of the effects of the extensive margin. For example, the model implies that the introduction of FCWMs increases demand and the total quantity of housing consumed, via the intensive margin. This leads to an increase in total welfare. If the extensive margin were being modeled, the results would be the same: total demand would increase and total welfare would improve. In fact, modeling the extensive margin would likely lead to a greater increase in welfare, because the only reason additional participants would enter the market would be if their marginal utility for entering is higher than the marginal utility for existing buyers to purchasing more housing.

The third issue is that the model treats the housing supply as an exogenous function of current prices. In this way, the housing supply can be interpreted as being dominated by new constructions rather than resales. The realism of this assumption depends on the specific housing market and time period that one is looking at. The main reason this assumption is being made is due to a data censoring issue. In particular, because the data on ownership histories comes from transactions data, one can never see the full stock of owners at any given time. It is therefore difficult to model the housing supply as a function of the stock of owners. If more complete
data on the stock of owners were available, the model is robust enough to let housing supply be an endogenous function of the owners via the model’s predicted sale and default probabilities.

The fourth issue is that, in the counterfactuals, the agents’ expectations are not endogenized into a rational expectations equilibrium. This is not an issue in estimation, because the estimated forecasting rule is consistent with the observed price process in the data, which is generated from an equilibrium. Under the counterfactual, however, the predicted price process may be inconsistent with the forecasting rule. It is therefore best to interpret the counterfactual results as the effect of a surprise change to the mortgage market. One way to try to make the forecasting rule consistent with the realized price process is to iterate on the coefficients of the forecasting rule. That is, simulate the equilibrium under an initial set of coefficients, then calculate a new set of forecasting coefficients using the simulated price process, then iterate until the coefficients converge. This method would be similar to the approach used by Krusell and Smith (1998) for computing high dimensional rational expectations equilibrium using simplified forecasting rules. Although still not a fully rational expectations equilibrium in which the agents are explicitly taking into account the shocks to the fundamentals, it is at least a rational expectations equilibrium under a restriction to the functional form of the forecasting rule. I performed this exercise for the counterfactuals and found that they did not change the qualitative nature of the results.

A fifth issue is that refinances are not observed and therefore the data does not give an accurate measure of an owner’s equity position at any given time. I try to control for these effects as much as possible by including using controls for the duration of ownership and time trends in the structural utility functions. Therefore, if owners were more likely to do cash-out refinancing in, say, 2004, then the time controls would indicate that owners are less likely to sell and more likely to default
after 2004, relative to other years. Nevertheless, these controls cannot fully capture the cross-sectional measurement error due to not observing refinances. Fortunately, failing to observe refinances in most cases causes the model to overestimate the equity positions of the owners, which would bias the coefficients on equity towards zero, and therefore cause me to understate the effects of the CWMs.

Finally, there is an issue with regards to extrapolating the results to other metropolitan areas. Los Angeles has a particularly high house price volatility compared to other housing markets, which would mean a greater scope for efficiency gains from risk sharing mortgage contracts. The effect of risk sharing mortgage contracts may be less pronounced in cities with lower house price volatility. One should therefore be careful about generalizing the results to housing markets outside of L.A.

### 2.7 Conclusion

Conventional mortgage designs do not protect borrowers from downside house price risk, nor do they allow lenders to benefit from the upside risk. In a conventional mortgage, the borrower is the sole bearer of house price risk. The paper shows that new mortgage designs which share the house price risk between buyer and lender can significantly improve the efficiency of the housing and mortgage markets. The paper also shows that contracts which share the house price risk, both upside and downside, between the borrower and lender are more efficient than contracts which only offer insurance to the borrower in return for a higher interest rate.

Although the model assumes a risk averse borrower and risk neutral lender, the results are more general than that. Even if the borrower and the lender have the same risk attitudes, if house prices are correlated with local labor market risks, then it is still efficient for the lender to hold some of the house price risk, because the lender is less exposed to local labor market conditions than the borrower.

An important contribution of the paper is that it offers a general framework
for studying other mortgage designs, or other institutional changes to the mortgage market. For example, the paper does not try to solve for the first-best optimal contract design, but the model is flexible enough to accommodate any kind of mortgage design one can think of, and so can be used in the future to try to find the first best contract design. Moreover, by modeling the mortgage market directly, the framework can address the question of to what extent did subprime lending with prepayment penalties contribute to the housing boom in the mid 2000’s? Gorton (2010) argues that 2/28 and 3/27 subprime mortgages with prepayment penalties were designed to extract some of the gains from rapid house price appreciation during the boom. These mortgages were characterized by low teaser rates in the first few years of the mortgage, followed by an interest rate spike after the teaser period ends. Lenders hoped that the jump in interest rates would incentivize borrowers to refinance at the end of the teaser period, thereby incurring the prepayment penalty. If house prices had gone up during the teaser period, the borrower can pay the prepayment penalty out of his capital gains. Proponents of subprime mortgage lending have argued that without the ability for lenders to extract some of the capital gains from house price appreciation, they would not have been able to lend to high risk borrowers. As shown in the paper, allowing lenders to extract some of the capital gains from house price appreciation does indeed lower interest rates and allow lenders to relax lending standards. The paper also shows that allowing lenders to extract capital gains also raises house prices. The model can naturally be used to investigate the effect of subprime lending on house prices.

On a final note, the results suggest that there is room for innovation in mortgage design. Recent experiences in U.S. housing and subprime mortgage markets are discouraging, and would seem to indicate that mortgage innovation has done more harm than good. But the problem with subprime mortgages was that although they allowed the lender to extract some gains from house price appreciation, they did not
shield borrowers from house price declines. Therefore, when house prices fell rapidly in 2007 and 2008, many borrowers were caught underwater, with no recourse but default, which is costly to both the borrower and the lender. The lesson to take away from the analysis is that despite our recent subprime experience, innovation in mortgage design should not be dismissed as all bad. Indeed, what happened with subprime was that we innovated along one dimension that felt appropriate at the time (due to rapidly increasing house prices), but failed to recognize a second dimension of innovation which would have been more appropriate during housing downturns (capital loss insurance). While financial innovation should always be approached with a healthy dose of respect and caution, the results suggest that mortgage designs which simultaneously protect the borrower from negative equity while also allowing the lender to share in capital gains from house price appreciation should be considered as serious alternatives to conventional mortgage designs.
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Table 2.2: Outcomes by year of sale or foreclosure

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<td>3584</td>
<td>30770</td>
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### Table 2.3: Summary statistics by initial purchase year

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<th>Income (Annual, $1,000s)</th>
<th>Down Payment ($1,000s)</th>
<th>Purchase Price ($1,000s)</th>
<th>Loan-to-Value Ratio</th>
<th>Debt-to-Income Ratio</th>
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<td>39.551</td>
<td>239.06</td>
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<td>53.815</td>
<td>30.326</td>
<td>220.12</td>
<td>0.8776</td>
<td>0.2972</td>
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<td>220.50</td>
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<td>0.3158</td>
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<tr>
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<td>26.227</td>
<td>212.75</td>
<td>0.8945</td>
<td>0.3091</td>
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<tr>
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<td>25.070</td>
<td>210.74</td>
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<td>0.3101</td>
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Table 2.4: Prices and interest rates by year

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<th>Year</th>
<th>$log(p_t)$</th>
<th>Price Index (1988=100)</th>
<th>Contract Rate</th>
<th>Unemployment Rate</th>
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<td>1989</td>
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<td>5.3060</td>
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<tr>
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<td>5.2634</td>
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Table 2.5: Estimation Results: Forecasting Rule and Structural Parameters*

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<th>Parameter</th>
<th>Description</th>
<th>Estimate</th>
<th>Std. Error</th>
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<td>Constant</td>
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<td>1.3191***</td>
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<tr>
<td>$\beta_3$</td>
<td>$log(p_{t-1}/p_{t-2})$</td>
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<td>Panel B: Structural Parameters</td>
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* *** p<0.01, ** p<0.05, * p<0.1
Table 2.6: Actual vs. Simulated Decisions: Model Fit

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<th>Sold Data</th>
<th>Simulated Data</th>
<th>Defaulted Data</th>
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Simulation done using estimated $\alpha$. 

46
Table 2.7: Estimated Type Parameters and Lender Returns

<table>
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<tr>
<th>Year</th>
<th>Mean of type parameter $\tau$</th>
<th>Expected total returns to lender</th>
<th>Equivalent 10-year treasury rate*</th>
<th>Actual 10-year treasury rate</th>
<th>Difference</th>
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* This is the interest rate on a 10-year T-bill that would generate an equivalent total return.
Table 2.8: Partial CWMs: Holding Fixed Prices, Interest Rates, Expectations, and Initial Purchase Decisions

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*Consumer welfare is measured in utils. Equivalent variation is the dollar value of annual consumption that must be given to the average consumer to make him indifferent between the base regime and the comparison regime, measured in $1,000’s. Lender returns are measured in equivalent 10-year rates. Housing supply and housing demand are measured in market value, in $millions.
Table 2.9: Partial CWMs: Equilibrium Prices and Interest Rates, Holding Fixed Forecasting Rule

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* Consumer welfare is measured in utils. Equivalent variation is the dollar value of annual consumption that must be given to the average consumer to make him indifferent between the base regime and the comparison regime, measured in $1,000’s.
Table 2.10: Full CWMs: Holding Fixed Prices, Interest Rates, Expectations, and Initial Purchase Decisions*

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* Consumer welfare is measured in utils. Equivalent variation is the dollar value of annual consumption that must be given to the average consumer to make him indifferent between the base regime and the comparison regime, measured in $1,000’s. Lender returns are measured in equivalent 10-year rates. Housing supply and housing demand are measured in market value, in $millions.
Table 2.11: Full CWMs: Equilibrium Prices and Interest Rates, Holding Fixed Forecasting Rule

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* Consumer welfare is measured in utils. Equivalent variation is the dollar value of annual consumption that must be given to the average consumer to make him indifferent between the base regime and the comparison regime, measured in $1,000's.
Table 2.12: Comparison of Equilibrium Outcomes between Full and Partial CWMs*

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* Equivalent variation is the dollar value of annual consumption that must be given to the average consumer to make him indifferent between the base regime and the comparison regime, measured in $1,000's.
Table 2.13: Full CWMs: Decomposing the Sources of Welfare Gains*

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<td>3.33</td>
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</table>

* As measured by equivalent variation. The contribution of risk sharing is determined by simulating the model where the housing supply is held fixed. The contribution of additional housing consumption is determined by simulating the model with endogenous housing supply, but replacing each consumer’s taste parameter with the population average. The contribution of distributional efficiency is the residual of the equivalent variation computed in the full simulation and the two contributions from risk sharing and additional housing consumption.
Figure 2.1: CWM Mortgage Payment vs. Appreciation
Figure 2.2: PCWM Debt-to-Value Ratio vs. Appreciation
Figure 2.3: FCWM Debt-to-Value Ratio vs. Appreciation
Estimates of the Size and Source of Price Declines
Due to Nearby Foreclosures

3.1 Introduction

Since 2007, house prices have fallen and foreclosures have surged in many parts of the United States. Two questions that have received much attention from policy makers are whether foreclosures are contributing to, or are merely a symptom of, the price decline, and if so, how? The answers to these questions are important because foreclosure externalities may justify government intervention into the housing and mortgage markets, and the appropriate type of intervention depends crucially on the source of the externality\(^1\).

There are two main mechanisms through which foreclosures may reduce house prices. The first, which we call the “disamenity effect”, is that foreclosed properties may attract neglect and vandalism, creating a negative externality on nearby homes. The second, which we call the “competitive effect”, is that foreclosures increase the

\(^1\) See the motivation for the Obama Administration’s *Making Home Affordable* plan (US Treasury 2009) and a Federal Reserve white paper to congress (“The U.S. Housing Market: Current Conditions and Policy Considerations” January 2012) as examples of how these issues are attracting much attention from policy makers.
supply of homes on the market, which should lower prices in a standard model of differentiated products price competition. This effect may be especially strong if banks price their homes more aggressively because they are more motivated to sell than the typical seller (Campbell et al. (2011b), Springer (1996)). However, we should not take the presence of either of these effects as given. First of all, banks ultimately need to sell the foreclosed properties, and so they have some incentive to maintain the condition of the property. Second, housing markets are characterized by significant search frictions (Wheaton (1990), Krainer (2001), Novy-Marx (2009)), and so the predictions of standard price competition models need not apply\(^2\).

Several studies in recent years have focused on estimating the effect of foreclosures on house prices using rich micro data on housing transactions (Lin et al. (2009), Immergluck and Smith (2001), Harding et al. (2009), Campbell et al. (2011b))\(^3\). These studies are largely distinguished by how each deals with a difficult identification problem: given that price decline is a necessary condition for foreclosure, homes that are nearby foreclosures will have lower prices for reasons that are independent of the foreclosure itself. Two prominent papers, Campbell et al. (2011b) and Harding et al. (2009), both find that a foreclosure reduces nearby house prices by about 1 percent. Harding et al. (2009) use a repeat sales approach to control for time-invariant unobserved home quality of homes nearby foreclosures, although they only allow prices to trend differentially at the MSA level, and thus it is difficult to separate their interpretation from a preexisting downward price trend in neighborhoods that are nearby foreclosures. Campbell et al. (2011b) use a difference-in-difference approach to better control for this. For homes within 0.1 miles of a foreclosure, they compare

\(^2\) For example, Turnbull and Dombrow (2006) find evidence that more supply induces more buyers to shop for homes, which has the potential to offset the negative competition effect.

\(^3\) There is a related literature that studies the impacts of foreclosures on other outcomes, including crime (Gould Ellen et al. (2011)), racial composition of neighborhoods (Lauria and Baxter (1999)), and health (Currie and Tekin (2011)). Goodstein et al. (2011) and Guiso et al. (2009) look at whether foreclosures lead to more foreclosures.
sales prices for homes that sell a year before and a year after the foreclosure. They use price changes for homes within a broader radius to control for preexisting local price trends. However, there is still the concern that homes in their treatment group trend differently from homes within their control group, as the authors themselves acknowledge, and they are unable to decompose their estimate into a disamenity effect and/or a competitive effect. To summarize the state of the existing literature, there is some evidence that foreclosures reduce nearby house prices, although causality is not definitive, and there is little evidence on the source of the price decline.\(^4\)

In this paper, we address these outstanding questions by supplementing the type of housing transaction data used in the existing studies with a new data source from the Multiple Listing Service (MLS), which is the dominant platform through which homes for sale are advertised in the US. Our combined dataset, which covers the universe of single-family home listings in the San Francisco metro area from January 2007 - June 2009, provides two pieces of information that have not been available to previous studies: the dates that REOs\(^5\) are on the market for sale, including the entry and exit date, and the list prices for all active home listings at any given week. We use this new information to make three main contributions to the literature. First, by exploiting the exogeneity of the precise timing of a new listing, we present new evidence that foreclosures have a causal effect on nearby house prices. Second, we show that the competitive effect, rather than the disamenity effect, is the important source of price declines. Third, we show that on average, the local effects of new REO supply are comparable in magnitude to the local effects of new non-REO supply. There is no evidence that aggressive pricing by desperate lenders

---

\(^4\) Harding et al. (2009) concludes that the root cause of the externality is the disamenity effect because the contagion effect is largest during the year preceding the foreclosure sale. The data in Harding et al. (2009) is from 7 MSAs across the country. The data in Campbell et al. (2011b) is from Massachusetts.

\(^5\) REO stands for Real Estate Owned. This is how properties are classified after the foreclosure sale is completed and the property is owned by the lender.
leads to extraordinarily stiff competition, on average.

We find strong evidence that the local market responds to the REO rather than
the reverse or to some correlated unobservable when we compare local list prices
immediately before and after a new REO listing. List prices, which are recorded
every week that a home is on the market and for all homes, regardless of whether
or not they eventually sell, provide enough observations within short time periods
and narrow geographic areas to get precise estimates using this type of regression
discontinuity design. We find that sellers are 12 percent more likely to adjust their
list price downwards in the exact week that a single REO enters the market nearby;
they are no more likely to adjust their list prices in the several weeks before and
after entry. Our preferred specification includes week and city fixed effects, and we
present several findings in support of the identification assumption that the precise
timing of a listing is not correlated with a local shock that causes nearby listings to
lower their list prices.

Having established new evidence of causality, we use the difference-in-difference
framework of Campbell et al. (2011b) to test for the effects of REO listing on sales
prices over time. The main difference relative to Campbell et al. (2011b) is that
we look before and after the listing date, rather than the foreclosure sale date, to
isolate the time period when the REO is competing against neighborhood listings
for buyers. Any price differential that we find centered around the listing date
should not be due to a disamenity effect because any disincentives to maintaining
the property should have begun to emerge closer to the foreclosure date, which is
usually multiple months before the listing date. Once the property is listed for sale,
the seller (and potentially the listing agent) has more incentive to preserve the quality
of the property as potential buyers may be visiting and inspecting the house.

Our estimates of the competitive effect are very comparable to the total foreclo-
sure externalities estimated in Campbell et al. (2011b) and Harding et al. (2009).
We find that while a single REO is on the market for sale, the sales price of a typical home within 0.1 miles of the REO is 1 percent lower on average. The cumulative effect is -3.2% for exactly two REO listings and -5% for more than two. These price declines are temporary. After the REO sells, prices recover to the pre-listing levels within 6 weeks for a single REO listing and within 12 weeks for multiple REO listings.

To further investigate the nature of the competitive effect, we compare the neighborhood response to new REO listings with the neighborhood response to new non-REO listings. If the price effects that we find in response to new REO listings are truly due to a competitive effect, then the price response to new non-REO listings should have a similar pattern. This is exactly what we find in the data. Sellers adjust their list prices downwards in the exact week that the new non-REO listing hits the market, sales prices decline while the non-REO remains listed for sale, and then recover once the property sells.

We find that the magnitude of the sales price decline in response to a single new, non-REO listing is comparable to the decline from a new, single REO listing. However, when we condition on whether or not the new listing is a close substitute with the neighboring listings, we find that an REO that is similar in observables to its neighbors depresses local prices by 1.4 percent more than a comparable non-REO listing. Placed within the context of a model of differentiated products price competition, this finding combined with our other results suggests that banks tend to price their homes more aggressively than the typical non-REO seller, but that the extra competitive effect of this aggressive pricing is softened by the fact that REO homes tend to be more differentiated from their neighbors.

