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Patric H. Hendershott
DePaul University

Jin Man Lee
DePaul University

James D. Shilling
DePaul University

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Patric H. Hendershott[¶]

Jin Man Lee[†]

James D. Shilling[‡]

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ABSTRACT

The recent unprecedented house price boom and Great Recession have had unusual and unusually large effects on housing turnover. Nominal house prices plummeted and unemployment surged, causing housing turnover to plunge. Subsequently, intervention by the Federal Reserve lowered mortgage rates to historic levels, which unlocked households with below-market interest rates. House prices have begun to recover and further increases are anticipated, but so is a reversal of the Federal Reserve's low interest-rate policy. The former will unlock households with negative equity, while the latter will lock in households with nonassumable fixed-rate mortgages. The net effect on housing turnover is uncertain.

This paper presents an econometric model of the determinants of housing turnover for Chicago, Illinois. We use a unique database for 33 submarkets (PUMAs) of Cook County collected by the DePaul Institute for Housing Studies to measure the mortgage position of homeowners. We combine these mortgage data with PUMA data on demographic and economic variables and estimate a housing turnover relationship. This relationship is then used to simulate how the economic recovery -- increases in house prices and mortgage rates -- will affect housing turnover. The results are generalized to twenty U.S. metropolitan areas that have homeowner equity positions similar to regions in Cook County in late 2012.

Keywords: Household Mobility, Trading Volume, Lock-in Effects

JEL Classification: G12, R2, R21, R31

[¶]DePaul University, 1 East Jackson Boulevard, Chicago, IL 60606, Email: phh3939@nisswa.net.

[†]DePaul University, 1 East Jackson Boulevard, Chicago, IL 60606, Email: jlee141@depaul.edu.

[‡]DePaul University, 1 East Jackson Boulevard, Chicago, IL 60604, Email: shilling@depaul.edu.

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1. Introduction

Movements in house prices and interest rates have been shown to have significant effects on mobility by creating or reducing "lock-in" effects. Falling house prices create an equity lock-in for owners who would be unable to buy another house because they owe more than the current house is worth (see Chan (2001) and Ferreira, Gyorko, and Tracy (2010, hereafter FGT)). Rising interest rates create an interest-rate lock-in for households with non-assumable fixed rate loans who want to avoid paying the market rate on another home (see Hendershott and Hu (1982), Quigley (1987), and FGT)).

The period before the Great Recession of 2007-09 was one of intense house price inflation, while the Great Recession created a mammoth house price deflation that created a huge equity lock-in, slowing mobility greatly. The Federal Reserve responded by lowering mortgage rates through their quantitative easing program, which unlocked households with below-market interest rates, thereby offsetting at least some of the equity lock-in. These dramatic events are examined here in the context of an econometric model of housing turnover for Chicago, Illinois, from 2005 to 2001. This period affords an unusual opportunity to study the link between interest-rate and equity lock-ins.

House prices have begun to recover and further increases are anticipated, but so is a reversal of the Federal Reserve's low interest-rate policy. The former will reduce the equity lock-in, but the latter will create an interest-rate lock-in. Sorting out how these opposite effects will affect housing mobility, the primary determinant of housing turnover, is the goal of this study.

The remainder of the paper is divided into six sections. The first documents how the special characteristics of the 2000-07 run-up in house prices and the sharp reversal affected mobility. We begin with a discussion of existing work on mobility, which both motivates the choice of variables determining housing turnover and leads to testable hypotheses. We then turn to a description of the 2005-11 Cook County data we employ. Based upon similarities in house price movements, 33 submarkets are combined into six distinct regions that we use to summarize the data. Section 4 presents the empirical model and Section 5 contains the empirical results. In Section 6, our estimated equations are simulated to determine the impact of plausible increases in house prices and interest rates on housing turnover in the six Cook County regions. We compare the extreme LTV distributions (below 0.8 and above 1.4) of twenty U.S. metropolitan areas with our regions. This matching process allows a generalization of the simulation results to areas beyond Cook County. Section 7 summarizes our findings.

2. Factors Influencing Household Mobility

Residential mobility affects household satisfaction and aggregate economic activity. Any restriction on mobility reduces satisfaction in that households are not living in the houses they prefer or in the location they desire. The greater mobility generates increased demands for household furnishings and many

services, i.e., higher GNP. While economists have studied many urban variables intensively -- e.g., homeownership, housing demand and house prices, the study of mobility has been limited.

We partition the determinants of household mobility into two broad categories: demographic and income-related variables, and house prices and mortgage rates. We summarize academic research on the impact of changes in these determinants.