Our results indicate the presence of a competitive effect. We test for a disamenity effect by testing for price changes during the months before foreclosure, and the months after foreclosure but before the foreclosure is listed for sale on the MLS.
This is when delinquency and eviction occur, and is precisely when the condition of the property is likely to deteriorate. We do not find any evidence that the average home nearby a single foreclosure declines in price during the 10 months before foreclosure, or in the 6 months after foreclosure and before listing. Thus, for the typical foreclosure, we find that the competitive effect is a significantly more important externality than the disamenity effect.

Finally, we test whether foreclosures affect other selling outcomes in addition to sales price. We find that a single new REO listing increases the time to sell (also called time on market (TOM)) of nearby homes by about 3.5 percent. Multiple new REO listings increase TOM by about 15 percent. Estimates of the effects of foreclosures on TOM are new to the literature, and are important because it is usually costly for sellers to keep their homes on the market.

Our findings suggest that new REO and non-REO listings have a similar effect on local prices. However, this insight does not imply that new REO and non-REO supply have the same effect on aggregate prices. In the case of non-REO sales, the seller often offsets the supply externality in one local area with an increase in demand in another when purchasing the next house. For REO sales, the delinquent borrower is unlikely to re-enter the housing market as a buyer. Thus, our estimates for REOs may be closer to the total effect of an additional foreclosure on the housing market, while our estimates for non-REOs probably overstate the aggregate effect of additional supply.

This paper proceeds as follows. Section 2 provides background information on the foreclosure process in California since the timing of this process is key for understanding our identification strategy. Section 3 introduces the data and present summary statistics. Sections 4 and 5 investigate the effects of REO listings on list price changes, sales prices, and TOM. Section 6 compares these competitive effects

6 See Molloy and Shan (2011) for empirical evidence of this.
to the competitive effects of non-REO listings. In Section 7, we test for a disamenity effect, and Section 8 concludes.

3.2 Background on the Foreclosure Process in California

Almost all foreclosures in California are handled out of court. After the borrower misses a mortgage payment, the lender issues the borrower a notice of default. If no foreclosure avoidance plan has been worked out and if the borrower does not cure the default within 90 days of the notice, a note is posted on both the property and in one public location announcing that the home will be auctioned off in no less than 21 days. The auction is public, and the lender typically makes an opening bid equal to the amount of the loan balance plus costs that accrue during the foreclosure process. Ownership of the property is transferred to the winning bidder, which is usually the lender\textsuperscript{7}, at a closing following the foreclosure auction. The date of this closing is often called the foreclosure sale date. If the delinquent borrower(s) are still present after the sale, the new owner must follow California legal procedures for eviction. This process usually takes about 30-45 days. In some cases, however, the delinquent borrower will accept a “cash-for-keys” payment to bypass the eviction process. The entire foreclosure process typically takes about 4-7 months\textsuperscript{8}. The foreclosure process in non-judicial states like California is typically faster than in judicial states\textsuperscript{9}.

If the lender receives control of the property after the auction, they typically transfer it to their real estate owned (REO) department, which prepares it for sale on the market to the general public. In most cases, the lender will work with a realtor to get the property listed on the MLS. Our data suggests that REOs appear on the MLS 3 months after the foreclosure auction on average, although there is a

\textsuperscript{7} Campbell et al. (2011b) find that this happens in 82 percent of cases.

\textsuperscript{8} http://www.foreclosures.com/foreclosure-laws/california/.

\textsuperscript{9} See Pence (2006) and Lender Processing Services Monitor monthly reports.
significant amount of variation in this window length.

3.3 Data

We use home sale and listing data for the core counties of the San Francisco Bay Area: Alameda, Contra Costa, Marin, San Francisco, San Mateo, and Santa Clara. The listing data comes from Altos Research, which provides information on the universe of single-family home listed for sale on the Multiple Listing Service (MLS) from January 2007 - June 2009. According to the National Association of Realtors, over 90 percent of non-arms length home sales were listed on the MLS in 2007. Every Friday, Altos Research records the address, mls id, list price, and some characteristics of the house (e.g. square feet, lot size, etc.) for all houses listed for sale. From this information, it is easy to infer the date of initial listing and the date of delisting for each property.\(^{10}\)

A property is delisted when there is a sale agreement or when the seller withdraws the home from the market. Properties are also sometimes delisted and then relisted in order to strategically reset the TOM field in the MLS. We consider a listing as new only if there was at least a 180 day window since the address last appeared in the listing data.\(^{11}\) The MLS data alone does not allow us to distinguish between delistings due to sales agreements or withdrawals, nor does it identify which listings are REO listings.

For these reasons, we supplement the MLS data with a transactions dataset from Dataquick that contains information about the universe of housing transactions in the SF metro area from 1988-2009. This includes REO sales. In this dataset, the variables that are central to this analysis are the address of the property, the date of

\(^{10}\) The initial listing date is censored for properties that are already on the market when our sample begins, and the delisting date is censored for those that are still on the market when our sample ends. We account for this censoring in our analyses below. See the Data Appendix for more details.

\(^{11}\) If the window is less than 180 days, we assume the property remained on the market during that interval at a list price equal to the list price in the final week before the gap begins. We tried a window size of 90 days and the main results are unchanged.
the transaction, the sales price, the latitude and longitude of the property, the name of the buyer and seller, and an indicator for whether the transaction is arms length.

Using the address, we merge the listing data with the transaction data. The data appendix describes the details of the merge and how we use the variables in the transaction data to identify REO listings and sales. Since foreclosures are typically recorded and thus appear in our transaction data prior to the listing of the REO on the MLS as discussed in Section 2, the availability of the transaction data back to 1988 ensures that there are no censoring issues in our identification of new REO listings. The data appendix also describes minor restrictions to the estimation sample (e.g. exclude properties with zero square feet).

Another advantage of MLS data is that we can observe the date when the buyer and seller agree on the sales price\(^{12}\). We use the agreement date as the sale date in all of our analyses since the sales price reflects housing market conditions at the time of agreement. The existing literature uses the closing date, which is the date when the buyer takes ownership of the home, to classify sales into, for example, pre and post foreclosure. Since closing dates lag agreement dates and the length of the lag is idiosyncratic to each transaction (see Table 1), the additional information provided by the agreement date reduces measurement error as well as bias in estimators that use a before and after comparison.

### 3.3.1 Summary Statistics

Table 1 presents summary statistics broken out by listing category for the data used in the analyses below. 30 percent of all sales are REOs in our sample. The median sales price of REOs is $315,000 compared to $725,000 for non-REOs. When we control for observable house characteristics and zip code by quarter fixed effects, the foreclosure

\(^{12}\) We assume that the agreement date is the date that the property is delisted from the MLS since the Bay Area MLS has a system of rules and fines in place to ensure that listings are updated promptly when a sale agreement occurs. See www.bareis.com for details.
sales price discount narrows, but is still economically and statistically significant at 15 percent (not reported). This estimate is difficult to interpret because both low unobserved house quality and the fact that banks have relatively high holding costs potentially contribute to the price discount. Theoretically, we should expect banks to have higher holding costs because they are not receiving any rental income while the home is for sale. The typical non-bank seller lives in the home while it is for sale and thus continues to receive the consumption benefits from the house each period that it does not sell. A higher urgency to sell should translate into lower prices in an illiquid market such as the housing market. That REOs are more likely to change the list price and are more likely to be sold rather than withdrawn as shown in Table 1 is consistent with a model where banks are more motivated to sell than the typical seller, on average (see Anenberg (2011)).

Table 2 shows the count of REO and non-REO transactions by county during our sample period. REOs tend to occur in areas where average house prices and incomes are lower than average. Relative to the entire country, the San Francisco area experienced high price declines and high foreclosure rates during our sample period. From 2007 to 2009, nominal prices, as reported by the Case-Shiller index, fell 36 percent in San Francisco compared to 28 percent in the 20-city composite. The foreclosure rate per household was higher than the national average in 4 of the 6 counties in our sample.

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13 The discount is the same when we use the list price rather than the sales price as the dependent variable.
14 See footnote 24 for an explanation of why REO TOM is high.
15 Data comes from RealtyTrac Foreclosure Market Report from 2008. The two counties where the foreclosure rate is lower are San Francisco and Marin.
3.4 Testing for a Causal Effect

We cannot identify foreclosure externalities by simply comparing sales prices of homes nearby foreclosures with prices of homes further away. Households that do not have enough wealth to absorb negative income shocks are more likely to default, and these very households are more likely to live in lower-amenity neighborhoods where the homes are of lower quality. Table 1 illustrates the importance of controlling for differences in homes nearby foreclosures. Houses that sell within 0.1 miles of a REO listing tend to be smaller and of significantly lower value. We can control for some of the differences in attributes, but we should be concerned that these homes differ along unobserved attributes as well.

One way to control for this is to compare sales prices before and after foreclosure, as in Campbell et al. (2011b). Due to the thinness of sales volume in local areas, the before and after periods need to be long – a year each in Campbell et al. (2011b) – in order to have enough precision. However, this introduces an additional source of endogeneity. Since price decline is a necessary condition for foreclosure, a foreclosure will tend to occur in a neighborhood that is declining in price at a faster than average rate. Endogeneity and the causal effect both create a correlation between the presence of a foreclosure and neighborhood price declines, and thus this approach cannot be definitive on whether foreclosures causally affect neighboring prices.

3.4.1 Econometric Specification

To control for these concerns, we look at the likelihood that homes on the market that are nearby new REO listings adjust their list price during a short window around the week that the REO is first listed for sale. If the exact week that the REO hits the market is not correlated with a local shock that causes nearby sellers to adjust their list prices, then any movement in list price is strong evidence that existing listings
are responding to the entry of the REO. List prices, which are recorded every week that a home is on the market and for all homes, regardless of whether or not they eventually sell, provide enough observations within short time periods and narrow geographic areas to get precise estimates using this type of regression discontinuity design.

Table 1 shows that 9 percent of sellers adjust their list price in a given week and the average list price change is -7 percent. Only 4 percent of list price changes are increases. The correlation between list price at the time of sale and sales price is 0.98, and the correlation between list price at the time of listing and the eventual sale price is 0.95. These statistics suggest that list price changes are a useful metric for analyzing changes in home values.

This motivates estimation of the following linear probability model:

\[
y_{i,j,t} = \sum_{m=0,>1} (\delta_{1,m} \text{NearbyREO}_{i,j,t-4}^m + ... + \delta_{0,m} \text{NearbyREO}_{i,j,t+4}^m) + \delta_{10,m} \text{NearbyREO}_{i,j,t}^m * \text{Dist}_i + \alpha_j + \gamma_t + \beta X_{i,t} + \epsilon_{i,j,t} \tag{3.1}
\]

where \(y_{ijt}\) is an indicator variable equal to 1 if house \(i\) in neighborhood \(j\) in week \(t\) changes its list price. \(\text{NearbyREO}_{i,j,t}^m\) is a dummy variable equal to one if listing \(i\) is within 0.5 miles of at least one (> 0) new REO listing that enters the market in week \(t\). Thus, we estimate the propensity to change the list price in the 4 weeks before \(\text{NearbyREO}_{t+1}, ..., \text{NearbyREO}_{t+4}\) and the 4 weeks after \(\text{NearbyREO}_{t-1}, ..., \text{NearbyREO}_{t-4}\) REO entry in addition to the actual week of entry. \(\text{NearbyREO}^{>1}\) denotes that a listing is nearby more than one new REO listing, and allows for multiple REO listings to have a different effect than a single REO single. \(\text{Dist}_i\) is the distance (or average distance if there are multiple REOs), in miles, of house \(i\) to the REO. \(\alpha_j\) is a set of neighborhood fixed effects, \(\gamma_t\) is a set of week fixed effects, and \(X_{it}\) is a vector of controls, which includes an indicator for whether the listing is an REO and the
number of weeks that the home has been on the market.

\[ \delta_{5,>0} + \delta_{10,>0} \text{Dist}_i \] is the change in the propensity to adjust list price in week \( t \) if 1 REO \( \text{Dist}_i \) miles from \( i \) enters in week \( t \). \[ \delta_{5,>0} + \delta_{5,>1} + (\delta_{10,>0} + \delta_{10,>1}) \text{Dist}_i \] is the change in the propensity to adjust list price in week \( t \) if multiple REOs at an average of \( \text{Dist}_i \) miles from \( i \) enters in week \( t \).

3.4.2 Results

Column (1) of Appendix Table 1 presents the results where neighborhood is defined as a city. Standard errors are clustered at the city level. The coefficients on the Nearby dummies are plotted in Figure 1 for distance=0. Sellers are no more likely to change their list prices in the 4 weeks before and the 4 weeks after a new REO listing. However, during the exact week of the REO entry, the probability that a seller adjusts their list price in response to an REO listing at a distance of zero increases by .007. Relative to the constant, this is an increase of 12 percent. The propensity to adjust price is declining in distance from the REO. An REO listing at a distance of .5 miles increases the propensity to adjust list price by only .002, and this estimate is not statistically significant.

As we would expect, the results are even stronger when multiple REOs are simultaneously listed for sale. When more than 1 new REO enters at a distance of zero, sellers are 28 percent more likely to adjust their list price in the exact week of entry relative to the weeks before and the weeks after.

We also run (3.1) with quarter-by-zip code fixed effects and house fixed effects in columns (2) and (3) of Appendix Table 1. The results are not sensitive to the type of fixed effects included. In Column (4) we change the dependent variable to the percentage change in list price conditional on a change in list price. The results show that sellers are indeed adjusting their list prices downwards, rather than upwards, when new REOs enter the market. Multiple REO listings elicit larger list price
changes than single REO listings.

### 3.4.3 Discussion

The downwards price movements here are consistent with a competitive effect since the date when the REO enters the MLS is the date when the REO begins competing with nearby listings for buyers. In Appendix 1, we present a simple 2-seller model where in equilibrium, REOs do not affect prices until the time of listing even if one seller is informed about the REO listing date in advance. When the elasticity of the probability of sale with respect to the list price is sufficiently low, the informed seller finds it optimal to price as if he has no information about the impending REO listing. If both agents are uninformed, then this pricing pattern will emerge as well.

The price movements are not consistent with a disamenity effect. It is unlikely that disamenities would emerge over the course of a single week, and even if they do, there is no reason to expect that it would be correlated with the week that the house is first marketed for sale. This evidence alone does not imply that a disamenity effect does not exist. We describe how we test for the presence of a disamenity effect in Section 7.

That the competitive effect of multiple REO listings extends to a broader area than the effect of a single REO listing is consistent with a model of differentiated products price competition. For example, consider a static, logit demand model where buyer utility is a function of price, distance from the buyer’s preferred location, and a logit error reflecting taste heterogeneity. Multiple properties further away can have a similar competitive effect as a single property closer-by. That the competitive effect declines with distance is also consistent with this type of model.

One potential concern is that REOs are more likely to enter the market during weeks when the local housing market conditions are particularly strong. However, we would expect to see upwards movement in list prices (or no movement since
list prices are sticky) during the week of listing if this were the case. In general, our identification assumption is reasonable because the precise timing of a listing is largely influenced by exogenous factors, such as when work to get the house “ready to show” is completed and the timing of various stages of the foreclosure process\textsuperscript{16}.

3.5 Estimating the Size of the Competitive Effect

The previous section established new evidence that foreclosures themselves, rather than correlated unobservables, have a causal effect on the selling behavior of nearby listings. The particular effect that we identified above is most likely due to the increased competition from additional homes listed for sale. In this section, we estimate the effect of this increased competition on sales prices and marketing time of nearby home listings.

3.5.1 Econometric Specification

We use a difference-in-difference specification that closely follows Campbell et al. (2011b). We compare sales prices before the REO is listed for sale with sales prices during the listing period, before the REO sells or is withdrawn. Any price differential that we find here should not be due to a disamenity effect because any disincentives to maintaining the property should have begun to emerge closer to the foreclosure date. Once the property is listed for sale, the seller (and potentially the listing agent) has more incentive to preserve the quality of the property as potential buyers may be visiting and inspecting the house.

We use prices of homes within 0.333 miles of a foreclosure as a control group, and identify the competitive effects off of differences in prices of homes within 0.1

\textsuperscript{16} Our week fixed effects control for any market-wide shock, as well as any seasonality in listings and demand. In addition, banking supervisory policy typically encourages banks to sell REOs as quickly as possible, which limits the scope for strategic timing of listings(FRB White Paper 2012).
miles\(^{17}\). The two key assumptions are that 1) homes values within 0.1 miles of the REO would not have been trending differently from home values within 0.333 miles of the REO listing in the absence of the foreclosure and 2) within this small geography, a REO should have differential effects on the prices of houses that are within even closer proximity. Our findings that the propensity to adjust list price is decreasing in distance from the REO supports assumption 2). We present evidence that supports assumption 1) below. Our main estimating equation is:

\[
\log(P_{ijt}) = \sum_{m=0,>1} (\delta_{\frac{1}{3},B,M} Before_{ijt}^{\frac{1}{3},M} + \delta_{\frac{1}{3},D,M} During_{ijt}^{\frac{1}{3},M}) + \\
\sum_{m=0,>1,>2} (\delta_{\frac{1}{10},B,M} Before_{ijt}^{\frac{1}{10},M} + \delta_{\frac{1}{10},D,M} During_{ijt}^{\frac{1}{10},M}) \\
+ \alpha_{jt} + \beta X_{it} + \epsilon_{ijt}.\tag{3.2}
\]

The variables within the summation are dummy variables and take on the value 1 when:

- \(Before_{ijt}^{k,m}\): Sale \(i\) occurs between 1 and 45 days before \(m\) REOs enter the MLS. \(i\) is also within \(k\) miles of the REO listings.

- \(During_{ijt}^{k,m}\): Sale \(i\) occurs during the listing period of \(m\) REOs (i.e. after the REOs enter, but before they sell or withdraw). \(i\) is also within \(k\) miles of the REO listings.

In the control group, we allow for different price trends in areas that experienced one or multiple foreclosures. In the treatment group, we further distinguish between the effect of one, two, and more than two local foreclosure listings as shown in the notation below the summation on the second line of equation (3.2).

\(^{17}\) When we use a 0.25 mile radius for the control group as in Campbell et al. (2011b), all of the main results are unchanged, except our estimates are less precise.
The estimates of interest are:

- $\delta_{D,>0}^{\text{10},D} - \delta_{B,>0}^{\text{10},B}$: The estimated effect of 1 REO listing on homes values of properties located within 0.1 miles of the listing, relative to homes within 0.1-0.33 miles of the listing.

- $(\delta_{D,>0}^{\text{10},D} + \delta_{D,>1}^{\text{10},D}) - (\delta_{B,>0}^{\text{10},B} + \delta_{B,>1}^{\text{10},B})$: The estimated effect of two REO listings on homes values of properties located within 0.1 miles of the listing, relative to homes within 0.1-0.33 miles of the listings.

- $(\delta_{D,>0}^{\text{10},D} + \delta_{D,>1}^{\text{10},D} + \delta_{D,>2}^{\text{10},D}) - (\delta_{B,>0}^{\text{10},B} + \delta_{B,>1}^{\text{10},B} + \delta_{B,>2}^{\text{10},B})$: The estimated effect of more than 2 REO listings on homes values of properties located within 0.1 miles of the listing, relative to homes within 0.1-0.33 miles of the listings.

In practice, instances where there are several simultaneous foreclosure listings within a local area are rare in our sample. For 27.5 percent of sales, $\text{During}_{10}^{\text{10},>0} = 1$. For 13.1 percent of sales, $\text{During}_{10}^{\text{10},>1} = 1$. For 6.8 percent of sales, $\text{During}_{10}^{\text{10},>2} = 1$.

The controls in equation (3.2) are a set of quarter-by-zip code fixed effects, property characteristics, an REO dummy, and TOM.

### 3.5.2 Results

#### Baseline Results

Table 3 reports the estimates from this model with standard errors clustered at the zip code-quarter level. We highlight several difference-in-difference estimates and their p-values in the panel above the full detail. The direct effect of an REO listing on home values for the average home within .1 miles of the REO relative to homes in the control group is about -1% and this diff-in-diff is statistically significant. The effect of two local REO listings is -3.2% and statistically significant. The effect of more than two REO listings is -5.2% and statistically significant.
Home prices within 0.1-0.33 miles decline by .6% ($\delta_{1,D,>0} - \delta_{1,B,>0}$) after an REO listing. Recall that this estimate combines any direct effect and an exogenous downward trend in home prices in neighborhoods nearby foreclosures. These results suggest that our -1% estimate from above is close to the total spillover effect, and that beyond 0.1 miles the spillover effect is significantly diminished. Harding et al. (2009) also finds very small spillover effects for properties located beyond 0.1 miles of the foreclosure. For multiple REOs, the price decline in the 0.1-0.33 group is larger. This evidence combined with the evidence presented above that multiple REO listings elicit list price changes even at distances beyond 0.33 miles suggests that foreclosure externalities do extend beyond the 0.1 mile radius when multiple foreclosures are simultaneously listed for sale within a local area. Our identification strategy only allows us to identify an upper-bound for this particular externality of -2.5 percent ($\left(\delta_{1,B,>0} + \delta_{1,B,>1}\right) - \left(\delta_{1,D,>0} + \delta_{1,D,>1}\right)$).

**Similarity to REO**

A model of differentiated products price competition, which is consistent with the findings presented so far, predicts that the competitive effect should be stronger when the REO is a closer substitute with the competing homes for sale. We test this prediction by categorizing sales that occur nearby an active REO listing as similar or dissimilar in observables to the REO listing. Specifically, we define the dummy variable

$$ similar_{it} = I\left[\sum_{j=1}^{J_t} \frac{|sqft_i - sqft_j|}{J_{it}} < 130 \right] \times I\left[\sum_{j=1}^{J_t} \frac{|yrblt_i - yrblt_j|}{J_{it}} < 3 \right] $$

where $sqft$ denotes square feet, $yrblt$ denotes year built, and $J_{it}$ denotes the number of active REO listings within .1 miles of sale $i$ at the time, $t$, that $i$ sells. $similar = 1$ in 20 percent cases where $During_{1/10,>0} = 1$. We add this variable to equation...
(3.2) along with an analogous variable measuring similarity of homes that sell in the
Before period\textsuperscript{18}. This latter variable controls for the possibility that homes in more
homogeneous areas tend to have higher or lower prices than average. The similarity
effect is identified off of the difference between the estimated coefficients on these
two variables. The results, shown in Column 2 of Table 3, imply that the effect of
an REO on nearby sales prices is -.7 percent when the nearby sale is not similar
in observables to the REO, versus -2.1 percent (-.7-.014) when the nearby sale is
similar\textsuperscript{19}.

Effects after REO Exits the Market

An alternative interpretation for the results in Figure 1 and Table 3 is that a new
REO listing depresses prices because it sends a negative signal to buyers and sellers
about the future quality of the neighborhood\textsuperscript{20}. We can distinguish between these
competing explanations by looking at price movements after the REO exits the
market. If the price effect we are picking up is truly a competitive effect, then
prices should eventually recover once the foreclosure no longer competes with existing
listings for buyers\textsuperscript{21}. If we are instead picking up an information effect, then prices
should remain depressed even after the REO sells.

We test this by augmenting our baseline diff-in-diff specification with the following
indicator variables for $k = \frac{1}{10}, \frac{1}{3}$ miles and $m = > 0, > 1$ REO listings:

- \textit{SoonAfter}$_{ij}^{k,m}$: Sale $i$ occurs between 1 and 45 days after $m$ REOs exit the

\textsuperscript{18} Specifically, this variable takes on the value 1 when a sale occurs 1-45 days before a nearby REO
enters the market, and the sale is similar in observables to the impending REO listing.

\textsuperscript{19} Precision is an issue in this specification. Thus, we chose the square feet and age thresholds
to balance a tradeoff (that we find empirically) between the number of observations in the similar
category versus strength of the effect.

\textsuperscript{20} We view this as a less likely explanation given that foreclosures are made public well before the
listing date, as discussed in Section 2, but we consider it nonetheless.

\textsuperscript{21} The price recovery need not be immediate because the decrease in supply may be offset by the
absorption of demand from the REO that sells.
market. i is also within k miles of the REO listings.

- After \(^{k,m}\) \(_{ijt}\) : Sale \(i\) occurs between 46 and 90 days after \(m\) REOs exit the market.
  \(i\) is also within \(k\) miles of the REO listings.

The results are presented in Column 3 of Table 3. During the 45 days after a single REO sale, prices completely recover to their pre listing level. This recovery is statistically significant. When there are multiple REO sales, prices also recover, but take longer to do so. There is a statistically significant increase in local prices soon after the sales, but we cannot reject the null that prices equal their pre-listing level until 46-90 days after the sales.

**Time on Market**

In addition to affecting price, competition can also affect how long it takes a listing to sell\(^{22}\). We test this in Column (4), which switches the dependent variable in equation (3.2) to \(log(TOM)\). The diff-in-diff estimate for a single REO listing is relatively modest at 3.5%. However, the effect of multiple REOs is much larger at 15 percent, and is statistically significant. A 15 percent increase amounts to an additional 2.5 weeks of marketing time for the typical listing in our sample. As with sales prices, TOM recovers to its pre listing levels once the REOs leave the market.

That new REO listings increase the marketing time of nearby listings is economically important for at least two reasons. First of all, it is costly for sellers (and realtors) to keep their homes on the market. These costs include keeping the home and family ready for visitors as well as opportunity costs associated with being unable to liquidate the house. Secondly, lack of liquidity in a local area can get amplified into the broader market given that sellers usually cannot buy a new home until they

\(^{22}\) For example, suppose a fixed number of potential buyers inspect the homes listed for sale in a local area each period. The more homes there are to choose from, the less likely it is that a buyer will choose any specific house, which should increase time to sale.
are able to sell their current one\textsuperscript{23}.

3.6 The Effects of non-REO Listings on Selling Behavior

In this section we compare the effects of new REO listings with the effects of new non-REO listings. This exercise is useful for two reasons. First of all, it tests the robustness of our conclusions about the competitive effect. If the price effects that we find in response to new REO listings are truly due to a competitive effect, then the price response to new non-REO listings should have a similar pattern. Secondly, it allows us to determine whether REOs present especially stiff competition, or whether the competitive effect of a new REO listed for sale is comparable to the effect of any home listed for sale. Section 3.1 discussed reasons why REOs may present especially stiff competition.

3.6.1 List Prices

We begin by testing whether list prices respond similarly. We augment specification (3.1) with an additional set of dummy variables for new non-REO listings:

\[
y_{i,j,t} = \sum_{m=0,>1} (\delta_{1,m} \text{NearbyREO}^m_{i,j,t-4} + \ldots + \delta_{9,m} \text{NearbyREO}^m_{i,j,t+4}) \\
+ \delta_{10,m} \text{NearbyREO}^m_{i,j,t} \cdot \text{Dist}_i + \delta_{11,m} \text{NearbyNonREO}^m_{i,j,t-4} + \ldots \\
+ \delta_{19,m} \text{NearbyNonREO}^m_{i,j,t+4} + \delta_{m,20} \text{NearbyNonREO}^m_{i,j,t} \cdot \text{Dist}_i \\
+ \alpha_j + \gamma_t + \beta X_{i,t} + \epsilon_{i,j,t}. \tag{3.4}
\]

As in equation (3.1), \(y\) is an indicator variable equal to 1 if there is a list price change. \(\text{NearbyNonREO}^m_{i,j,t}\) is a dummy variable equal to one if listing \(i\) is within 0.5 miles of \(m\) new non-REO listings that enters the market in week \(t\).

\textsuperscript{23} See Ortalo-Magné and Rady (2006) and Anenberg and Bayer (2011).
Figure 2 plots the coefficients on the Nearby dummies for the case of a single REO and non-REO listing for distance=0. Appendix Table 2 shows the full detail. Neighborhood listings respond to new non-REO listings in the same way that they respond to new REO listings. All of the action occurs in the exact week of listing, not in the weeks before or the weeks after listing. In the exact week of listing, the propensity to change list price for listings at distance=0 from the REO and non-REO increase by .0066 and .0065, respectively. There is no economically or statistically significant difference between the two. The effect of multiple listings and the effect of distance is also the same.

Appendix Table 2 columns 1-3 reports the results with week and city, house, and quarter-by-zip code fixed effects, respectively. The results are similar across all three specifications. Column (4) changes the dependent variable to the percentage change in list price conditional on a change in list price. Sellers adjust their list prices downwards by a larger amount when there are multiple new REO listings, but this difference is not statistically significant.

3.6.2 Sales Prices and Time on Market

To compare the effect of REO and non-REO listings on sales prices, we use the same differences-in-differences specification as in equation (3.2) with an additional set of dummy variables that categorize sales as before, during, or after non-REO listings. Table 4 presents the results. The effect of an non-REO listing on home values for the average home is -.89% and this difference is statistically significant. At -.89% for non-REO versus -.96% for REO, the effect of a non-REO listing is very comparable and statistically indistinguishable from the effect of an REO listing$^{24}$. The difference

$^{24}$ In some cases, we observe a house come onto the MLS before it is foreclosed upon, go off the market while the foreclosure occurs, and then come back onto the market after the foreclosure. A realtor tells us that these are failed short sales. If the off-market window is less than 180 days, our algorithm treats this entire listing as REO. This tends to increase the TOM of REOs, as shown in Table 1. We re-estimated Table 4 treating these as 2 separate listings, the one before the foreclosure
is larger for multiple REO listings relative to multiple non-REO listings, but we still cannot reject the null that the differences are significant.

Column (2) tests for effects on TOM. A single new REO and non-REO listing increases neighborhood TOM by a small and comparable amount. As with price, multiple REO listings have a larger cumulative effect on TOM than multiple non-REO listings (15 percent versus 6 percent for the two REO listing case). Here, we are able to reject the null that the difference-in-difference-in-difference is the same.

In Column (3) we include our measure of similarity as defined in equation (3.3). For REOs, similarity increases the magnitude of the competitive effect by 1.4 percent. This is unchanged from the estimate presented in Section 5. For non-REOs, however, similarity only increases the magnitude of the competitive effect by .2 percent, and this estimate is imprecise.

3.6.3 Discussion

Our results show that when we condition on substitutability, REOs have a stronger competitive effect than non-REOs. Unconditionally, however, the competitive effects are similar. A likely explanation for these results is that banks price their homes more aggressively for the reasons discussed in Section 3, so that conditional on substitutability, the competitive effect from REOs is stronger. However, if REOs tend to be more differentiated from their neighbors than non-REOs, the unconditional competitive effects can be similar.

We do find evidence of higher degrees of differentiation for REOs. We show this by calculating for each new listing the average percentage difference (in absolute value) between the list price of the new listing and the list prices of the active listings within 0.1 miles of the new listing\textsuperscript{25}. We use list prices to account for both observed as non-REO and the one after the foreclosure as REO. The results are qualitatively the same.

\textsuperscript{25} That is, for each new listing \(i\), we calculate \(\frac{1}{J_i} \sum_{j=1}^{J_i} |p_{ij}^L - p_i^L|\) where \(J_i\) denotes the number of
and unobserved heterogeneity in housing characteristics\textsuperscript{26}. Across all new listings, the standard deviation of this difference is about 20 percent. This illustrates that there is a significant amount of differentiation even among homes within 0.1 miles of each other. The median difference is 18 percent for a new REO listing versus 14 percent for a new non-REO listing, which is consistent with a higher degree of differentiation for REOs.

3.7 Testing for a Disamenity Effect

The previous sections have presented strong evidence that foreclosures depress nearby house prices through a competitive effect. We now test whether an additional externality arises through the disamenity effect.

A disamenity effect may emerge during two time periods. The first is prior to foreclosure as the borrower realizes that foreclosure is imminent and has less incentive to maintain the property condition. For example, the owner may be more likely to let the grass grow long and the paint chip. The second is after the foreclosure, which is when the property is often vacant. Vacancy potentially attracts vandalism, crime, and squatters.

To test for the disamenity effect, we add dummy variables to the diff-in-diff specification (3.2) that further categorize sales according to whether they occur in the 10 months prior to a foreclosure and/or in the 6 months after a foreclosure but before the house is listed on the MLS. We include separate dummy variables for each two month window during this 16 month period. We continue to distinguish between sales within .1 and sales within .33 miles of a foreclosure to control for exogenous trends active listings within 0.1 miles of i and \( p^L \) is the log list price. When \( J_i = 0 \) this difference is treated as missing for observation \( i \).

\textsuperscript{26} Unobserved housing characteristics are particularly relevant here because foreclosed properties are probably less likely to have renovations, show well, etc. This should be reflected in the list price level.
in neighborhoods where foreclosures tend to occur. The identification assumption is that the disamenity effect, if present, has a stronger effect on home prices within 0.1 miles of the foreclosure relative to home prices within 0.33 miles. Any significant price decline during this pre-listing period could be interpreted as a disamenity effect.

3.7.1 Results

The results are summarized in Figure 3. The full set of results with all of the explanatory variables are reported in Appendix Table 3. Figure 3 shows that sales prices of homes within .1 miles of a single foreclosure do not depend on the timing of the sale in relation to the foreclosure phase. None of the changes in the pre-listing period are statistically significant. The detailed results show some evidence of price decline when there is more than 1 foreclosure in the post-foreclosure, pre-listing phase; however, the estimates are imprecise.

3.7.2 Discussion

Our results suggest that the average foreclosure does not depress nearby house prices through a disamenity effect\(^{27}\). We emphasize that our identification strategy does not allow us to distinguish whether this is because most neglected houses do not depress neighboring prices, or whether most foreclosed properties are not neglected.

Our results in this section also support the first identification assumption from Section 5 that homes values within 0.1 miles of an REO would not have been trending differently from home values within 0.33 miles of an REO listing in the absence of the listing. If this assumption is false, then we would expect to see different trends

\(^{27}\) One reason that Harding et al. (2009) find a contagion effect in the year prior to the foreclosure could be that many foreclosures are listed on the market as short sales prior to foreclosure. Thus, the pre-foreclosure price decline that they find could be due to the competitive effect of the short-sale listing rather than the disamenity effect as they conclude. These types of listings do not affect our estimate of the disamenity effect as we require the pre and post-foreclosure windows to be before the initial listing. See footnote 24 for more details. In addition, the conclusions in Harding et al. (2009) are established based on averages across 7 MSAs. At the MSA level, their results on pre-foreclosure price declines are quite imprecise (their Table 4).
during the year before listing as well\textsuperscript{28}. The results here also support our claim that the source of price decline during the listing period is due to increased supply rather than the disamenity effect. A disamenity effect that only emerges long after the foreclosure process is complete contradicts most accounts of when physical neglect of foreclosed properties occurs in practice.

We conclude this section with a quotation from Robert Klein of Safeguard Properties, a company that provides property preservation services to banks and mortgage servicers, in the Washington Post\textsuperscript{29} which reconciles our findings with anecdotal accounts of the disamenity effect that receive much attention in the media:

..for every vacant property that’s sitting over there with no windows, no doors, with grass and graffiti all over the place, I will show you a thousand that are being maintained. You don’t hear about those. All you hear about are the exceptions.

3.8 Conclusion

In this paper, we use a new dataset from the MLS to show that foreclosures do indeed have a causal effect on nearby house prices, and that the competitive effect rather than the disamenity effect is the important source of price declines. A new foreclosure listing lowers nearby house prices by 1 percent, which is a significant effect given that 1) 27.5 percent of sales in our sample are of homes nearby an active foreclosure listing and 2) houses in our sample typically sell for over a half million dollars. We find that on average, new REO listings have a comparable effect on local prices as new non-REO listings. We find that the high degree of differentiation

\textsuperscript{28} The results are also inconsistent with a pre-listing price decline due to anticipation of the competitive effect.

\textsuperscript{29} “Good Business for Bad Times: Mortgage Field Services” October 29th 2011, the \textit{Washington Post}. 

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between REO properties and nearby homes softens the extra competitive pressure from banks that price aggressively.

Our sample covers home listings in the 6 core counties of the San Francisco bay area from 2007-2009. The foreclosure process in California and during our sample period was relatively quick. Thus, there are fewer instances where multiple properties in the same local area are simultaneously in the post-delinquency, pre-listing phase. If there is a non-linearity in the disamenity effect, as some evidence in Section 7 suggests, then in judicial states or in 2010-2011 when legal and regulatory issues slowed foreclosures, the disamenity effect could be more important. In addition, we only look at the effects of REOs sold via the MLS. It is possible that homes sold directly to investors, which represent a small share of total foreclosures, are more likely to be in disrepair and may generate an externality through a disamenity effect.

A costs-benefit analysis of various foreclosure relief policies is beyond the scope of this paper. However, conditional on the decision to intervene, our results favor policies that keep foreclosures off the market altogether rather than subsidies for the preservation of foreclosed properties. In future research, we plan to combine our data with a model of default decisions and neighborhood price competition in hopes of making stronger policy recommendations.