2.1 Demographics and Income

By far the most heavily researched topic by economists in this area concerns the impact of demographic variables on household mobility. When people marry, have children, or separate through divorce or widowhood, they can experience dramatic changes in their demand for housing services; that is to say, the change in demand may cause an imbalance between current consumption of housing and desired consumption of housing services that will induce the household to move. Many of these demographic changes could also change location preferences (cause changes in the need to be near good schools, to be near employment opportunities) and lead to a move.¹ Most mobility studies have included age of household, race, sex of head of household, number of children, etc., as typical demand shift variables. There is also a large literature that correlates changes in the demand for housing with variations in permanent income, marital status, and household size.

Moving seems like the simplest means for households to adjust their housing consumption/location.² But there are typically substantial costs of moving (both out-of-pocket and psychic). Households will decide to move (and to sell their house) only when the benefits of moving (higher utility) outweigh the costs of moving. Hanushek and Quigley (1979) analyzed survey data gathered as part of the Housing Allowance Demand Experiment. Using data for households who moved into their dwelling units within the past twelve months, they estimate an elasticity of moving in response to changes in desired housing of 0.9 to 1.5.

Venti and Wise (1984) also use survey data to analyze the effects of moving costs and disequilibrium rent on the probability of a move among low-income renters. They find that moving costs (especially psychic) are high, with the result that consumption quantities of housing often differ greatly from those that would prevail if moving were costless. They estimate elasticities that are slightly higher than those of Hanushek and Quigley.

The bulk of the empirical evidence shows that household mobility is greatly affected by the formation and dissolution of households (Goodman, 1978). Mobility is also related to the family's life-cycle stage, past mobility, and housing tenure (Quigley and Weinberg, 1977). Quigley (1987) finds that household mobility decreases with the age of the household head and increases with the education of the head.

¹ Clark and Withers (1999) present evidence that a job change in the local housing market often acts as a trigger for a residential move. However, in later work Clark and Withers (2002) argue that most local moves occur for reasons other than labor market gains. It might be, for example, that such moves are undertaken in search of better or safer schools, renters may prefer to buy, or couples might prefer a location that provides career opportunities for both partners.

² Additions/alterations also allow housing consumption adjustments.

Education is interpreted as a proxy for awareness of alternative opportunities and the ability to adjust to change. Engelhardt and Greenhalgh-Stanley (2010) find evidence that the married elderly, the vast majority of which are homeowners, can and do live independently and maintain their desired living arrangement, while older widows may desire to move due to the need for nonhousing services.

Ferreira, Gyourko, and Tracy (2010) find that mobility decreases with age until the household head reaches the early fifties and increases thereafter. They also find that mobility increases with years of housing tenure. The latter is consistent with a life-cycle pattern of housing choices where households go through several trade-up purchases before owning a home that they will live in for an extended period of time. They find that larger households are less mobile than smaller households, supporting the generalization that kids increase the transaction costs involved in moving. Their final demographic conclusion is that mobility responds more to increases than to decreases in family size.

Many scholars recognize that the event of moving from one dwelling to another or one location to another is linked to income or changes in income. Quigley (1987), for example, shows that household relocation decisions are a positive function of income. His results suggest that an increase in income causes an outward shift in the housing demand curve, hence motivating the household to relocate. Wagner and Mulder (1998) report that household mobility is caused by and timed in accordance with events such as marriage, birth of children, divorce, death of a partner, entering or finishing stages in one's education, and income changes.

DiPasquale and Wheaton (1996) show that household mobility is positively related to local population growth rates, especially to the growth rate in young adults between the ages of 20 and 35 – which are by far the most mobile segments of the population. Strassmann (2000) finds a positive relation between the varying turnover in the metropolitan housing markets in the U.S. and the variation in economic growth between metropolitan areas. He also relates the level of turnover in the housing stock in cities to affordability and house prices.

Clark and Withers (1999) present evidence that a job change will often spark a residential move and that job changes are much more influential on household mobility than often believed. However, in later work they argue that most local moves occur for reasons other than labor market gains (Clark and Withers, 2002). It might be, for example, that such moves are undertaken in search of better or safer schools or renters switching to owning. It has also been shown that homeowners are less likely to change residence in conjunction with a job change than renters, and a dual-earner household is more closely bound to the place of residence than a single-income household. Finally, Follain and Velz (1995) find that household mobility is directly related to changes in, rather than levels of, employment.

2.2 House Prices and Mortgage Rates

Several scholars have shown that house prices can have a significant effect on the decision to move and which dwelling to choose (Molin, Oppewal and Timmermans, 1996). Theoretical studies by Stein (1995), Ortalo-Magne and Rady (1999, 2006), and others argue that households can be subject to significant down payment constraints. These studies stress that an increase in house price can increase the wealth of existing homeowners, giving them more money for a possible down payment, thereby increasing the demand for housing at the next size or quality level. Thus, this theory predicts a positive correlation

between the level of housing prices, or changes in them, and household mobility and turnover. On the other hand, higher house prices restrict renter households from moving to become owners.