3.9 Appendix

3.9.1 Model of Price Setting in Response to New REO Listing

Here we present a stylized model to understand how the pricing pattern in Figure 1 emerges in equilibrium. Suppose there are two players \(i = 1, 2\) and two time periods \(t = 1, 2\). Each player has a single house of identical quality to sell. The demand for house \(i\) can be summarized by the function

\[
\gamma(p_{it}^L, R_t)
\]

(3.5)
where $\gamma()$ denotes the probability that player $i$’s house sells given each players’ list price, $p^L$, and $R$, which is a dummy variable equal to one if there is an REO listing, exogenous to the model, to compete with. We assume that

1. $\frac{\partial \gamma_i}{\partial p^L_i} < 0$

2. $\frac{\partial \gamma_i}{\partial p^L_{-i}} > 0$

3. $\gamma(p^L_i, p^L_{-i}, 1) < \gamma(p^L_i, p^L_{-i}, 0) \forall p^L_i, p^L_{-i}$

We assume that $R_1 = 0$ and $R_2 = 1$. $R_t$ is observable to both players at time $t$. We impose the following information asymmetry at $t = 1$: one of the players knows that $R_2 = 1$ whereas the other player does not know $R_2$, but believes that $R_2$ is Bernoulli. Otherwise, the two players are identical.

We assume that if a home sells, it sells at its list price. For simplicity we assume that the discount factor equals one. We write player $i$’s expected profit function in $t = 1$ as

$$
\Pi^1_i = \gamma(p^L_{i1}, p^L_{-i1}, 0) \cdot p^L_{i1} + (1 - \gamma(p^L_{i1}, p^L_{-i1}, 0)) \cdot \Pi^2_i. \quad (3.6)
$$

$\Pi^2_i$ takes a similar form, except if the home does not sell, the seller receives some exogenous terminal utility $x$. Consider the informed player’s optimal choice of period 1 price in a pure-strategy Bayesian Nash equilibrium. He can pretend he is not informed about $R_2$, and price according to the equilibrium that would arise if both players are symmetrically uninformed about $R_2$. Alternatively, he could lower his price to increase his chances of selling in $t = 1$ since he knows demand in $t = 2$ will be low. It is straightforward to show that this is exactly what he would do if he were a monopolist. However, by lowering his price, the informed player signals to the uninformed player that demand will be low, which would cause the uninformed player to lower his period 1 price in equilibrium. Thus, some of the gains that the informed seller would get from lowering his price are competed away.
Whether the informed player prices low or high depends on the elasticity of $\gamma()$ with respect to price. For $\gamma()$ sufficiently inelastic, the informed player will not adjust his period 1 price for the impending REO listing. In period 2, both players will lower their prices once $R_2 = 1$ becomes common knowledge. Under this parametrization, the equilibrium price pattern is just as it appears in Figure 1.

3.9.2 For Online Publication Only: Data Appendix

We first describe how we merge the listing data from Altos Research with the transaction data from Dataquick. The listing data contains separate variables for the street address, city, and zip code of each listing. The address variable contains the house number, the street name, and the street suffix in that order as a single string. We alter the street suffixes to make them consistent with the street suffixes in the transaction data (e.g. change “road” to “rd”, “avenue” to “ave”, etc). In some cases, the same house is listed under 2 slightly different addresses (e.g. “123 Main” and “123 Main St”) with the same MLSIDs. We combine listings where the address is different, but the city and zip are the same, the MLSids are the same, the difference in dates between the two listings is less than 3 weeks, and at least one of the following conditions applies:

1. The listings have the same year built and the ratio of the list prices is greater than 0.9 and less than 1.1.

2. The listings have the same square feet and the ratio of the list prices is greater than 0.9 and less than 1.1.

3. The listings have the same lotsize and the ratio of the list prices is greater than 0.9 and less than 1.1.

4. The first five characters of the address are the same.
The address variables in the transaction data are clean and standardized because they come from county assessor files. We merge the listing data and the transaction data together using the address. We classify a listing as a sale if there is a match and the difference in closing date (the date in the transaction data) and the agreement date (the date the property is deslisted from the MLS) is greater than zero and less than 365 days. If a listing merges with an observation in the transaction data that does not satisfy this timing criteria, we record the latitude and longitude coordinates of the property but do not treat the listing as a sale. We drop all listings that do not match to at least 1 record in the transaction data because we do not have the latitude and longitude for these listings\(^{30}\). Listings do not match to a sales record for one of two reasons: a listing last sold prior to 1988 or there is a quirk in the way the address is recorded in the transaction or listing data. Before we do the merge, we flag properties that sold more than once during a 1.5 year span during our sample period. To avoid confusion during the merge that can arise from multiple sales occurring close together, we drop any listings that merge to one of these flagged properties (< 1 percent of listings). We also drop listings where the ratio of the minimum list price to the maximum list price is less than the first percentile.

For the list price specifications, we do not treat listings where the initial listing date is the first week in our dataset as a new listing. We do this because we do not know whether these listings truly began in the initial week of the sample, or whether they had been on the market previously. For the specifications that use sales prices and TOM as the dependent variable, we make the following restrictions to the estimation sample:

1. Drop sales with prices that are below 50000 or above 2875000 (1st and 99th percentiles, respectively). Drop sales with square feet equal to zero or greater

\(^{30}\) This eliminates about 15 percent of listings. These dropped listings do not include REO listings because an observation appears in the transaction data at the foreclosure sale date.
than 5000.

2. Drop sales where the TOM is greater than 2 years (< 10 sales).

We spent a great deal of time familiarizing ourselves with the data to develop the following algorithm that we believe to be highly accurate in identifying REO listings. We classify a listing as an REO if it merges with an arms length sales record where the following conditions hold:

1. The buyer’s name does not have a comma, which always separates a last name and a first name in our dataset. This suggests that the buyer is not an individual and perhaps is a bank.

2. The buyer’s name does not contain the strings “ESTATE”, “FAMILY”, “LIVING”, “RELOC”.

3. The buyer’s name contains strings that suggest it is a bank, mortgage servicing company, or GSE (e.g. “BANK”, “MTG”, “FANNIE”).

These arms length transactions are the transfer of ownership when a foreclosure occurs. In most cases, a non-arms length transaction occurs within a couple years of this transfer where the seller is a non-individual. This subsequent sale is the REO.

We use the transfer rather than the REO sale to identify REO listings because our transaction data is right-censored. We do, however, use the seller names for the REO sales that we observe to help generate a list of strings that we search for in the buyer’s name in the algorithm described above.
Figure 3.1

Note: This figure shows the change in the propensity to adjust list price in the 4 weeks before, the week of, and the 4 weeks after local, new REO listing(s). The propensity to adjust list price is allowed to vary linearly with distance from the REO listing. The coefficients reported here are for distance = 0 miles. The detailed regression output is reported in Appendix Table 1. All changes are relative to a baseline of .059.
Figure 3.2

Change in Propensity to Adjust List Price Around New Listing

Note: This figure compares the change in the propensity to adjust list price in response to 1 local, new REO and to 1 local, new non-REO listing. Effects are plotted for the 4 weeks before, the week of, and the 4 weeks after the new listing. The propensity to adjust list price is allowed to vary linearly with distance from the REO listing. The coefficients here are for listings that are 0 miles from the REO listing. The detailed regression output is reported in Appendix Table 2. All changes are relative to a baseline of .059.
This figure shows how sales prices within .1 miles of a single foreclosure depend on the timing of the sale in relation to the phase of the foreclosure process. F denotes the date of the foreclosure and During Listing denotes the time period after the foreclosure is listed on the MLS but before it sells or is withdrawn. The numbers in the x-axis are in days. All sales between F - 300 and F + 180 are also restricted to be before the foreclosure is listed on the MLS. All estimates are indexed to the estimate for F - 240 to F - 300, which is normalized to 0. The detailed regression output is reported in Appendix Table 3.
Table 3.1: Summary Statistics by Listing Category

<table>
<thead>
<tr>
<th></th>
<th>Sale Price ($)</th>
<th>Square Feet</th>
<th>Age</th>
<th># Bathrooms</th>
<th>Time on Market (Weeks)</th>
<th>Closing Gap (Days)</th>
<th>Sale/List Price (\frac{\text{List Price}<em>t}{\text{List Price}</em>{t-1}}) (Ratio)</th>
<th>(\frac{\text{List Price}<em>t}{\text{List Price}</em>{t-1}})^2 (Fraction)</th>
<th>(\frac{\text{List Price}<em>t}{\text{List Price}</em>{t-1}})^2 (Fraction)</th>
<th>(\Delta) List Price (%)</th>
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</thead>
<tbody>
<tr>
<td>REO, No Sale (N=9,120)</td>
<td>Mean</td>
<td>1607</td>
<td>45</td>
<td>2.0</td>
<td>19</td>
<td>0.09</td>
<td>0.0047</td>
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<td></td>
<td>p25</td>
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<td>0.0039</td>
<td>0.0039</td>
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<td>0.0039</td>
<td>-0.092</td>
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<td>18</td>
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<td>Nearby REO, Sale</td>
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1. Defined as closing date - agreement date.
2. Takes on the value 1 if the list price does not equal the list price in the week before.
3. Takes on the value 1 if the list price exceeds the list price in the week before.
4. Conditional on a price change occurring.
5. The sale is within 0.1 miles of an active REO listing.
Table 3.2: Number of REO and non-REO Sales by County

<table>
<thead>
<tr>
<th>County</th>
<th>REO</th>
<th>non-REO</th>
<th>Share REO</th>
<th>Median Price</th>
</tr>
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<td>Alameda</td>
<td>4757</td>
<td>10938</td>
<td>0.303</td>
<td>$530,000</td>
</tr>
<tr>
<td>Contra Costa</td>
<td>9229</td>
<td>9178</td>
<td>0.501</td>
<td>$360,000</td>
</tr>
<tr>
<td>Marin</td>
<td>214</td>
<td>2194</td>
<td>0.089</td>
<td>$840,000</td>
</tr>
<tr>
<td>San Francisco</td>
<td>253</td>
<td>3041</td>
<td>0.077</td>
<td>$832,000</td>
</tr>
<tr>
<td>San Mateo</td>
<td>912</td>
<td>5777</td>
<td>0.136</td>
<td>$803,000</td>
</tr>
<tr>
<td>Santa Clara</td>
<td>3870</td>
<td>13611</td>
<td>0.221</td>
<td>$700,000</td>
</tr>
<tr>
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<td>44739</td>
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<td>$600,000</td>
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Table 3.3: Effects of REO Listings

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<th>(3)</th>
<th>(4)</th>
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<td>Dependent Variable</td>
<td>Log sales price</td>
<td>Log sales price</td>
<td>Log sales price</td>
<td>Log time on market</td>
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<td>-0.0073</td>
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<td>During 2 REO Listing Relative to Before Listing</td>
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<tr>
<td>During &gt;2 REO Listing Relative to Before Listing</td>
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<td>0.1723</td>
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<td>During 1 REO Listing Relative to Before Listing, .1-.33 miles</td>
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<tr>
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<td>Soon After 1 REO Sale Relative to During Listing</td>
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<td></td>
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<td>Additional Effect when Similar to 1 REO</td>
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</tr>
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<td>(0.0030)</td>
<td>(0.0029)</td>
<td>(0.0133)</td>
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<tr>
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<td>-0.0306***</td>
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<td>(0.0048)</td>
<td>(0.0045)</td>
<td>(0.0043)</td>
<td>(0.0186)</td>
</tr>
<tr>
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<td>-0.0158***</td>
<td>-0.0111***</td>
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<td>(0.0042)</td>
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<td>(0.0174)</td>
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<td>-0.0154*</td>
<td>-0.0155*</td>
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<td>(0.0167)</td>
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<td>0.5832***</td>
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<td>(0.0182)</td>
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Clustered standard errors in parentheses; p-values in italics.

*** p<0.01, ** p<0.05, * p<0.1

1. The "before" period is 1-45 days before an REO enters the MLS database.
2. The "during" period is after a listing, but before the property is delisted.
3. "Soon after" and "after" are differentiated to mean 1-45 days and 46-90 days after an REO sale, respectively.
4. "Far" and "close" signify a sale within .33 and .1 miles of an REO sale, respectively.
5. Similar is a dummy variable equal to 1 when the sale is similar in observables to the REO listing. See text for exact definition.
6. The number of observations in specification 2 is lower because we need to omit observations where...
Table 3.4: Effects of non-REO and REO Listings

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1) Log sales price</th>
<th>(2) Log time on market</th>
<th>(3) Log sales price</th>
</tr>
</thead>
<tbody>
<tr>
<td>During 1 REO Listing Relative to Before Listing</td>
<td>-0.0096 0.0357 -0.0073</td>
<td>0.0467 0.1273 0.1713</td>
<td>0.0125 0.0881 0.0668</td>
</tr>
<tr>
<td>During 1 non-REO Listing Relative to Before Listing</td>
<td>-0.0089 0.0260 -0.0072</td>
<td>0.0125 0.0881 0.0668</td>
<td>0.0056 0.0019 0.1273</td>
</tr>
<tr>
<td>During 2 REO Listing Relative to Before Listing</td>
<td>-0.0285 0.1509</td>
<td>0.0056 0.0019</td>
<td>0.0088 0.0393</td>
</tr>
<tr>
<td>During 2 non-REO Listing Relative to Before Listing</td>
<td>-0.0156 0.0593</td>
<td>0.0088 0.0393</td>
<td>0.0088 0.0393</td>
</tr>
<tr>
<td>Additional Effect when Similar to 1 REO</td>
<td>-0.0143</td>
<td>0.0688</td>
<td>0.0021 0.6827</td>
</tr>
<tr>
<td>Additional Effect when Similar to 1 non-REO</td>
<td>-0.0021</td>
<td>0.6827</td>
<td>0.0021 0.6827</td>
</tr>
</tbody>
</table>

Full Detail

I[Before >0 REO listing, far] -0.0235*** 0.0098 -0.0239*** (0.0030) (0.0133) (0.0030)
I[Before >1 REO listing, far] -0.0352*** 0.0447*** -0.0344*** (0.0044) (0.0186) (0.0044)
I[Before >0 REO listing, close] -0.0109*** 0.0156 -0.0154*** (0.0039) (0.0174) (0.0042)
I[Before >1 REO listing, close] -0.0136 -0.0417 -0.0155* (0.0086) (0.0415) (0.0085)
I[During >0 REO listing, close] -0.0080 0.0219 -0.0068 (0.0222) (0.0691) (0.0226)
I[During >0 REO listing, far] -0.0304*** 0.0636*** -0.0304*** (0.0033) (0.0139) (0.0033)
I[During >1 REO listing, far] -0.0535*** 0.0581*** -0.0519*** (0.0044) (0.0167) (0.0044)
I[During >0 REO listing, close] -0.0205*** 0.0513*** -0.0226*** (0.0032) (0.0162) (0.0035)
I[During >1 REO listing, close] -0.0324*** 0.0755*** -0.0322*** (0.0050) (0.0227) (0.0051)
I[During >2 REO listing, close] -0.0249*** 0.0263 -0.0223*** (0.0066) (0.0261) (0.0068)
I[Soon After>0 REO sale, far] -0.0309*** 0.0364*** (0.0036) (0.0141)
I[Soon After>1 REO sale, far] -0.0437*** 0.0120 (0.0052) (0.0191)
I[After>0 REO sale, close] -0.0104*** -0.0060 (0.0038) (0.0191)
I[After>1 REO sale, close] -0.0208** -0.0421 (0.0085) (0.0299)
I[After>2 REO sale, close] -0.0540*** 0.0457 (0.0159) (0.0529)
I[Before >0 non-REO listing, far] 0.0004 -0.0519*** 0.0013 (0.0033) (0.0135) (0.0032)
I[Before >1 non-REO listing, far] 0.0037 -0.0013 0.0038 (0.0027) (0.0118) (0.0026)
I[Before >0 non-REO listing, close] 0.0009 -0.0169 -0.0020 (0.0025) (0.0117) (0.0028)
I[Before >1 non-REO listing, close] 0.0088* -0.0188 0.0102** (0.0049) (0.0263) (0.0051)
| Specification | Before >2 non-REO listing, close | Before >2 non-REO listing, far | During >0 non-REO listing, far | During >1 non-REO listing, far | During >0 non-REO listing, close | During >1 non-REO listing, close | During >2 non-REO listing, close | Soon After >0 non-REO sale, far | Soon After >0 non-REO sale, close | Soon After >1 non-REO sale, close | Soon After >2 non-REO sale, close | Similar before REO listing | Similar during REO listing | Similar before non-REO listing | Similar during non-REO listing | Square feet | Square feet * square feet | REO dummy | # weeks from initial listing | Constant | Zip code by quarter fixed effects | Observations | Adjusted R-squared |
|---------------|----------------------------------|-------------------------------|------------------------------|-------------------------------|----------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------|------------------|-----------------------------|------------------|-----------------|------------------|-------------------|------------------|------------------------------------------------|----------------|-----------------|
|               | 0.0146                           | -0.0156                       | 0.0192*                      | (0.0098)                      |                                  | (0.0576)                      | (0.0108)                      | -0.0114**                    | -0.0099                       | -0.0097**                      | (0.0047)                      | (0.0200)                      | (0.0047)                      | -0.0075**                    | 0.0046                      | -0.0090**                     | (0.0037)                      | (0.0150)                      | (0.0037)                      | -0.0079***                    | 0.0091                       | -0.0092***                     | (0.0024)                      | (0.0105)                      | (0.0025)                      | 0.0021                      | 0.0144                      | 0.0042                      | (0.0038)                      | (0.0157)                      | (0.0039)                      | 0.0033                      | 0.0025                       | -0.0003                      | (0.0052)                      | (0.0244)                      | (0.0054)                      | -0.0023                      | 0.0017                      | (0.0034)                      | (0.0143)                      | 0.0080***                    | -0.0017                      | (0.0028)                      | (0.0115)                      | -0.0001                      | 0.0007                       | (0.0023)                      | (0.0111)                      | 0.0033                      | -0.0399*                     | (0.0045)                      | (0.0239)                      | -0.0108                      | 0.0221                       | (0.0108)                      | (0.0548)                      | 0.0184***                    | (0.0069)                      | 0.0041                      | 0.0093**                     | (0.0041)                      | 0.0072**                    | (0.0034)                      | 0.5842***                    | -0.0793**                    | 0.5935***                    | (0.0180)                      | (0.0313)                      | (0.0187)                      | -0.0535***                    | 0.0409***                    | -0.0551***                    | (0.0033)                      | (0.0069)                      | (0.0035)                      | -0.1292***                    | 0.0507***                    | -0.1283***                    | (0.0046)                      | (0.0162)                      | (0.0046)                      | -0.0008***                    | -0.0008***                   | (0.0001)                      | (0.0001)                      | 12.5505***                   | 2.0164***                    | 12.5323***                   | (0.0229)                      | (0.0412)                      | (0.0233)                      | X                            | X                            | X                            | 63457                        | 63457                        | 61789                        | 0.901                        | 0.225                       | 0.901                        |

Clustered standard errors in parentheses; p-values in italics.