Declines in house prices may lower mobility through similar channels. More important, declines will eliminate equity of households with large mortgages. Such households would be unable to sell for enough to pay off the existing lender, much less than to come up with cash for a new down payment. Chan (2001) uses a sample of mortgages originated by Chemical Bank between late 1989 and early 1994. She finds that increases in the LTV to above 0.95 reduce mobility by roughly a third. Using data from the American Housing Survey (AHS) for 1985-2005, FGT find a 46 percent lower mobility rate for the 2.6 percent of their sample that had negative equity.

Significant negative equity of the amount experienced in the Great Recession has caused distressed sales and mortgage defaults (see data below).³ With turnover being measured as sales divided by number of housing units, these will increase mobility, dampening the direct effect of negative equity.

It may not be just current house price levels that are critical to household mobility, but also the level of the current house price relative to the price at purchase as well. Evidence in Genevose and Mayer (2001) suggests that sellers can be subject to “loss aversion,” that is to say, homeowners may not be psychologically willing to sell their houses for less than they paid for them and thus declines in prices could reduce mobility even for those with positive equity.

Homeowners with fixed-rate mortgages can also be locked into homes if they have a below-market interest rate on a non-assumable loan [Hendershott and Hu (1982), Quigley (1987), and FGT].⁴ Hendershott and Hu provide evidence that household mortgage capital gains owing to rising mortgage rates during the 1967-74 period greatly reduced mobility. Quigley finds that the lock-in effect of higher mortgage interest rates has a negative and significant effect on household mobility. His results suggest that a 2 percentage point increase in interest rates decreases the cumulative probability of moving by about 15 percent over the life cycle. FGT state that their estimated response is at least as large. Of course if households are already locked-in owing to a lack of housing equity, having a below market interest rate will not have an additional effect. Thus it is a below-market rate on a non-assumable fixed-rate loan where borrowers have positive equity that will reduce mobility.

The 2007-12 period was one of declining mortgage rates. The Federal Reserve Board lowered rates in order to stabilize the housing market and increase employment. But the lower interest rates will not last forever. As the economy grows and house price and general inflation increase, the Federal Reserve will eventually have to raise interest rates to combat this inflation. While increases in house prices will unlock

³ Studies by Harding, Rosenblatt, and Yao (2009) and Campbell, Giglio, and Pathak (2011) demonstrate empirically that there is a contagion house price effect associated with negative equity. The more households are experiencing negative equity in a neighborhood, the more likely that house prices are lower. But, as house prices decline, the extent of negative equity will rise with feedback effects on household mobility.

⁴ The mortgage lock-in effect can lead to increased spending on maintenance and additions (Potepan, 1989). Fisher and Williams (2011) provide evidence that an increase in mortgage interest rates raises the probability of maintenance and additions expenditures, although the maintenance and additions may also need to be financed with a loan.

households with low or mildly negative equity, mortgage rate increases are likely to generate lock-in effects similar to those observed in the late 1960s and early 1970s.

From the above discussion, the following hypotheses emerge: First, rates of housing turnover increase with income and decrease with education and age. Second, housing turnover rates are slowed by an interest-rate lock-in. Third, rates are also slowed by high loan-to-value ratios. Fourth, given significant negative equity, defaults on home mortgages could lead to higher rather than lower housing turnover rates. As conditions for strategic defaults increase, then higher turnover rates will ensue. If there is a valuable option to “wait-and-see” or take no action, then lower turnover rates will be slowed. These hypotheses are explored using data for Cook County in Illinois.

3. The Data

We estimate a Panel using data from 33 Cook County submarkets. Basic mortgage and price data come from the Cook County Office of Deed Recordings (all mortgage transactions and house sales during the 1990-2011 period). These data have collected by the DePaul Institute for Housing Studies. Moreover, quarterly constant quality house price indices have been computed by the Institute for each of the 33 submarkets over the 1997-2011 period (see the Appendix).

Data on income, employment and demographics are from the PUMA (public use micro areas) database drawn from the American Community Survey. PUMA areas each contain roughly 100,000 households. The PUMA data cover only the 2005-2011 period. This gives us 231 (33*7) observations in the panel. We also use data from the county assessor for number of housing units.

3.1 Price and Transactions Data

To illustrate our data, we aggregate the 33 submarkets into six regions of Cook County (the number of PUMAs is given in parentheses): North (6), South (7), West (4), Southwest (5), Chicago Inner (7) and Chicago Outer (4). These aggregations are based on relatively common movement in house prices. Figure 1 shows a map of Cook County with the 33 different PUMAs and six regional aggregates. The 33 different PUMAs are identified on the map according to numbers. The six regions are identified by different shades. Nominal prices (scaled to 100 in 2000Q1) over the 1997-2012 are given for the regions in Figure 2. In general prices rose strongly through 2007 and then collapsed.

The increases ranged from 66 percent in South Cook County to 98 percent in Outer Chicago with the other four regions having 71 to 86 percent increases. Prices then plummeted by 50 percent or more in the West, South, and Outer Chicago, resulting in a 2012 price less than the 2000 price (Outer Chicago had both the largest increase and greatest reversal). The outlier is Inner Chicago, where prices fell by less than a quarter and were still 40 percent above the 2000 level in 2012.

Figure 3 contains the national rate on 30-year fixed-rate mortgages (Freddie Mac survey), the unemployment rate for the Chicago MSA and our aggregate Cook County house price index. The boom during the second half of the 1990s is reflected in a low unemployment rate and rising mortgage rate and house prices. The higher interest rates at the end of the decade popped the dot.com bubble, which led to the 2001 recession. Unemployment rose by 3.5 percentage points, but easy money substantially lowered

interest rates and house prices kept rising. During the 2002-07 period, the unemployment rate fell by nearly 4 percentage points, while the mortgage rate was relatively flat and house prices surged. Then the Great Recession hit, collapsing house prices and boosting unemployment. The Fed responded by lowering interest rates. The mortgage rate fell from over 6 percent in 2006-07 to under 4 percent in early 2012.

The ratios of total transactions and distressed sales to the number of housing units during the 2005-11 period are plotted in Figure 4. The transactions rate plummeted from above 7 percent in 2005 to 3 percent in 2008 and remained there through 2011. In contrast the distressed sales ratio rose from a negligible amount to over 1 percent in 2009-11. In fact, in the North, South, and Far South, distressed sales accounted for half of transactions during the Great Recession. Owing to the greater price decline, these sales rates in the West, Far South, and South have been roughly double those in the North and Northwest suburbs.

3.2 Demographic and Economic Data

Table 1 presents our key demographic and economic average values for each of the regions in 2005 and 2011, as well as the changes between these years. All demographic series except household size are fractions of the regions households in the relevant categories. Thus the age fractions and the race shares each sum to unity.

Economic variables include the unemployment rate, the share of adults working full time, and relative income variables. To determine the latter, we first take the aggregate income for the 33 PUMAs (all of Cook County) and determine quartile breaks for each year. Then for each PUMA we tabulate the shares of the households in each of the quartiles. The shares of the households in each PUMA that were in the highest and lowest quartiles for 2005 and 2011 (and the change) are listed in the table.

The North and Southwest regions are similar. They are relatively more male, married, and white (and Asian). They are better educated and have higher income (more in top quartile, less in bottom quartile). The North is more so on all of these counts, while the Southwest has relatively few young (under age 35).

On the other hand, the South is least male, most black, and oldest (over age 64), and relatively few are married. Households there have low education and the lowest employment and income. Outer Chicago is the most Hispanic region, and they have the least education and low employment and income.

Inner Chicago is predominately young urban professionals. They are the youngest (and not old, 65+), least married, and have the smallest household size. They have the most households with college degrees and are the most employed. The West is the most balanced of the regions.

As discussed above, borrowers can be "locked-in" to their current residences through two channels. First, if they have low or negative equity, and second, if they have positive equity but have a below-market interest rate on a non-assumable fixed-rate loan. Table 2 gives the distribution of mortgages by LTV level for each of our six regions in the first quarters of 2005 and 2011, and the change between them.

We estimated individual LTVs as follows. For houses that did not sell during 2005-11, the fair market value (from assessor) in 2005 is used for that date, and our price index is used to forecast and backcast house values. For houses that did sell in our window, the selling price on that date is forecast and backcast with our price index. We have all mortgage transactions from 1990, both loans with purchases and mortgage refinances (and second mortgages). Thus we can forecast and backcast loan amounts using amortization schedules. But if a house had no mortgage transaction after 1989, we have no indicator of the size of the owner's mortgage. Thus we have deleted from our sample all households for which there are no post-1989 mortgage data. This deletion lowers the number of transactions by 8 percent and the number of housing units by 24 percent.

Very high LTV loans were negligible in 2005, as were those between 0.9 and 1.15 in the North and Northwest suburbs. The share with very high LTVs rose by only 0.04 and 0.09, respectively in the North and Northwest suburbs between 2005 and 2011, but this fraction surged by 0.25 to 0.33 in the other regions.

The table also has data on our mortgage-rate lock-in variable, the share of borrowers with conventional fixed-rate mortgages with LTV less than 90 percent and with a below-market interest rate. We restrict this calculation to those with LTVs below 90 percent because, as we show below, borrowers with higher LTVs were already locked-in. About a fifth of fixed-rate mortgages were below market in 2005 only about a tenth in 2011. But over half were below market in both 2006 and 2007.