*** p<0.01, ** p<0.05, * p<0.1

1. The "before" period is 1-45 days before a listing enters the MLS database.
2. The "during" period is after a listing, but before the property is sold.
3. "Soon after" and "after" are differentiated to mean 1-45 days and 46-90 days after a sale, respectively.
4. "Far" and "close" signify a sale within .33 and .1 miles of a sale, respectively.
5. Similar is a dummy variable equal to 1 when the sale is similar in observables to the listing. See text for exact definition.
6. The number of observations in specification 2 is lower because we need to omit observations where the square footage or age is missing.
4.1 Introduction

A life insurance policy is typically a long term contract in which the policyholder pays a fixed annual premium in return for a guarantee that his/her beneficiaries will receive a sum of cash, called the death benefit, if the policyholder dies within the coverage period. There are two broad categories of life insurance products: Term Life and Whole Life. A Term Life policy covers a person for a specific duration at a fixed or variable premium each year. If the policyholder stops paying the premium (for example, because he/she no longer needs coverage) then he/she is considered to have lapsed, and the life insurer is no longer liable for paying the death benefit if the policyholder dies. Moreover, the policyholder does not receive any refund on the premiums already paid into the policy. Whole Life policies cover a person for their entire life, usually at a fixed premium. Unlike Term Life policies, Whole Life policyholders who no longer need or want coverage can surrender their policy to the life insurance company in exchange for an amount of cash known as the surrender
value of the policy. The surrender value of the policy is typically pre-specified to depend on the length of time that the policy has been in effect, and on the amount of premiums that have been paid into the policy. For this reason (and for the simple fact that Whole Life policies are guaranteed for life), premiums in Whole Life policies are much higher than premiums in Term Life policies. A Whole Life policy can be thought of as a financial product combining both insurance protection and a tax-advantaged investment instrument.

An interesting and somewhat counter-intuitive fact of life insurance markets is that life insurance policies either do not have surrender values (as is the case with Term Life insurance) or they have surrender values that are not adjusted for health status (as is the case with Whole Life insurance). To understand why this particular feature of life insurance markets is surprising, consider Tom, a 60 year old policy-holder in the 25th year of his 30-year term policy. Tom’s children all have jobs, and his wife recently died. With no one to protect, Tom would like nothing more than to liquidate his insurance policy and take a vacation. His life insurance company should also be happy to buy back Tom’s policy, especially because Tom’s health has deteriorated, and the premiums that he locked in 25 years ago are no longer actuari-ally commensurate to his current mortality risk. Given the possibility for gains from trade between people like Tom and their life insurance companies, why is it that, in practice, life insurance policies either have no surrender value, or they have a surrender value that is more reflective of the insurance policy’s role as an investment vehicle than of the actuarial value of the insurance protection?\footnote{We are defining actuarial value as the expected net present value of the death benefit payment less the net present value of premium payments. Thus, a policyholder who receives a negative shock to health has a much higher expected death benefit payment, and thus a higher actuarial value.}

It has been suggested by Doherty and Singer (2002) and the Deloitte Report (2005) that health contingent surrender values face regulatory difficulties. While this may indeed be the case, we have not been able to find any specific regulations or
laws that explicitly prevent the writing of health contingent surrender values in life insurance contracts. In response to inquiries sent to the North Carolina Department of Insurance, regulators said that they were not aware of any such regulations, either in North Carolina or in other states. Another possibility, also suggested in Doherty and Singer (2002), is that there may be large administrative costs to implementing health contingent surrender values. This is certainly a possibility, but it begs the question of why a life settlements market has been able to emerge precisely to take advantage of the gap between the actuarial value of a life insurance policy and its surrender value.²

In this paper we argue that, regardless of the presence of any regulatory or administrative difficulties, the contracts that would emerge in the equilibrium of a market in which life insurers can perfectly commit to contract terms, policyholders’ incomes are deterministically increasing over the relevant part of their life cycle, and there is no settlement market, will not contain a positive surrender value. Our analysis follows closely the Hendel and Lizzeri (2003b, HL henceforth) model of life insurance contracts. HL studied a model in which consumers’ mortality risks change over time, and these changes are symmetrically observed by both the consumer and the life insurance companies. Because the consumers’ mortality risks change over time, they face reclassification risk, which is the risk that a deterioration in health makes it more costly for them to obtain life insurance on the spot market. HL showed that, in equilibrium, a competitive life insurance market will offer dynamic contracts that insure against reclassification risk by charging a higher premium up front, in exchange for fixed premiums that do not depend on mortality risk later. This practice of charging higher than actuarially fair premiums in the early term of a policy, and

² A life settlement is a financial transaction in which a policyholder sells his/her policy to a third party for more cash than the surrender value offered by the policy itself. The third party subsequently assumes responsibility for all future premium payments, and is entitled to the death benefits if the original policyholder dies within the coverage period. The industry is young but growing rapidly, from just a few billion dollars in the late 1990s to around $12-$15 billion 2007.
less than actuarially fair premiums in the later term of a policy, is known as front loading, and is widely evidenced in the life insurance industry.

In our model, we expand on the HL model by allowing for surrender values that are endogenously chosen. We find that having a positive surrender value introduces a dynamic commitment problem in which some ex post poor risks who would have otherwise dropped out of the pool for exogenous reasons, instead end up capturing the surrender value (think of the example of Tom). This makes it more costly for life insurers, who operate competitively, to provide reclassification risk insurance via front loading. Specifically, for any level of premiums guaranteed in the second stage of the contract, a higher up front premium must be charged in the first stage of the contract if the contract contains a positive surrender value. If the policyholder’s income is rising over the term of the contract, this represents a transfer of wealth from a state of low income to a state of high income. Because of this, the policyholder is not willing to accept a higher up front cost in return for the higher liquidity provided by the surrender value. Our results help explain why surrender values are not observed in Term Life policies, and why the surrender values in Whole Life policies reflect only the investment value of the policy.

The logic underpinning our analysis relies on the assumption that life insurance companies can perfectly commit to not buy back policies from individuals whose health has deteriorated. It also assumes the absence of a life settlement market that would purchase policies for which there is a gap between the actuarial value and the surrender value (and thus keep these policies in the pool). In reality, a life settlements market has emerged precisely to take advantage of that gap, so we also analyze the effects that a settlement market would have on the equilibrium of our model. We find that without endogenously chosen surrender values, the presence of a life settlement market reduces ex ante consumer welfare. This happens because even though life insurers can commit to zero surrender values, policyholders who no longer need their
policies ex post cannot commit to not sell their policies on the settlement market. The original insurer is thus required to honor some policies that otherwise would have been lapsed or surrendered for less than the actuarial value. In a competitive setting, this increased cost will have to be passed on to consumers. This reduces ex ante consumer welfare for the same reason that, without a settlement market, buyers prefer not to buy policies containing a surrender value. Our analysis of the welfare effect of the settlement market mirrors the analysis of Daily, Hendel, and Lizzieri (2008b, henceforth DHL) and echoes the arguments expressed in the Deloitte Report (2005).

To take the analysis one step further, we also ask the question of how the equilibrium choice of life insurance contracts, and in particular the choice of the surrender values, might respond to the presence of a settlement market. We find an interesting and policy relevant result, which is that endogenously chosen, health-contingent surrender values can partially, but not completely, mitigate the welfare loss associated with the settlement market, especially if there are less frictions in surrendering one’s policy than in a life settlement transaction. However, if surrender values are restricted to not depend on the policyholder’s health status, then the equilibrium surrender value will be zero, and the equilibrium contracts and allocations will be identical to the case in which there is a settlement market but no surrender values.

Our results and the results of DHL should not be taken to mean that the life settlement market is unequivocally bad for consumers. Both of our analyses assume deterministic and growing income, and that policyholders lapse and surrender for purely exogenous reasons (such as loss of bequest motive). If income is risky, then a life settlement market can provide increased liquidity in a state of high marginal utility. This possibility is recognized in DHL and also discussed in Doherty and Singer (2002) and Singer and Stallard (2005). The role of risks correlated with marginal utility (loss of employment) versus risks uncorrelated with marginal utility (loss of bequest motive) in life insurance lapsation is an important issue for empirical study.

Frictions in life settlement transactions can arise, for example, from marketing costs. This friction is unlikely to arise in a surrender because the life insurance companies already know who their policyholders are.
contingent surrender values, then our results suggest that, given the emergence of
the life settlement market, it would be wise to take a second look at whether such
regulations are justified. If such regulations do not exist, then it will be interesting
to observe whether life insurance companies will begin to offer health contingent
contracts in response to the life settlement market.

More broadly speaking, our research contributes to the literature on dynamic
contracts and market incompleteness. Our results suggest that secondary markets for
dynamic contracts can result in dynamic inefficiencies by eroding the commitment
power of agents. Moreover, our results suggest that options on contracts do not
necessarily move the market towards more completeness unless those options can
be conditioned on all the states which would lead to exercise of the option. In our
context, the surrender value is like an option on the life insurance policy, but it is
not useful unless it can be conditioned on health status.

The remainder of the paper is structured as follows. In Section 2 we present
our baseline model with endogenous surrender values but no settlement market. In
Section 3, we extend the baseline model to include a life settlement market, but
do not allow for surrender values. In Section 4, we examine how surrender value
will be chosen in the presence of a settlement market, and show that the usefulness
of surrender values depends crucially on whether they can be made contingent on
health. In Section 5 we summarize our findings and discuss directions for future
research. All proofs are collected in the appendix.

4.2 A Model of Life Insurance With Endogenously Chosen Surrender
Values

4.2.1 The Model

Health, Income and Bequest Motives. Consider a perfectly competitive market for life
insurance that includes risk averse individuals (policyholders) and risk neutral life
insurance companies. There are two periods. In the first period, the policyholder has a probability of death \( p_1 \in (0, 1) \) known to both himself and the insurance companies. In the second period, the policyholder has a new probability of death \( p_2 \in (0, 1) \), which is randomly drawn from a continuous and differentiable c.d.f. \( \Phi(\cdot) \) with a corresponding density \( \phi(\cdot) \). A consumer’s period 2 health state \( p_2 \) is not known in period 1, but \( p_2 \) is learned by both the insurance company and the consumer (and is thus common knowledge) at the start of period 2.

The policyholder’s income stream is \( y - g \) in period 1 and \( y + g \) in period 2, where \( y \) is interpreted as the mean life cycle income and \( g > 0 \) captures the income growth over the periods. Both \( y \) and \( g \) are assumed to be common knowledge.

The policyholder has two sources of utility: his own consumption should he live, and his dependents’ consumption should he die. When the policyholder is alive, he derives utility \( u(c) \) from consuming \( c \geq 0 \). If he dies, then he derives utility \( v(c) \) if his dependents consume \( c \geq 0 \). \( u(\cdot) \) and \( v(\cdot) \) are both strictly concave and twice differentiable.

In period 2, there is a chance the policyholder loses his bequest motive.\(^5\) We denote the probability of bequest motive loss by \( q \). The bequest motive is realized at the same time as the period 2 health state, but unlike the realization of health status, the bequest motive is private information to the policyholder and cannot be contracted upon. If the policyholder loses his bequest motive, then he does not receive utility \( v(\cdot) \) from his dependents consumption when he dies. We assume that there are no capital markets. Thus, the consumer cannot transfer income from period 1 to period 2. The only way for the consumer to ensure a stream of income for his dependents is to purchase life insurance.

\(^5\) A loss of bequest motive could result from divorce, or from changes in the circumstances of the intended beneficiaries of the life insurance policy. For example, the policyholders children may have graduated from college and found well paying jobs.
Timing, Commitment, and Contracts. Now we provide more details about the timing of events. At the beginning of period 1, after learning the period 1 health state $p_1$, the consumer may purchase a long term contract from an insurance company. A long term contract specifies a premium and face value (the amount of death benefits) for period 1, $(Q_1, F_1)$, a menu of health-contingent premiums and face values $(Q_2(p_2), F_2(p_2))$ for each period 2 health state, and a menu of surrender values $S_2(p_2)$ for each period 2 health state.\footnote{It may seem strange to allow for health contingent premiums and face amounts, but such contracts do exist in the life insurance market. For example, some types of annual renewable term policies will award you a premium discount if you prove your good health. Moreover, as we will see, absent a secondary market, the equilibrium outcome can be replicated with contracts that are not contingent on second period health.}

After purchasing a contract, the consumer pays $Q_1$ in premiums. He then consumes his remaining income, given by $y - g - Q_1$. With probability $p_1$ he dies. If he dies, his dependents consume the face amount of the policy, $F_1$. If he lives, then at the start of period 2, both the insurance company and the policyholder learn the period 2 health state $p_2$, and the policyholder learns whether or not he has a bequest motive. The policyholder then has three options: 1) he can continue with his contract by paying the premium $Q_2(p_2)$. In this case he consumes $y + g - Q_2(p_2)$ and if he dies, his dependents receive $F_2(p_2)$. 2) He can surrender his policy for $S_2(p_2)$ and purchase a new policy on the spot market, given by $(Q, F)$. In this case, he consumes $y + g + S_2(p_2) - Q$, and if he dies his dependents consume $F$. 3) He can surrender his policy and remain uninsured. In this case he consumes $y + g + S_2(p_2)$ and his dependents consume nothing if he dies. This choice is equivalent to surrendering his policy and purchasing a new contract with premium and face amount $(0, 0)$. Figure 4.1 illustrates the timing of information arrival and decisions in our model.
4.2.2 Equilibrium Contracts

To characterize the equilibrium contract, we first consider the actions of a policyholder in the second period. If the policyholder loses his bequest motive, then his best course of action is to surrender his policy and remain uninsured. If the policyholder retains his bequest motive, then he can either keep his policy or surrender it and purchase a new policy. If he keeps his policy, his expected utility is:

$$u(y + g - Q_2(p_2)) + p_2 v(F_2(p_2))$$  \hspace{1cm} (4.1)
If he surrenders and repurchases on the spot market, his expected utility is:
\[
\max_{Q,F} u(y + g + S_2(p_2) - Q) + p_2v(F)
\]
\[
\text{s.t. } p_2F - Q = 0
\]  
(4.2)

The constraint in (4.2) simply requires that competition drives the actuarial value of any spot contract to zero.

We will assume without loss of generality that in equilibrium, the policyholder who retains his bequest motive will always keep the policy rather than surrender and repurchase. To see why this does not result in any loss of generality, let \((Q^*(p_2), F^*(p_2))\) be the solution to (4.2). If the policyholder surrenders and repurchases, he consumes \(y + g + S_2(p_2) - Q^*(p_2)\) and his dependents consume \(F^*(p_2)\) if he dies. This outcome could have been replicated by choosing \(Q_2(p_2) = Q^*(p_2) - S_2(p_2)\) and \(F_2(p_2) = F^*(p_2)\).\(^7\) Moreover, by choosing \(Q_2(p_2)\) and \(F_2(p_2)\) in this way, the firm is indifferent between whether the policyholder surrenders or continues the policy. Since any outcome that can be achieved via surrender and repurchase can be replicated by an appropriate choice of second period contract terms, we will assume that the equilibrium contract is chosen such that if the policyholder has a bequest motive, then it is always (weakly) better for him to keep the policy than to surrender and repurchase. This assumption manifests itself in a constraint on the choice of second period contract terms; namely, they must be chosen such that \(p_2F_2(p_2) - Q_2(p_2) \geq S_2(p_2)\).

Under perfect competition, the equilibrium contract must maximize ex ante consumer welfare subject to a zero profit constraint. Thus, the equilibrium contract must solve:

\(^7\) This raises the possibility that \(Q_2(p_2)\) might be negative. We place no restriction on the sign of \(Q_2(p_2)\), but in equilibrium we will find that it is always chosen to be positive for any \(p_2\). In general, relaxing the constraints in an optimization problem do not result in any loss of generality unless the constraint would have been binding.
We require the surrender value to be non-negative because policyholders cannot commit to contracts requiring them to pay the insurance company in the case of voluntary surrender. The first order conditions for an optimum with respect to \( Q_1, F_1, Q_2(p_2), F_2(p_2), \) and \( S_2(p_2) \) are:

\[
\begin{align*}
\mu' & = u'(y - g - Q_1) \\
\mu & = v'(F_1) \\
\mu - \frac{\lambda(p_2)}{(1 - p_1)(1 - q) \phi(p_2)} & = u'(y + g - Q_2(p_2)) \\
\mu - \frac{\lambda(p_2)}{(1 - p_1)(1 - q) \phi(p_2)} & = v'(F_2(p_2)) \\
\mu + \frac{\lambda(p_2)}{(1 - p_1)q \phi(p_2)} - \frac{\gamma(p_2)}{(1 - p_1)q \phi(p_2)} & = u'(y + g + S(p_2))
\end{align*}
\]

where \( \mu > 0, \lambda(p_2) \geq 0, \) and \( \gamma(p_2) \geq 0 \) are the Lagrange multipliers.

It is easy to see that constraint (4.6) must bind for all \( p_2 \). If it were slack for some \( p_2 \), then \( \gamma(p_2) = 0 \). This implies that \( u'(y + g + S(p_2)) \geq u'(y - g - Q_1) \), which is impossible. The intuition is clearly illustrated by the first order conditions. The consumer wants to equalize marginal utility between states as much as possible, but the surrender value is only received in the state that already has the lowest marginal utility. The optimal decision then is to push surrender value down to its lower bound.
Proposition 1. In the absence of a life settlement market, equilibrium life insurance contracts will not include a positive surrender value.