4. Empirical Model

We specify a linear regression model for trading volume of the form

$$T_{it} = \alpha + X'_{it}\beta + \varepsilon_{it} \quad (1)$$

where T_{it} is the trading rate in PUMA i in year t , represented by the ratio of sales to the total number of housing units in PUMA i in year t , X_{it} is a set of variables determining that volume, ε_{it} is an error term (which arises from unobservable variables that differ across geographic submarkets and over time), and β is a vector of parameters to be estimated. The principal determinants of mobility were discussed in Section 2, and we expect these to be the principal determinants of the trading rate. We also include a full set of fixed-effect controls for differences between PUMAs that are otherwise not accounted for by other independent variables in the model. The fixed-effects model does not include fixed time effects.

Because the traditional OLS regression assumes a symmetric distribution of errors and might predict negative values of T_{it} , we apply a logit transformation to transform the relative trading frequencies (T_{it}) to the logs of the odds ratio: $L_{it} = \log(T_{it}/(1 - T_{it}))$. The ratio of T_{it} to $1 - T_{it}$ defines the odds of a house being sold in PUMA i in year t . This ratio increases from 0 to 1. In turn, the L_{it} ratio can take any value between plus and minus infinity. Hence, the transformed equation given by

$$L_{it} = \log(T_{it}/(1 - T_{it})) = \alpha + X'_{it}\beta + \varepsilon_{it} \quad (2)$$

which is a true logit equation, can be estimated using standard econometric techniques because the dependent variable is not a discrete variable. Once the parameters in (2) have been determined, one can

calculate predicted values of T_{it} by substituting values for X_{it} into equation (2), taking antilogarithms, and solving for \hat{T}_{it} .

Equation (2) is identical to the logit equation estimated by FGT and Chan (2001). Still, there are significant differences in the data employed in the estimation. First, FGT and Chan do not have any information on the location of the residence. Second, FGT and Chan use MSA and county-level price indices to update house prices and thus the contemporaneous LTV. The implicit assumption in their calculations is that the correlation between one's house price and the MSA and county-level index is quite strong. This assumption is questionable. Evidence in Bertus, Hollans, and Swidler (2008), and McDuff (2012) indicates that there is very little correlation between a MSA and county-level index and individual house price appreciation.⁵

5. The Results

Estimates for two equations are reported in Table 3. The equations differ in that changes in the employment rate and employment, rather than the levels, are included in the second equation. Because we do not have data before 2005, including the changes reduces our sample for the second equation from seven years (2005-11) to six. Given that there are 33 PUMAs, the sample is reduced from 231 observations to 198. The equations explain 73.8 and 68.3 percent, respectively, of the variation in the dependent variable. Figure 5 shows a plot of the actual versus predicted values of T_{it} averaged across all 33 PUMAs for the two models. The results demonstrate a reasonable fit. Both the sharp drop to 2008 and the steadiness through 2011 are captured.

The mortgage lock-in variable is the most statistically significant variable in either equation, having a t-ratio of nine.⁶ Both of the loan-to-value variables are statistically significant in both equations with t-ratios of three and four. All coefficients are negative; lock-ins reduce mobility. These are, of course, the variables we are most interested in. We discuss the implications of these coefficients in some detail below.

A number of income and demographic variables are significant in model 1. Mobility increases with income and decreases with education and age (is basically greater for those over age 26). These effects are greatly dampened in model 2.⁷ Mobility is greater for only highest income quartile, the impact of education falls by a third (and is statistically insignificant) and the age effect is cut by about three-quarters. The model results differ because model 1 uses data from 2005 and model 2 does not. When model 1 is run over the same 2006-11 estimation period, the explanatory power drops to 66.2 percent and the coefficients generally are quite similar to those of model 2. Thus we will explain model 2 results in some detail and will use them in our forecasting.

⁵ It is also worth noting that FGT and Chan only observe a small number of households in a negative equity situation. In FGT's sample in only 2.6 percent of their observations does a household have negative equity. In Chan's sample, households are assumed to be mobility-constrained if they have an LTV above 80 percent.

⁶ The rise in lock-ins from twenty percent in 2005 to sixty percent in 2006 explains most of the decline in the aggregate transaction rate during this period.

⁷ In both models the PUMA fixed effect dummy variables capture the impacts of the race, marital status, and gender variables.

Figure 6 shows a plot of the actual versus predicted values of T_{it} for each of the six regions. Most regions show a reasonably good fit, as indicated by the fact that the observations cluster along the 45-degree line. However, transactions in Inner Chicago are poorly explained, owing largely to a problem with 2006. Four of the five outliers to the right in the figure are for PUMAs in that year.

The impact of changes in interest-rate lock-in are large. With all variables at their end of sample values, including the lock-in fraction at 0.07, raising the lock-in fraction all the way to unity virtually eliminates transactions (the average transactions rate from 0.035 to 0.003). Lowering the lock-in to zero raises the transactions rate by 15 percent to 0.040. In general, restricting the mortgage rate lock-in to borrowers with LTVs below 0.90 percent significantly improved the fit of all regression models tested by providing a significant reduction in the residual sum of squares. Restricting the mortgage rate lock-in to borrowers with LTVs below 0.90 had little influence on the estimates of the lock-in variable, suggesting that prior work has not been too greatly affected by failure to control for the interaction between interest-rate and equity lock-in effects.

Owners with loans with LTV above 1.15 are more deeply locked in than are those with LTV between 0.9 and 1.15 and thus are less mobile. However, the highest LTV loans are more likely to lead to distressed sales.⁸ Thus the coefficient on the greater than 1.15 LTV variable could be larger or smaller than that on the LTV between 0.9 and 1.15 variable. That the greater than 1.15 coefficient is smaller implies that the distressed sales effect dominates.

With the other variables put at their 2011 values, we increase houses prices by first 25 percent and then 50 percent. The 25 percent increase shifts all households with LTVs in the intermediate range to LTVs below 0.9 and many households with higher LTVs to the intermediate range. The 50 percent increase shifts almost all households with LTVs above 1.5 to below 0.9 (5 percent shift to 0.9 to 1.15 LTVs). The smaller price increase raises turnover from 0.035 to 0.038. The 50 percent increase raises turnover to 0.041.

The change in unemployment has a significant negative coefficient, although the effect of changes is not that great. When turnover is 0.070 a percentage point rise lowers the turnover rate from 0.061 to 0.063, a decrease of 3 percent. And, of course, the rate would bounce back the next year unless the decline continued.

6. Simulated Impacts of Increases in House Prices and Interest Rates

During 2012, the mortgage rate decreased by a full percentage point to 3.66 percent, but reversed that in the first half of 2013. House prices continued falling by modest amounts, but rebounded by about 10 percent in the first half of 2013. A further price rise seems highly likely. Nominal prices in Chicago at the end of 2012 were still 22 to 55 percent below their 2007 peak (real prices are another 20 percent lower). And the Federal Reserve is certain to allow interest rates to rise at some point in response to rising prices

⁸ The model 1 coefficient of LTV above 1.15 falls (in absolute value) from -2.18 to -1.75 when the 2005 data are not used.

generally. In this section we use our model to simulate the impacts of possible price and interest-rate changes on household mobility.⁹

We begin by initializing the model to “current” conditions. All variables are set equal to their last sample period values (fourth quarter 2011). We then update the LTV and the lock-in variables to the fourth quarter of 2012 by changing regional house prices by the actual PUMA changes (13 percent decrease in the West, 2 percent increase in Inner Chicago, and 1-4 percent decreases in the other regions) and lowering the mortgage interest rate by a full percentage point.

End of 2011 and updated values of the key variables for the six regions are shown in Table 4. The main impact of the update is to eliminate virtually all locked-in households. But because less than 7 percent of mortgage borrowers were locked-in, the increase in turnover is modest -- less than 0.005 except in Inner Chicago. There the decrease in lock-in was the greatest (0.053), and the increase in turnover was 0.009. The effects of the lower interest-rate lock-ins are offset by falling house prices and higher LTVs between 0.90 and 1.15, especially in the North.

Table 5 shows the impacts of a one-time increase of 10 and 50 percent in house prices for the six regions. The first section of the table gives the initial turnover rate and the distribution of borrowers in the three LTV categories, less than 0.9, 0.9-1.15 and over 1.15. The second and third sections give the results for the two increases in house prices. A 10 percent increase lowers LTVs by a little and thus increases turnover by a bit -- 0.001-0.002. But a fifty percent increase in prices substantially lowers LTVs and thus increases turnover by 0.006 to 0.010. This increase reduces the LTV to under 0.9 for virtually all households in Inner Chicago. The greatest increase in turnover is in the West, where percent of borrowers with an LTV less than 0.9 increases from an initial value of 61 percent to 87 percent (which is the largest increase across the six regions).

While these results are for regions of Cook County, a number of metropolitan areas throughout the U.S. have LTV distributions that are similar to those of these regions. Zillow has reported LTV distributions for a number of metropolitan areas in the fourth quarter of 2012, ranging from under 80 percent to over 200 percent in 20 percent increments. To allow comparison with our regions, we have computed similar distributions for our regions. Table 6 contains the extreme ends of the distributions, namely loans with an LTV below 80 percent and those with an LTV above 140 percent. Comparable data for the 20 metropolitan areas in the Case-Shiller data set are interspersed. Spaces occur to indicate which regions the areas are like. The first three areas are similar to Chicago Inner, the next five to the North, etc. The largest turnover increase with respect to a large increase in prices was the West, which is quite similar to Phoenix and Tampa.