Proposition 1 is consistent with the empirical observation that Term Life policies do not include surrender values. Whole Life policies, as we have mentioned previously, often do contain a surrender value. The industry has sometimes advertised the surrender value option as a redemption of front loaded premiums, but many industry analysis disagree and think that it should be better interpreted as a saving instrument that exploits the tax advantages of life insurance payouts (see, e.g. Gilbert and Schultz (1994, Chapter 6)). Proposition 1 suggests that the latter interpretation is more appropriate. In the absence of a settlement market, it would not be efficient to specify a surrender value in a pure life insurance contract.

Since surrender values are zero in equilibrium, we can simplify the optimization problem in (4.3) by imposing $S_2(p_2) = 0$ for all $p_2$. The problem then reduces to a model that is similar to the model of Hendel and Lizzeri (2003b). In fact, the equilibrium contracts can be characterized in much the same way as in Proposition 1 of HL.

Proposition 2. (Proposition 1 of Hendel and Lizzeri 2003) The equilibrium contract satisfies the following:

1. In each period and in each health state for which there is a bequest motive, premium and face value are chosen to equalize the marginal utility of consumption and the marginal utility of dependents’ consumption:

   \[ u'(y - g - Q_1) = v'(F_1) \]  
   \[ u'(y + g - Q_2(p_2)) = v'(F_2(p_2)) \quad \text{for all } p_2 \]  

2. There is a period 2 threshold health state, $p_2^*$ such that for all $p_2 \leq p_2^*$, the period 2 premiums are actuarially fair, and for all $p_2 > p_2^*$, the period 2 premiums are
constant with respect to health status, and therefore actuarially favorable to the policyholder.

3. For any \( q \), there is a threshold \( \hat{g} \) such that when the income growth parameter \( g \) is smaller than \( \hat{g} \), then \( p^*_2 \) is strictly less than 1. Thus, reclassification risk insurance will always be provided for individuals with low income growth.

Figure 4.2 illustrates the profile of period 2 premiums with respect to health state when there is no settlement market. \( Q^{FI}_2(p_2) \) is defined as the actuarially fair level of premium payment that solves (4.9) (i.e. the level of premium that satisfies both \( p_F - Q = 0 \) and \( u'(y + g - Q) = v'(F) \)). We see that for a set of ex post healthy consumers the premium is set to the actuarially fair level. For a set of ex post unhealthy consumers, the premium is actuarially favorable. One can also see from the zero profit constraint that in period 1, \( Q_1 > Q^{FI}(p_1) \), so that in equilibrium, policyholders are paying a higher than actuarially fair premium in the first period. This is exactly the phenomenon of front loading.

It is instructive to consider the intuition for why the contract is structured in this way. In a world of full commitment, the policyholder would ideally prefer to insure against all reclassification risk by writing a contract that does not depend on period 2 health states at all. However, policyholders with better than expected health realizations will not be able to commit to the second period terms. If premiums were completely constant across health states, then the healthiest of policyholders will prefer to surrender their policy and purchase a policy with better terms on the spot market.\(^8\)

Figure 4.2 also illustrates one of the mechanisms by which surrender values in-

\(^8\) Indeed, a long term contract with second period premiums that are constant in health realizations will replicate the outcome of the equilibrium described in Proposition 2. Ex post healthy policyholders will simply let the policy lapse and repurchase on the spot market. As we will see, the ability for the health-contingent equilibrium contract to be replicated by a non-health-contingent contract is a feature does not carry over when a settlement market is introduced.
crease the upfront cost of insurance. Without a surrender value, some poor health risks, with mortality risk greater than $p^*_2$, will lose their bequest motive and let their policies lapse. Because these poor health risks have lower than actuarially fair premiums, the life insurance company stands to save a lot of money when they lapse. If on the other hand there is a positive surrender value, these individuals who would have otherwise lapsed will instead capture the surrender value. The cost of the surrender value will then have to be passed on in the form of higher upfront costs. The reasoning outlined here is the same reasoning for why a life settlement market can reduce ex ante consumer welfare. Even if surrender values are set to zero, the settlement market can act in the place of surrender values, and because consumers cannot commit to not participating on the settlement market, this raises the upfront cost of insurance. We explore this line of reasoning more formally in the next section.
4.3 Introducing the Life Settlement Market

We now study the equilibrium life insurance contract in the presence of a settlement market. Policyholders may now sell their policies on the life settlement market in period 2. We assume that, like the life insurance companies, life settlement firms can observe and contract on the policyholder’s second period mortality risk $p_2$. If the policyholder’s second period premium and face value are $Q_2(p_2)$ and $F_2(p_2)$, then the policy can be sold for a fraction $\beta < 1$ of its actuarial value on the settlement market (i.e. the policyholder receives $\beta (p_2 F_2(p_2) - Q_2(p_2))$). $\beta$ can represent either the degree of competition in the secondary market, or the amount of fees or commissions required by the settlement firms, or any other frictions associated with the settlement market.\(^9\) We assume that the settlement market operates at the beginning of period 2, just after the mortality risk and bequest motive are learned, but before any life insurance premiums are paid and before consumption occurs. This is an innocuous assumption because perfect competition among life insurance companies ensures that the expected net present value of period 1 contracts are zero, and thus there is no surplus to be recovered on the settlement market for period 1 contracts. To better contrast the role of surrender values, we first consider the case in which surrender values are restricted to be zero.

4.3.1 Equilibrium Contracts with a Settlement Market

To characterize the equilibrium contract in the presence of a settlement market, we assume that policyholders participate in the life settlement market if and only if they lose their bequest motive. This assumption does not change the equilibrium outcome for the same reasoning as discussed in Section 4.2.2. If the policyholder

\(^9\) Currently, the life settlement industry typically offers about 20% of the death benefits to sellers after commissions and fees. Since $\beta$ is relative to the actuarial value of the policy, and not the death benefit, the plausible range of $\beta$ is around 0.4 to 0.6 (see Life Insurance Settlement Association (2006)).
retains his bequest motive, any allocation that can be achieved by selling his policy to the settlement market and repurchasing insurance on the spot market, could have been achieved with the appropriate contract choice in period 1. The equilibrium contract is therefore of a form \((Q_1^s, F_1^s), (Q_2^s(p_2), F_2^s(p_2)) : p_2 \in (0, 1)\), and is chosen to solve:

\[
\begin{align*}
\max & \quad u(y - g - Q_1^s) + p_1 v(F_1^s) \\
& + (1 - p_1) \int \left\{ (1 - q) \left[ u(y + g - Q_2^s(p_2)) + p_2 v(F_2^s(p_2)) \right] + q u(y + g + \beta V_2^s(p_2)) \right\} d\Phi(p_2) \\
\text{s.t.} & \quad Q_1^s - p_1 F_1^s + (1 - p_1) \int [Q_2^s(p_2) - p_2 F_2^s(p_2)] d\Phi(p_2) = 0, \\
& \quad p_2 F_2^s(p_2) - Q_2^s(p_2) \geq 0 \text{ for all } p_2,
\end{align*}
\]

where \(V_2^s(p_2) = p_2^s F_2^s(p_2) - Q_2^s(p_2)\) is defined as the actuarial value of the second period contract terms. Constraint (4.12) is required because consumers cannot commit to contracts with negative actuarial value in period 2. If the policy has negative actuarial for some health state in period 2, then the policyholder would simply let the policy lapse and purchase a new policy on the spot market.

It is important to emphasize that the solution to (4.10) is not the same as the solution to (4.3) with the restriction that \(S_2(p_2) = \beta V_2^s(p_2)\). Although setting \(S_2(p_2) = \beta V_2^s(p_2)\) would restore the objective function in (4.10) to be identical to that in (4.3), the zero profit constraints would still be different. In (4.4), \(\beta V_2^s(p_2)\) enters the zero profit constraint, but in (4.11), the full \(V_2^s(p_2)\) enters in. Put it differently, even if policyholders are selling their policies for free, the life insurance company is still liable for every policy sold to the settlement market.

**Proposition 3.** The equilibrium contract satisfies the following:

\(^{10}\) The \(s\) superscript is used to denote the equilibrium contract in the presence of a settlement market.
1. In each period and in each health state for which there is a bequest motive, premium and face value are chosen to equalize the marginal utility of consumption and the marginal utility of dependents’ consumption:

\[ u'(y - g - Q_1^g) = v'(F_1^g) \]

\[ u'(y + g - Q_2^g(p_2)) = v'(F_2^g(p_2)) \quad \text{for all } p_2 \]

(4.13)  
(4.14)

2. There is a period 2 threshold health state \( p_2^{**} \) such that for all \( p_2 \leq p_2^{**} \), the period 2 premiums are actuarially fair, and for all \( p_2 > p_2^{**} \), the period 2 premiums are actuarially favorable to the policyholder. Unlike in the case without settlement markets, the second period premiums are increasing with respect to mortality risk.

3. There is a threshold \( \hat{q} \) such that, if \( q > \hat{q} \), then for any \( g > 0 \), \( p_2^{**} = 1 \). That is, if the probability of bequest motive loss is high enough, the equilibrium contract is simply a sequence of spot contracts.

The equilibrium contract in the presence of a settlement market exhibits many similarities to the equilibrium contract without a settlement market, but also has two key differences. The first similarity is that marginal utilities are still equalized between the policyholder and his dependents’ consumption in states with a bequest motive. This similarity is very natural to occur because the firms care only about the actuarial value of the contract, and not the allocation between premium and face amount. Thus, within any health state, there is always one degree of freedom for the policyholder to adjust premiums and face values appropriately to equalize the marginal utilities between his own and his dependents’ consumption. The second similarity is that there is a mortality risk threshold above which reclassification risk insurance is provided.

The first key difference between the equilibrium contracts with and without settlement markets is the form in which reclassification risk insurance is provided. Figure
4.3 shows the profile of second period premiums with respect to mortality risk. We can see that in the presence of a settlement market, reclassification risk insurance no longer takes the form of guaranteed flat premiums in the second period. Instead, reclassification risk insurance is now provided in the form of premium discounts relative to the spot market premium. An interesting corollary of this result is that the equilibrium allocation in the presence of a settlement market can no longer be replicated by a non-health-contingent contract. Premiums and face values must be health contingent in order to generate the equilibrium outcome in the settlement market. As the settlement market continues to grow and become a more important player in the life insurance market, we will be interested to see if life insurance policies with health contingent premiums become more popular.

The second key difference between equilibrium contracts with and without settlement markets is the extent to which the market is even capable of providing reclassification risk insurance. Notice that the threshold health states, $p_2^*$ and $p_2^{**}$
are not necessarily the same. In fact, as Proposition 3 shows, if the probability of bequest motive loss is too high, no reclassification risk insurance can be provided at all. The equilibrium contract will be equivalent to a sequence of spot contracts. This illustrates a potentially severe consequence of the life settlement market: it can lead to the unraveling of dynamic contracts. Clearly, consumer welfare is reduced if such an unraveling occurs. However, as has been shown in Daily, Hendel, and Lizzeri (2008b), a more general welfare result can be shown. In the context of our model, the presence of a settlement market is generically welfare reducing.

**Proposition 4.** *Ex ante consumer welfare is reduced by the presence of a settlement market.*

The argument we use in proving Proposition 4 is as follows: for any contract that is feasible in the presence of a settlement market, we construct a different contract that is feasible in a world without a settlement market. The constructed contract offers identical coverage in the second period, but at a lower first period premium. The gain in welfare from the lower first period premium must be compared to the loss in welfare from the reduced liquidity in second period states without a bequest motive. We show that consumers are weakly better off under the constructed contract without a settlement market.

Proposition 4 formalizes an intuitive argument provided in Proposition 2 of Daily, Hendel, and Lizzeri (2008b). They argued that the settlement market effectively transfers resources from period 1 when income is low to period 2 when income is high. Such transfers, due to the concavity of the utility function, are welfare reducing. The informal argument provided in their paper hinges on the hypothesis that the equilibrium first period premium is higher with a settlement market than without. This hypothesis does not hold in general. An extreme example of when the hypothesis fails is provided in Proposition 3. When $q$ is sufficiently large and there is a settlement
market, the insurance market can only offer spot contracts, which implies that the first period premium is $Q_1^s = Q_{FI}$, the actuarially fair premium. In contrast, if $q$ is large but $g$ is very small, reclassification risk insurance is still offered when there is no settlement market. In this case, $Q_1 > Q_{FI}$ due to front loading. Thus, for sufficiently high $q$ and small $g$, the equilibrium first period premium is actually lower in the presence of a settlement market. Nevertheless, consumer welfare is still reduced because of the unraveling of dynamic contracts.

Many would consider the emergence of a settlement market as a form of market completion (e.g. Doherty and Singer (2002)). After all, consumers who lose their bequest motives in period 2 can share the surplus in the actuarial value of their policy with the settlement firm, something they could not do when there is no settlement market. So at a first glance, the welfare result in Proposition 4 is somewhat surprising. However, from Lipsey and Lancaster (1956), we know that once we depart from complete markets, the second best solution may not be the one with the least degree of market incompleteness. In our context, market incompleteness due to lack of commitment power and an inability to contract on bequest motives exists regardless of the settlement market. Therefore, moving towards “more completeness” by introducing the settlement market is not necessarily second best.

Another way to think of the welfare result is that the settlement market weakens the consumer’s ability to commit to not asking for a return of their front loaded premiums in the event that they lose their bequest motive. Without a life settlement market, the life insurance company is the monopsonist buyer of surrendered or lapsed policies, and can commit fully to not buy them, even if it is in their ex post best interest to do so. With the introduction of a settlement market, the commitment power of the monopsonist, which was earlier enforcing commitment among

\[11\] For another example, Levin (2001) showed that in an Akerlof lemons model, greater information asymmetries between buyers and sellers do not necessarily reduce the equilibrium gains from trade.
consumers, becomes eroded.

4.4 Life Insurance and Life Settlements with Endogenous Surrender Values

4.4.1 Health contingent surrender values

So far, we have analyzed equilibrium life insurance contracts in an environment without a settlement market and with endogenously chosen surrender values, and in an environment with a settlement market but without surrender values. One can loosely think of the former as a model of life insurance markets before the innovation of the life settlement markets, and of the latter as a model of life insurance markets in their current state: with a settlement market but without endogenous surrender values.

We now turn our attention to the case in which there is a settlement market, but surrender values are also endogenously chosen and allowed to be health contingent.

Contracts are now of the form

\[ (Q_1^{ss}, F_1^{ss}), (Q_2^{ss}(p_2), F_2^{ss}(p_2), S_2^{ss}(p_2)) : p_2 \in (0, 1), \]

and chosen to solve the following:

\[
\begin{align*}
\max &\quad u(y - g - Q_1^{ss}) + p_1 v(F_1^{ss}) \\
&\quad + (1 - p_1) \int \left\{ (1 - q) \left[ u(y + g - Q_2^{ss}(p_2)) \right. \right. \\
&\quad \left. \left. + p_2 v(F_2^{ss}(p_2)) \right] + qu(y + g + S_2^{ss}(p_2)) \right\} d\Phi(p_2)
\end{align*}
\] (4.15)

s.t. \( Q_1^{ss} - p_1 F_1^{ss} + (1 - p_1) \int \{(1 - q) [Q_2^{ss}(p_2) - p_2 F_2^{ss}(p_2)] - q S_2^{ss}(p_2)\} d\Phi(p_2) = 0, \)

\( p_2 F_2^{ss}(p_2) - Q_2^{ss}(p_2) \geq 0 \) for all \( p_2, \)

\( S_2^{ss}(p_2) - \beta V_2^{ss}(p_2) \geq 0 \) for all \( p_2 \) \hspace{1cm} (4.16)

\hspace{1cm} (4.17)

\hspace{1cm} (4.18)

We have assumed that in equilibrium, the surrender value is always chosen to be at least as great as \( \beta V_2^{ss}(p_2), \) the amount that could be obtained on the settlement market. This is an innocuous assumption. The insurance company will never set the

---

\footnote{The subscript \( ss \) is chosen to denote the equilibrium contract with endogenous surrender values in the presence of a life settlement market.}
surrender value to be lower than what could be obtained on the settlement market because by offering just an $\epsilon$ more, the insurance company can repurchase the policy for $\beta V^{ss}_2(p_2) + \epsilon$. This is preferred to letting the policy be sold to the settlement market, in which case the insurance company is liable for $V^{ss}_2(p_2)$.

**Proposition 5.** In the presence of a settlement market, equilibrium health contingent surrender values will equal the amount that can be obtained from the settlement market: $S^{ss}_2(p_2) = \beta V^{ss}_2(p_2)$.

Proposition 5 shows that if insurance companies are allowed to compete with settlement firms by offering health contingent surrender values, they will do so in a way so as to just barely undercut the settlement firms. This is not surprising given our results from Sections 2 and 3. When $S^{ss}_2(p_2) = \beta V^{ss}_2(p_2)$, policyholders are indifferent between surrendering the contract and selling it on the settlement market. If $\beta < 1$, however, the life insurance companies clearly benefit from a surrender rather than a sale. Therefore, by surrendering their contracts to the insurance companies instead of selling them, policyholders can obtain any second period allocation for a lower first period premium.\(^{13}\) When a settlement market exists, policyholders are clearly better off when they are allowed to endogenously choose health contingent surrender values.

**Proposition 6.** When a settlement market exists, consumer welfare is higher (strictly higher if $\beta < 1$) when life insurance companies can offer health contingent surrender values.

Although Proposition 6 shows that endogenously chosen, health contingent surrender values can reduce the welfare loss caused by the settlement market, the welfare

---

\(^{13}\) This also implies that, in equilibrium, no policyholder will actually participate on the settlement market. Nevertheless, the threat of the settlement market is itself enough to place a lower bound on the chosen surrender values.
loss cannot be eliminated completely. The reason for this is quite clear. As shown in Proposition 1, consumers would ideally set the surrender values to zero, but the presence of a settlement market makes it so that such a commitment is not possible. The presence of a settlement market forces the credible lower bound of the surrender value up to $\beta$ times the actuarial value of the policy. The welfare gain attributed to surrender values comes only through the increased efficiency of surrender as opposed to sale on the settlement market.

**Proposition 7.** *Ex ante consumer welfare is lower when there is a settlement market than when there is no settlement market.*

4.4.2 Non health contingent surrender values

There is one last case we have yet to consider. What if we allow for endogenously chosen surrender values, but restrict them to not depend on health status? Whether due to regulations or other reasons, this seems to be the most relevant case to real world life insurance markets. We already know that health contingency of surrender values is irrelevant when there is no settlement market. But if there is a settlement market, will a non-health-contingent surrender value help mitigate the welfare loss caused by the settlement market?