Table 7 shows the impact of continuously rising rates on fixed-rate mortgages. The interest-rate increase is 1 percentage point a year for three years, rising from 3.66 percent (end 2012 value) to 6.66 percent. These rate increases are preceded by a 10 percent increase in house prices (in year t+1) in the first simulation and a 50 percent increase in the second simulation. The interest-rate increases occur in years

⁹ The unemployment rate will certainly fall, but its impact on turnover is small. A percentage point decline would raise turnover for 0.002 for that year only, with turnover falling back if the rate ceased falling.

t+2, t+3, and t+4. This type of rate rise is hardly unprecedented. In fact, the mortgage rate rose by 7 percentage points between 1977 and early 1982 (and it has already increased by 1 point).

A continual rise in mortgage rates would lock more and more borrowers with nonassumable fixed-rate mortgages into their existing location. The lower section of the table indicates just what share of all borrowers are locked in, while the upper section gives the turnover rate. The three-year increase in the lock-in is large -- 0.28 to 0.40 -- except for the South, where it is only 0.18. The latter is low because the South had the fewest households with LTVs less than 0.9 who could be interest-rate locked-in (they weren't equity locked in). After the 10 percent increase in price, only 55 percent in the South had LTV less than 0.9, in sharp contrast to Inner Chicago where 91 percent had that low an LTV (see Table 5). The increased lock-in led to a 0.012 to 0.041 decrease in turnover, the largest being in Inner Chicago and the smallest in the South.

A 50 percent increase in price sharply reduces equity lock-in (lowers LTV to below 0.9), thereby creating the potential for more interest-rate lock in, and that is what we see in the lower right panel of Table 7. Lock in increases by 0.40 to 0.46 except for the South where the increase is only 0.30. Again, the relatively low South number reflects the relatively few borrowers with LTVs below 0.9 (only 71 percent versus a high of 98 percent in Inner Chicago). The larger increase in lock in leads to a larger decrease in turnover of 0.021 to 0.046. And again the smallest decrease is in the South and the largest in Inner Chicago.

Recall from Table 6, that the LTV distribution in New York, Portland, and San Francisco is like that in Inner Chicago, and the Las Vegas distribution is like that in the South. These areas are likely to see the extreme impacts of turnover slowdown in response to increases in interest rates. Of course, areas with greater usage of adjustable-rate mortgage financing would be subject to less lock-in.

What does all this suggest for the economy in the near term? Increases in house prices normally create homeowner equity and allow take-out refinancing to fund greater consumption.¹⁰ But in the current situation, much of house price increases will simply be bringing LTVs down to the now required 80 to 90 percent. The price increase will have limited ability to fund greater consumption. Moreover, where the price increase does create significant positive "useable" equity, an easing of the Federal Reserve's Quantitative Easing program would lock many owners into what would become below-market mortgages. That is, they would not be refinancing and withdrawing equity for consumption or selling and moving into more expensive houses (and stimulating housing construction). Put another way, the normal strong housing-wealth effect on consumption (Case, Quigley and Shiller, 2011) could be severely dampened.

7. Summary and Conclusions

Homeowners can get "locked into" their existing residences in two ways. First, if they overleveraged and then house prices fell, they cannot sell and have sufficient funds to make a down payment on another house. That is, they are equity locked in. Second, if they have a non-assumable fixed-rate mortgage and

¹⁰ Mian and Sufi, 2010, suggest that homeowners withdrew \$1.25 trillion during the 2002-06 period to fund consumption.

interest rates rise sufficiently, moving from their current interest rate to what it would be on a new purchase is too costly. In this case, they are interest-rate locked in. In both cases, mobility and the residential turnover rate decline.

The house price collapse in the Great Recession, along with overleveraging during the house price boom locked many homeowners in, while the Federal Reserve's response to the recession -- lowering interest rates including long-term rates through their quantitative easing program -- unlocked borrowers who had below-market interest rates. The net impact on turnover has been negative, in part because the equity lock-in is relevant to all homeowners, which the interest-rate lock-in is applicable to only those financing with non-assumable fixed-rate loans (and are not already equity locked-in).

A recovery of house prices is underway, which will unlock many households and increase turnover. However, the expected cessation of the Quantitative Easing program will raise interest rates, potentially creating a huge interest-rate lock-in. This paper attempted to document what the turnover effects of the lock-ins were in recent years and simulated what the impact of future house price and interest rate changes might be.