Contracts are now of the form $\langle (Q_1, F_1, S), (Q_2(p_2), F_2(p_2)) : p_2 \in (0, 1) \rangle$, and are
chosen to solve:\(^*\)

\[
\begin{align*}
\max &\ u(y - g - Q_1) + p_1 v(F_1) \\
&+ (1 - p_1) (1 - q) \int_0^1 [u(y + g - Q_2(p_2)) + p_2 v(F_2(p_2))] d\Phi(p_2) \\
&+ (1 - p_1) q \int_{S \geq \beta V_2(p_2)} u(y + g + S) d\Phi(p_2) \\
&+ (1 - p_1) q \int_{S < \beta V_2(p_2)} u(y + g + \beta V_2(p_2)) d\Phi(p_2)
\end{align*}
\]

\[s.t.\ V_2(p_2) \geq S, \text{ for all } p_2,\]  
\[S \geq 0,\]  
\[Q_1 - p_1 F_1 = (1 - p_1) (1 - q) \int_0^1 V_2(p_2) d\Phi(p_2) + (1 - p_1) q \int_{S \geq \beta V_2(p_2)} S d\Phi(p_2)\]  
\[+ (1 - p_1) q \int_{S < \beta V_2(p_2)} V_2(p_2) d\Phi(p_2)\]

To understand the above problem, let us first explain the constraints. Constraint (4.20) is the analog of constraints (4.18) and (4.5). These constraints require the actuarial value of the contract terms for any period 2 health state to be at least equal to the surrender value. As before, this requirement reflects the consumer’s ability to commit. If the actuarial value of the contract was less than the surrender value, the consumer would surrender the contract and repurchase better insurance on the spot market. But the outcome of such an action can be replicated by an appropriate choice of contract terms in period 1, so we simply assume that contract terms are chosen such that these actions do not occur for individuals with a bequest motive. Constraint (4.21) simply requires that the cash value be non negative, because the consumer cannot commit to a negative payout in any state. Constraint (4.22) is the

\[\text{We omit subscripts here both for notational clarity and because the equilibrium outcome will be equivalent to the case with a settlement market and no surrender values.}\]
zero profit condition reflecting perfect competition in the market. The first integral in the right hand side of (4.22) is the expected loss the insurance company suffers from consumers who retain their bequest motive. The second integral in the RHS of (4.22) is the expected loss the insurance company suffers from consumers who lose their bequest motive and find it optimal to surrender the policy back to the original insurer. The third integral in the RHS of (4.22) is the expected loss the insurer suffers from consumers who lose their bequest motive but find it optimal to sell the policy on the settlement market.

Now let us explain the objective function. The first integral in (4.19) is the expected second period utility to consumers with a bequest motive, for whom constraint (4.20) ensures that they remain with the original contract terms. The second integral is the expected second period utility for consumers who lose their bequest motive and find it optimal to surrender their contract back to the insurance company. The third integral is the expected second period utility for consumers who lose their bequest motive and find it optimal to sell their contract on the settlement market.

Note that problem (4.19) is substantially more complicated than problem (4.15) because now the policyholders who lose their bequest motive must choose whether to sell the policy on the settlement market or surrender the policy back to the insurer. However, using a rather intuitive perturbation argument, we can prove the following result:

**Proposition 8.** In the presence of a settlement market, if surrender values are not allowed to be health contingent, then the equilibrium contract will not contain a positive surrender value.

To understand the intuition for Proposition 8, it is useful to consider the effect of raising $S$ from 0 to $\epsilon$ on the firm’s second period profits. In figure 4.4, the curve labeled $V_2(p_2)$ depicts the period 2 actuarial value with respect to health state
Figure 4.4: The Effect of Increasing $S$ by $\epsilon > 0$ on Primary Insurer’s Period-2 Profit.

$p_2$, under the equilibrium of Section 4.3.1. The curve labeled $\beta V_2(p_2)$ depicts the settlement firm’s payment with respect to $p_2$. If the primary insurer raises the non-health contingent surrender value from 0 to $\epsilon$, policyholders with period 2 health in regions A and B, and who no longer have a bequest motive, will surrender their policies to the primary insurer for a payment of $\epsilon > \beta V_2(p_2)$. The area labeled A captures the loss in profits from the change, since the firm will be paying these consumers $\epsilon$ after the change, whereas before the change they were paying $V_2(p_2) < \epsilon$. The area labeled B captures the gain in profits from the change, since the firm was paying $V_2(p_2)$ before the change, but they are paying $\epsilon < V_2(p_2)$ after the change. As is clear from the graph, area A is first order proportional to $\epsilon$, while area B is second order proportional to $\epsilon$. When $\epsilon$ is small, the firm’s second period losses increase as a result of increasing $S$ from 0 to $\epsilon$. In order to maintain zero profit, the insurance company has to increase the first period premium $Q_1$. It is easy to see that the utility cost of increasing the first period premium is $u'(y - g - Q_1)$. It turns out that the utility gain for the consumer when $S$ increases from 0 to $\epsilon$ is captured by $(1 - p_1)qu'(y + g)\Phi(\hat{p}_2)$ where $\hat{p}_2$ is defined by $V_2(\hat{p}_2) = \epsilon$. The marginal
Table 4.1: Comparison of Consumer Welfare Across Market Regimes: A Summary

<table>
<thead>
<tr>
<th>Settlement Market</th>
<th>Cash Surrender Value</th>
<th>None</th>
<th>Non-Health Contingent</th>
<th>Health Contingent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>A = A' = A''</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>C = C' ≤ B</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Inequalities are strict when \( \beta < 1 \)

utility gain in the second period is thus smaller than the marginal caused by the increase in the first period premium, so the tradeoff is welfare reducing. Similar perturbation arguments can be used to show that marginally decreasing \( S \) from any positive level if always welfare improving. Thus, the optimal \( S^* = 0 \). Proposition 8 tells us that when insurance companies are offering surrender values that do not depend on health, then such an option is essentially useless. Thus, the consumer welfare is the same as if surrender values were not specified at all.

Table 4.1 summarizes our welfare results for the various regimes analyzed. We see that the introduction of a settlement market is unambiguously welfare reducing within the context of our setup. We also find that without a settlement market, surrender values will not be used at all, regardless of whether they can be made contingent on health. When a settlement market is present, however, the health contingency of surrender values becomes very important. In particular, if surrender values are allowed to be health contingent, then they can be chosen in such a way as to reduce the welfare loss caused by the settlement market. If they are not allowed to be health contingent, then they will not be used at all.
4.5 Conclusion

We began by asking the question of why life insurance policies in reality do not contain surrender values that are reflective of the policies’ actuarial value. We found that policyholders choose not to include surrender values because doing so would cause a dynamic commitment problem. Policyholders would want to commit ex post not to exercise the surrender value, since it occurs in a state of relatively low marginal utility. But when the second period arrives, they cannot credibly commit to not exercise the surrender value. In contrast, the life insurance can commit not to buy back policies with a zero surrender value. Therefore, commitment is enforced through the insurance company by choosing a zero surrender value.

We then extend our model to study the effects of a life settlement market on the structure of life insurance contracts and on consumer welfare. We replicate and expand on the results in Daily, Hendel, and Lizzeri (2008b), finding that the introduction of a life settlement market changes the nature through which reclassification risk insurance is provided. In particular, we find that the equilibrium contract in the presence of a settlement market is health contingent, and cannot be replicated by any contracts that are not health contingent (unlike the case in which there is no settlement market). We also find that the settlement market generically leads to lower consumer welfare ex ante. In the most extreme case, the presence of a settlement market can unravel the market for dynamic contracts to a sequence of spot contracts with no insurance against reclassification risk at all.

We also examine how endogenously chosen surrender values can operate in the presence of a settlement market. We show that allowing for health contingent surrender values improves consumer welfare, but consumers are still worse off than if there were no settlement market. We also showed that if surrender values are not allowed to depend on health, then they will again not be used at all, even in the...
presence of a settlement market. This surprising result has policy relevance, because current life insurance markets do not offer any policies with health adjusted cash values, whether due to regulations or other reasons.

Taking the above results into account, our research suggests an interesting development to look out for in the life insurance industry. Specifically, our results suggest that health contingent contracts, whether through health contingent premiums or surrender values, should become more popular as the life settlement market becomes a bigger player in the life insurance industry.

**Directions for future research.** There are several important avenues for further research. First, our analysis and the analysis of Daily, Hendel, and Lizzeri (2008b) only study the effect of life settlement markets when the surrendering or lapsation of policies is driven by the loss of bequest motives, which is not correlated with marginal utility. The sale of life insurance policies could, however, be a result of large income losses or expense increases. In a companion paper, Fang and Kung (2010a), we consider a model of life insurance markets that explicitly features both income and mortality risks. We examine the effects of a life settlement market on consumer welfare when a policyholder’s decision to surrender or lapse may be driven by income shocks. The life settlement market allows life insurance policies to be used as an instrument for consumption smoothing when the policyholder experiences large negative income shocks. Because payments received from life settlements in such low income states have a high marginal value, the life settlement market can indeed make consumers better off. We also find that, when lapsation is driven by income shocks, the welfare effects of the settlement market depend on what other consumption smoothing devices are available.

The theoretical analyses into life settlement markets thus far suggest that the welfare effect of a life settlement market depends on why policyholders lapse or surrender. If policyholders lapse only because of their loss of bequest motive, or
for other exogenous reasons uncorrelated with marginal utility, then the settlement market makes consumers worse off. If lapsation is driven by income or expense shocks, or other factors correlated with marginal utility, then a life settlement market may make consumers better off. Therefore, it is crucial to answer the question of why policyholders lapse empirically. To the best of our knowledge, there has been no formal empirical analysis of this issue in the literature. In Fang and Kung (2010b), we use data from the HRS to estimate a dynamic model of life insurance purchase, renewal, and lapsation. We then use these estimates to disentangle the separate contributions of health shocks, income shocks, and bequest motive shocks to the observed lapsation rate of life insurance policies.
Appendix.

Proof of Proposition 1

Proof. See main text.

\[\square\]

Proof of Proposition 2

Proof. The statement of the optimization problem is given by the objective function (4.3), and constraints (4.4) and (4.5), with \( S_2(p_2) = 0 \) for all \( p_2 \). Part 1 of the Proposition follows directly from the first order conditions (4.7a)-(4.7d).

To prove part 2 of the Proposition, let \( B \) be the health states for which constraint (4.5) binds and let \( NB \) be the health states for which constraint (4.5) does not bind. We first show that if \( p_2 \in B \) and \( p_1' \in NB \), then \( p_2 < p_1' \) and \( Q_2(p_2) \leq Q_2(p_1') \).

Complementary slackness conditions require that \( \lambda(p_2) \geq 0 \) and \( \lambda(p_1') \leq 0 \). The first order conditions then imply that:

\[
u'(y + g - Q_2(p_2)) = \mu - \frac{\lambda(p_2)}{(1 - p_1)q\phi(p_2)} \leq u'(y + g - Q_2(p_1')) = \mu
\]

Since \( u' \) is decreasing, it must be that \( Q_2(p_2) \leq Q_2(p_1') \). The conditions in (4.8)-(4.9) also imply that \( F_2(p_2) \geq F_2(p_1') \).

To show that \( p_2 < p_1' \), suppose the contrary. Since \( p_1' \in NB \) implies that \( Q_2(p_1') < p_1'F_2(p_1') \). Therefore:

\[Q_2(p_2) \leq Q_2(p_1') < p_1'F_2(p_1') \leq p_2F_2(p_2)\]

where the last inequality follows from the postulated \( p_2 \geq p_1' \) and the fact that \( F_2(p_2) \geq F_2(p_1') \). Thus, \( Q_2(p_2) < p_2F_2(p_2) \), which contradicts \( p_2 \in B \).

We have shown that if \( p_2 \in B \) and \( p_1' \in NB \), then \( p_2 < p_1' \). This immediately implies the existence of a \( p_2^* \) such that premiums are actuarially fair if \( p_2 \leq p_2^* \), and
actuarially favorable if \( p_2 > p_2^* \). To see that \( Q_2(p_2) \) is constant for \( p_2 > p_2^* \), simply note that \( \lambda(p_2) = 0 \) for \( p_2 \in NB \). Therefore, by the first order condition (4.7c), \( u'(y + g - Q_2(p_2)) = \mu \), and so \( Q_2(p_2) \) is constant in \( p_2 \).

Finally, to prove part 3 of the Proposition, suppose that \( p_2^* = 1 \), so that premiums are actuarially fair for all second period health states. The first order conditions imply that \( u'(y + g - Q_2(p_2)) \leq u'(y - g - Q_2) \) for all \( p_2 \), and thus \( Q_2(p_2) \leq Q_1 + 2g \) for all \( p_2 \). However, for any \( p_2 > p_1 \), it must be the case that \( Q_2(p_2) > Q_1 \), because premiums are actuarially fair. Thus, when \( g \) is sufficiently small, it is impossible to have \( Q_2(p_2) \leq Q_1 + 2g \) for all \( p_2 \).

\( \square \)

**Proof of Proposition 3**

*Proof.* The first order conditions of the optimization problem are the following:

\[
\begin{align*}
u'(y - g - Q_1) &= \mu & (A1) \\
v'(F_1) &= \mu & (A2) \\
(1 - q)u'(y + g - Q_2(p_2)) + \beta qu'(y + g + \beta V_2^*(p_2)) &= \mu - \frac{\lambda(p_2)}{(1 - p_1)\phi(p_2)} & (A3) \\
(1 - q)v'(F_2^*(p_2)) + \beta qu'(y + g + \beta V_2^*(p_2)) &= \mu - \frac{\lambda(p_2)}{(1 - p_1)\phi(p_2)} & (A4)
\end{align*}
\]

where \( \mu > 0 \) is the Lagrange multiplier of constraint (4.11) and \( \lambda(p_2) \geq 0 \) is the Lagrange multiplier of constraint (4.12). Part 1 of the Proposition follows directly from these first order conditions.

The proof for the existence of a threshold \( p_2^* \) follows the same steps as in the proof of Proposition 2. To see that \( Q_2(p_2) \) is increasing in \( p_2 \) for \( p_2 > p_2^* \), we first
rewrite the first order conditions in the following manner:

\[(1 - q) u'(y + g - Q^*_2(p_2)) + \beta qu'(y + g + \beta V^*_2(p_2)) = u'(y - g - Q^*_1),\]

\[v'(F^*_2(p_2)) = u'(y + g - Q^*_2(p_2)),\]

\[V^*_2(p_2) = p_2 F^*_2(p_2) - Q^*_2(p_2).\]

Taking derivatives with respect to \(p_2\) for each equation, we obtain:

\[(1 - q) u''(y + g - Q^*_2(p_2)) \frac{dQ^*_2}{dp_2} = \beta^2 qu''(y + g + \beta V^*_2(p_2)) \frac{dV^*_2}{dp_2},\]

\[v''(F^*_2(p_2)) \frac{dF^*_2}{dp_2} = -u''(y + g - Q^*_2(p_2)) \frac{dQ^*_2}{dp_2},\]

\[\frac{dV^*_2}{dp_2} = F^*_2(p_2) + p_2 \frac{dF^*_2}{dp_2} - \frac{dQ^*_2}{dp_2}.\]

Solving for \(\frac{dQ^*_2}{dp_2}\), we obtain:

\[\frac{dQ^*_2}{dp_2} = \frac{F^*_2(p_2)}{(1 - q) u''(y + g - Q^*_2(p_2)) \beta^2 qu''(y + g + \beta V^*_2(p_2)) + 1 + p_2 \frac{u''(y + g - Q^*_2(p_2))}{v''(F^*_2(p_2))}},\]

which is strictly positive if \(q > 0\).

Finally, we prove part 3 of the Proposition, the potential for unraveling. Once again, let \(NB^s\) denote the set of health states for which constraint (4.12) is non-binding. If \(NB^s\) is not empty, then for any \(p_2 \in NB^s\) the contract terms must satisfy:

\[(1 - q) u'(y + g - Q^*_2(p_2)) + \beta qu'(y + g + \beta V^*_2(p_2)) = u'(y - g - Q^*_1),\]

(A5)

which can be rewritten as:

\[(1 - q) [u'(y + g - Q^*_2(p_2)) - \beta u'(y + g + \beta V^*_2(p_2))]

= u'(y - g - Q^*_1) - \beta u'(y + g + \beta V^*_2(p_2)).\]

(A6)

First note that the zero profit condition (4.11) implies that if \(NB^s\) is non empty, then we must have \(Q^*_1 \geq Q^*_1^{FI}\), where \(Q^*_1^{FI}\) was defined in the text as the level of
premium that solves:

\[ u'(y - g - Q_1^{FI}) = v'(F_1^{FI}) \]

\[ p_1F_1^{FI} - Q_1^{FI} = 0 \]

Notice that \( Q_1^{FI} \) does not depend on \( q \), but is decreasing in \( g \). Let \( \bar{g} \) be the upper bound of the values that \( g \) can take, and let \( Q_1^{FI} \) denote the actuarially fair premium at \( g = \bar{g} \). Therefore the right hand side (RHS) of (A6) is bounded below, for any \( g > 0 \), by:

\[ \text{RHS} > u'(y - Q_1^{FI}) - \beta u'(y) . \]

Now examine the left hand side (LHS) of (A6). We will consider two cases. For the first case, suppose that \( \lim_{x \to 0} u'(x) = u'(0) < \infty \). Because \( Q_2^*(p_2) \) is always smaller than \( y + g \) in equilibrium, we have that

\[ LHS = (1 - q) [u'(y + g - Q_2^*(p)) - \beta u'(y + g + \beta V^*_2(p))] < (1 - q) u'(0) . \]

Thus if

\[ q > \hat{q} \equiv 1 - \frac{u'(y - Q_1^{FI}) - \beta u'(y)}{u'(0)} \]

then the LHS of (A6) will always be smaller than the RHS. Thus, equation (A5) can never be satisfied for any \( p_2 \), and \( NB^* \) must be empty.

For the second case, suppose that \( \lim_{x \to 0} u'(x) = \infty \). Since \( p_2 \in NB^* \), we have that \( p_2F_2^*(p_2) - Q_2(p_2) > 0 \). This implies that:

\[ u'(y + g - Q_2^*(p_2)) < v' \left( \frac{Q_2^*(p_2)}{p_2} \right) \quad \text{(A7)} \]

Notice that the LHS of (A7) is increasing as \( Q_2^*(p_2) \) varies from 0 to \( y + g \), and the RHS is decreasing in \( Q_2^*(p_2) \) over the same interval. If \( u'(y + g) \geq v'(0) \) then (A7) cannot be satisfied for any value of \( Q_2^*(p_2) \), so \( NB^* \) must be empty. So let us consider the case in which \( u'(y + g) < v'(0) \), so that at \( Q_2^*(p_2) = 0 \), the LHS of (A7)
is less than the RHS. Since \( u'(0) = \infty \), we know that at \( Q_2^*(p_2) = y + g \), the LHS of (A7) is greater than the RHS. Because the LHS is continuous and monotonically increasing in \( Q_2^*(p_2) \) and the RHS is continuous and monotonically decreasing in \( Q_2^*(p_2) \), there must exist some \( x \) such that the LHS and the RHS are equal to each other at \( Q_2^*(p_2) = x \). For each \( p_2 \) and \( g \) let \( x(p_2; g) \) denote this quantity. \( Q_2^*(p_2) \) must be bounded above by \( x(p_2; g) \). Now let us write \( x(p_2; g) \) and \( \bar{u}' \equiv \max_g u'(y + g - x(g)) \). We hence have:

\[
LHS = (1 - q) \left[ u'(y + g - Q_2^*(p)) - \beta u'(y + g + \beta V_2^*(p)) \right] \\
< (1 - q) u'(y + g - Q_2^*(p)) \\
\leq (1 - q) u'(y + g - x(p_2; g)) \\
\leq (1 - q) u'(y + g - x(g)) \\
\leq (1 - q) \bar{u}'
\]

Thus, if

\[
q > \hat{q} \equiv 1 - \frac{u' \left( y - Q_1^*F_1 \right) - \beta u'(y)}{\bar{u}'}
\]

then the LHS of (A6) will always be smaller than the RHS and (A5) can never be satisfied for any \( p_2 \). So \( \mathcal{NB}^* \) must be empty.

\[ \square \]

**Proof of Proposition 4**

*Proof.* We will show that for any feasible contract of problem (4.10), we can construct a feasible contract for problem (4.3) that makes the consumers better off ex ante.

Let \( C^* = \langle (Q_1^*, F_1^*), (Q_2^*(p_2), F_2^*(p_2)) : p_2 \in [0, 1] \rangle \) be a feasible contract for problem (4.10) when there is a settlement market. Thus, \( Q_1^* - p_1 F_1^* = (1 - p_1) \int V_2^*(p_2) d\Phi(p_2) \), where \( V_2^*(p_2) \equiv p_2 F_2^*(p_2) - Q_2^*(p_2) \).
Now consider a contract \( \hat{C} \equiv \left\langle (\hat{Q}_1, F_1^s), \{(Q_2^s(p_2), F_2^s(p_2)) : p_2 \in [0, 1]\} \right\rangle \) where \( \hat{Q}_1 \) is given by:

\[
\hat{Q}_1 - p_1 F_1^s = (1 - p_1) (1 - q) \int V_2^s(p_2) d\Phi(p_2).
\]

Since \( q \in (0, 1) \), we know that \( \hat{Q}_1 < Q_1^s \). That is, \( \hat{C} \) is exactly the same contract as \( C^s \) except that the first period premium is decreased from \( Q_1^s \) until the zero profit condition for the no-settlement-market case (4.4) holds. It is easy to show that \( \hat{C} \) is a feasible contract for problem (4.3).

We will now show that \( \hat{C} \) in a world without settlement market is better than \( C^s \) in a world with settlement market. To see this, let

\[
W^s(C^s) = p_1 v(F_1^s) + u(y - g - Q_1^s) +
(1 - p_1) \int \left\{ (1 - q) [p_2 v(F_2^s(p_2)) + u(y + g - Q_2^s(p_2))] + q u(y + g + \beta V_2^s(p_2)) \right\} d\Phi(p_2)
\]

denote the expected consumer welfare associated with contract \( C^s \) in a world with the settlement market. Let

\[
W(\hat{C}) = p_1 v(F_1^s) + u(y - g - \hat{Q}_1) +
(1 - p_1) \int \left\{ (1 - q) [p_2 v(F_2^s(p_2)) + u(y + g - Q_2^s(p_2))] + q u(y + g) \right\} d\Phi(p_2)
\]

denote the expected consumer welfare associated with contract \( \hat{C} \) in a world without the settlement market. Note that

\[
W(\hat{C}) - W^s(C^s) = u(y - g - \hat{Q}_1) - u(y - g - Q_1^s) - (1 - p_1) q \int [u(y + g + \beta V_2^s(p_2)) - u(y + g)] d\Phi(p_2)
\]

\[
\geq u(y - g - \hat{Q}_1) - u(y - g - Q_1^s) - (1 - p_1) q \left[ u(y + g + \beta \int V_2^s(p_2) d\Phi(p_2)) - u(y + g) \right]
\]

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where the inequality follows from Jensen’s inequality due to the concavity of $u(\cdot)$. Further note that:

$$q \left[ u\left( y + g + \beta \int V_2^*(p_2) d\Phi(p_2) \right) - u(y + g) \right]$$

$$= qu \left( y + g + \beta \int V_2^*(p_2) d\Phi(p_2) \right) + (1 - q) u(y + g) - u(y + g)$$

$$\leq u \left( y + g + \beta q \int V_2^*(p) d\Phi(p) \right) - u(y + g),$$

where again the inequality follows from Jensen’s inequality. Thus,

$$W \left( \hat{C} \right) - W^*(C^*) \geq u(y - g - \hat{Q}_1) - u(y - g - Q_1^*)$$

$$- (1 - p_1) \left[ u \left( y + g + \beta q \int V_2^*(p_2) d\Phi(p_2) \right) - u(y + g) \right]$$

First note that $Q_1^* - \hat{Q}_1 = (1 - p_1) q \int V_2^*(p_2) d\Phi(p_2)$. By the continuous function theorem, we know that there exists $\delta_1 \in (0, 1)$ such that

$$u(y - g - \hat{Q}_1) - u(y - g - Q_1^*)$$

$$= u' \left( y - g - Q_1^* + \delta' \left( Q_1^* - \hat{Q}_1 \right) \right) (Q_1^* - \hat{Q}_1).$$

Similarly, there exists $\delta_2 \in (0, 1)$ such that

$$(1 - p_1) \left[ u \left( y + g + \beta q \int V_2^*(p_2) d\Phi(p_2) \right) - u(y + g) \right]$$

$$= (1 - p_1) \left[ u' \left( y + g + \delta_2 \beta q \int V_2^*(p_2) d\Phi(p_2) \right) \beta q \int V_2^*(p_2) d\Phi(p_2) \right]$$

$$= u' \left( y + g + \delta_2 \beta q \int V_2^*(p_2) d\Phi(p_2) \right) \beta \left( Q_1^* - \hat{Q}_1 \right).$$
Hence

\[ W\left(\hat{C}\right) - W^s(C^s) \]

\[ \geq \left[ u'\left(y - g - Q_1^s + \delta'(Q_1^s - \hat{Q}_1)\right) - \beta u'\left(y + g + \delta_2\beta q \int V_2^s(p_2) d\Phi(p_2)\right) \right] \]

\[ \times (Q_1^s - \hat{Q}_1) \geq 0 \]

where the last inequality will be strict if \( Q_1^s - \hat{Q}_1 \) is strictly positive, i.e., if there is dynamic reclassification risk insurance under contract \( C^s \).

Now let \( C^s \) be the equilibrium contract in the presence of the settlement market. The above argument shows that the contract \( \hat{C} \) constructed through a simple reduction of first period premium is feasible for the problem without the settlement market; and \( \hat{C} \) provides weakly (or strictly, if \( C^s \) offers some dynamic insurance) higher expected utility to the consumers for the case without settlement market than \( C^s \) would provide for consumers with settlement market. Because \( \hat{C} \) is only a candidate contract for the case without settlement market, the equilibrium contract in that case must provide no lower expected consumer welfare than \( \hat{C} \).

\( \square \)

**Proof of Proposition 5**
Proof. The first order conditions for the solution to problem (4.15) are:

\[ u' (y - g - Q_1^{ss}) = \mu \quad \text{(A8a)} \]
\[ v' (F_1^{ss}) = \mu \quad \text{(A8b)} \]
\[ u' (y + g - Q_2^{ss}(p_2)) = \mu - \frac{\lambda(p_2)}{(1 - p_1)(1 - q)\phi(p_2)} - \frac{\beta\gamma(p_2)}{(1 - p_1)(1 - q)\phi(p_2)} \quad \text{(A8c)} \]
\[ v' (F_2^{ss}(p_2)) = \mu - \frac{\lambda(p_2)}{(1 - p_1)(1 - q)\phi(p_2)} - \frac{\beta\gamma(p_2)}{(1 - p_1)(1 - q)\phi(p_2)} \quad \text{(A8d)} \]
\[ u' (y + g + S^{ss}(p_2)) = \mu + \frac{\gamma(p_2)}{(1 - p_1)q\phi(p_2)} \quad \text{(A8e)} \]

where \( \mu > 0, \lambda(p_2) \geq 0, \) and \( \gamma(p_2) \geq 0 \) are respectively the Lagrange multipliers for constraints (4.16), (4.17) and (4.18).

From these conditions, we see that constraint (4.18) must bind for all \( p_2 \) because otherwise \( \gamma(p_2) = 0 \), which implies that \( u'(y + g + S_2^{ss}(p_2)) = u'(y - g - Q_1^{ss}) \), which is impossible.

\[ \square \]

Proof of Propositions 6 and 7

Proof. The proofs are similar to the proof of Proposition 4 so we omit them for brevity.

\[ \square \]

Proof of Proposition 8
Proof. The Lagrangian for problem (4.19) is:

\[ \mathcal{L} = u(y - g - Q_1) + p_1 v(F_1) \]

\[ + (1 - p_1) (1 - q) \int_0^1 [u(y + g - Q_2(p_2)) + p_1 v(F_2(p_2)) + p_1 q \int_{S > \beta V_2(p_2)} u(y + g + S) d\Phi(p_2) \]

\[ + (1 - p_1) q \int_{S < \beta V_2(p_2)} u(y + g + \beta V_2(p_2)) d\Phi(p_2) \]

\[ + \int_0^1 \lambda(p) [Q_2(p_2) - p_2 F_2(p_2) + S] d\Phi(p_2) + \gamma S \]

\[ + \mu \left[ (Q_1 - p_1 F_1) + (1 - p_1) (1 - q) \int_0^1 [Q_2(p_2) - p_2 F_2(p_2)] d\Phi(p_2) \right] - (1 - p_1) q \int_{S > \beta V_2(p_2)} S d\Phi(p_2) \]

\[ + (1 - p_1) (1 - q) \int_{S < \beta V_2(p_2)} [Q_2(p) - p_2 F_2(p_2)] d\Phi(p_2) \] (A9)

where \( \{\lambda(p_2) \leq 0 : p_2 \in [0, 1]\} \), \( \gamma \geq 0, \mu \geq 0 \) are respectively the Lagrange multiplier for constraints (4.20), (4.21), and (4.22).

Using standard arguments, we can show that under the optimum, \( V_2(\cdot) \) must be continuous and monotonically increasing in \( p_2 \), with \( V_2(p_2) > 0 \) for some \( p_2 \) if there is some dynamic reclassification risk insurance in equilibrium. Thus we know that for every \( S \geq 0 \) with \( S \) sufficiently small, there exists a \( \hat{p}_2 \) such that \( \beta V_2(\hat{p}_2) \geq S \) if and only if \( p_2 \geq \hat{p}_2 \) where \( \beta V_2(\hat{p}_2) = S \). Thus from the Implicit Function Theorem, we have:

\[ \frac{d\hat{p}_2}{dS} = \frac{1}{\beta V_2'(\hat{p}_2)}. \] (A10)
Therefore, the Lagrangian (A9) can be rewritten as:
\[
\mathcal{L} = u(y - g - Q_1) + p_1 v(F_1) \\
+ (1 - p_1) (1 - q) \int_0^{p_2} [u(y + g - Q_2(p_2)) + pv(F_2(p_2))] d\Phi(p_2) \\
+ (1 - p_1)q \int_0^{p_2} u(y + g + S)d\Phi(p_2) + (1 - p_1)q \int_{p_2}^{1} u(y + g + \beta V_2(p_2))d\Phi(p_2) \\
+ \int_0^{1} \lambda(p) [Q_2(p_2) - p_2 F_2(p_2) + S] d\Phi(p_2) + \gamma S \\
+ \mu \left[ (-1 - p_1)q \int_0^{p_2} Sd\Phi(p_2) + (1 - p_1)(1 - q) \int_{p_2}^{1} [Q_2(p) - p_2 F_2(p_2)] d\Phi(p_2) \right],
\] (A11)

Applying the Leibniz rule and (A10), we have that the derivative of the Lagrangian (A11) with respect to \( S \), evaluated at the optimum (superscripted by \( * \)), is
\[
\frac{\partial \mathcal{L}}{\partial S} = (1 - p_1)q \int_0^{p_2} u'(y + g + S^*)d\Phi(p_2) + (1 - p_1)q u(y + g + S^*) \frac{\phi(p_2^*)}{\beta V_2^*(p_2^*)} - (1 - p_1)q u(y + g + \beta V_2^*(p_2^*)) \frac{\phi(p_2^*)}{\beta V_2^*(p_2^*)} + \int_0^{1} \lambda(p_2)d\Phi(p_2) + \gamma \\
- \mu(1 - p_1)q \int_0^{p_2} d\Phi(p_2) - \mu(1 - p_1)q S^* \frac{\phi(p_2^*)}{\beta V_2^*(p_2^*)} \\
- \mu(1 - p_1)q [Q_2^*(p_2^*) - p_2^* F_2^*(p_2^*)] \frac{\phi(p_2^*)}{\beta V_2^*(p_2^*)}.
\] (A12)

Since by definition, \( \beta V_2^*(p_2^*) = S^* \), (A12) simplifies to:
\[
\frac{\partial \mathcal{L}}{\partial S} = (1 - p_1)q u'(y + g + S^*)d\Phi(p_2^*) + \int_0^{1} \lambda(p_2)d\Phi(p_2) + \gamma \\
- \mu(1 - p_1)q \Phi(p_2^*) + \mu(1 - p_1)q (1 - \beta) V_2^*(p_2^*) \frac{\phi(p_2^*)}{\beta V_2^*(p_2^*)}.
\] (A13)

We now argue that \( \frac{\partial \mathcal{L}}{\partial S} \) is strictly negative when \( S \) deviates from 0 to a small \( \varepsilon > 0 \). To see this, note that in the \( \varepsilon \)-neighborhood of \( S = 0 \), we have \( \gamma = 0 \),
\[ \lim_{s \to \varepsilon = 0^+} V_2^*(\hat{p}_2^*) = \varepsilon, \] thus
\[
\lim_{s \to \varepsilon = 0^+} \frac{\partial L}{\partial S} = (1 - p_1)q \left[ u'(y + g) - \mu \right] \Phi(\hat{p}_2^*(0)) + \int_0^1 \lambda(p_2) d\Phi(p_2),
\]
where \( \hat{p}_2^*(0) = \lim_{w \to 0^+} \hat{p}_2(\varepsilon) \) and \( \hat{p}_2(\varepsilon) \) solves \( \beta V_2(\hat{p}_2(\varepsilon)) = \varepsilon \). Note that the first order condition with respect to \( Q_1 \) implies that \( u'(y - g - Q_1^*) = \mu > u'(y + g) \) and that \( \lambda(p_2) \leq 0 \) for all \( p_2 \), we have:
\[
\lim_{s \to \varepsilon = 0^+} \frac{\partial L}{\partial S} < 0.
\]
The same argument can be used to show that if the optimal \( S^* \) was strictly positive, a deviation of \( S \) from \( S^* \) to \( S^* - \varepsilon \) will be strictly preferred. Thus the optimal \( S^* \) must be equal to 0.
\[ \square \]
The research presented in this dissertation can be thought of as falling into two over-arching themes. The first theme is dynamic contract design with one-sided commitment. Chapters 2 and 4 of the dissertation study optimal contract designs in the situation where one side of the party cannot commit to the contract terms. In Chapter 2, the lack of commitment is reflected by the borrower’s ability to default on the mortgage loan. In Chapter 4, the lack of commitment is reflected in the policyholder’s ability to let the policy lapse by not paying premiums. The commonality in both cases is that the exercise of the default option carries with it real economic costs. When the default option has an economic cost, I showed that having a more state-contingent contract up front can mitigate the realization of these costs. This naturally raises the question of why we do not see more state contingent contracts in consumer financial markets? There are many possible explanations. One is that administering and enforcing state contingent contracts is difficult and costly. The second is that state-contingency can introduce moral hazard if the uncommitted party can influence the states. There could also be behavioral or informational frictions to the use of more state contingent contracts. For example, consumers may
feel like they lack the expertise to understand highly state contingent contracts, and therefore avoid them. Which explanation is most plausible is an open question, and it is an interesting area for future research.

The second theme of my research has been the interactions between housing markets and mortgage markets. This also falls into the broader category of the interactions between real markets and financial markets. In light of the recent financial crisis, both areas have received increased attention from economists. Chapter 2 of my dissertation contributes to the literature by introducing a framework that simultaneously models both the mortgage and housing markets. The model is unique because most models in the housing literature treat the mortgage side as given, while most models in the mortgage literature treat the housing side as given. My paper is one of the few to combine the two markets while also allowing for a role for dynamic contract design and maintaining a close connection to empirical microdata. Chapter 3 of my dissertation contributes to our understanding of how defaults and foreclosures generate pricing externalities on neighboring properties. We provide strong evidence that the effect of foreclosures on neighborhood prices is causal, and we also provide strong evidence that a supply effect is the channel through which the foreclosure price effect operates. We do not find evidence of a disamenity effect, which is an alternative hypothesis for what creates the price effect. These results are new as there are no papers currently which attempt to identify the sources of foreclosure spillover effects. If we believe that price declines due to nearby foreclosures are primarily driven by competition, then it calls into question whether or not the foreclosure price effect can be interpreted as an externality.
Bibliography


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Biography

Edward Kung was born on April 15th, 1984 in Flushing, New York. He received his Bachelors degree from the University of Illinois at Urbana Champaign in 2006, and his Ph.D. in Economics from Duke University in 2012. He will be starting as an Assistant Professor of Economics at the University of California at Los Angeles in the Fall of 2012.