We used a unique database for 33 submarkets (PUMAs) of Cook County collected by the DePaul Institute for Housing Studies to measure the mortgage positions of homeowners. We combine these mortgage data with PUMA data on demographic and economic variables to estimate our turnover equation. We simulate the impact of house price and interest-rate increases on turnover in different regions of Cook County. Because these regions vary widely in the distribution of the underlying homeowner equity position, the simulation results are applicable to wide parts of the U.S.

Appendix: House Price Indices

The house price indices for the 33 Cook County PUMAs were created by the Institute of Housing Studies at DePaul University. The indices are calculated monthly. The underlying house price data from the Cook County Recorder of Deeds include information on the date the transaction occurred, the property location, and the sales price.

The house price indices are constructed using a repeat sales approach similar to that of Case-Shiller (1987, 1989). The indices weigh each observation based on how representative that observation is of the overall population. This weighting corrects for the fact that lower-value properties generally trade more frequently than higher-valued properties. The weights also reflect the number of transactions that occur in each PUMA.

The house price indices are based on all single-family sales. That is, the indices include both regular and distressed sales and those financed by both conventional and FHA/VA loans and conforming and jumbo loans. The indices are calculated for 33 PUMAs. A Hodrick-Prescott filter is used to smooth out extreme observations in the data for each PUMA, while still allowing for systematic adjustments in prices to occur due to distressed sales. The indices are available at the website <http://www.housingstudies.org/>.

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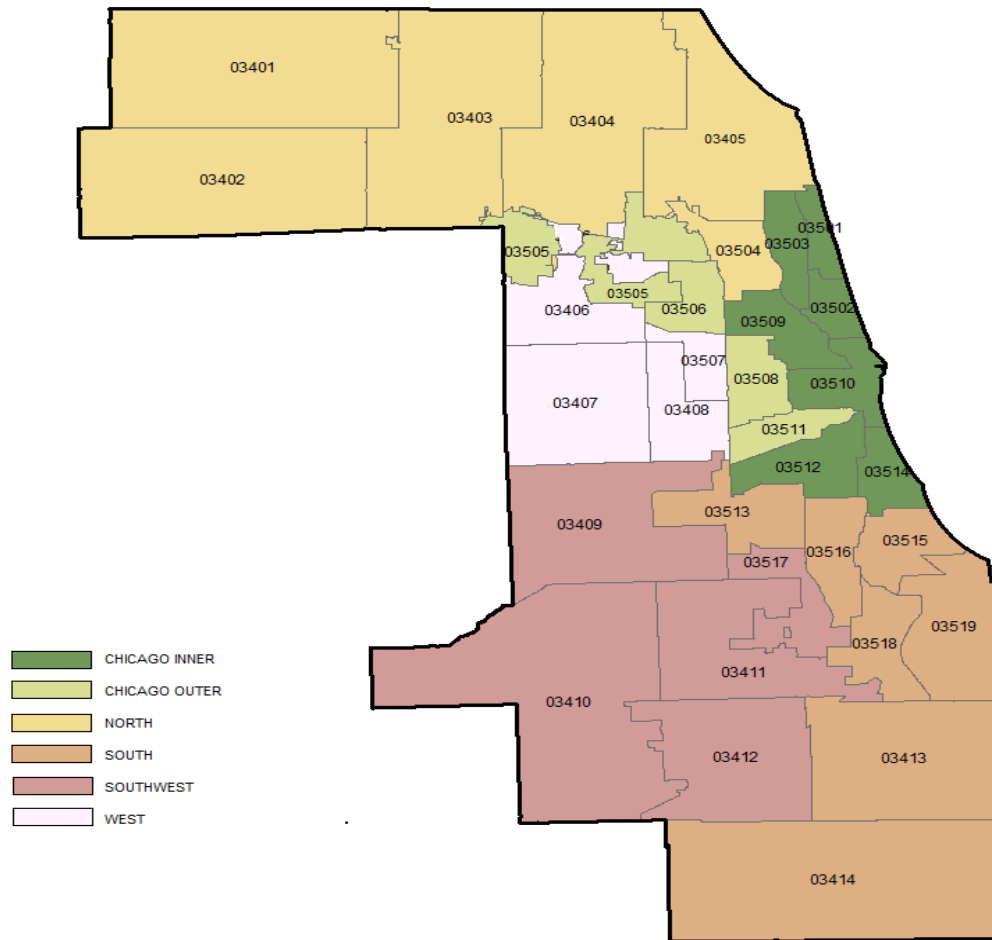


Figure1. Public Use Microdata Area (PUMA)

Source: United States Census Bureau, Illustrated by the Institute for Housing Studies

Note: We aggregate the 33 submarkets into six regions of Cook County (the number of PUMAs is given in parentheses): North (6), West (4), Southwest (5), South (7), Chicago Inner (7), and Chicago Outer (4). These aggregations are based on relatively common movement in house prices.

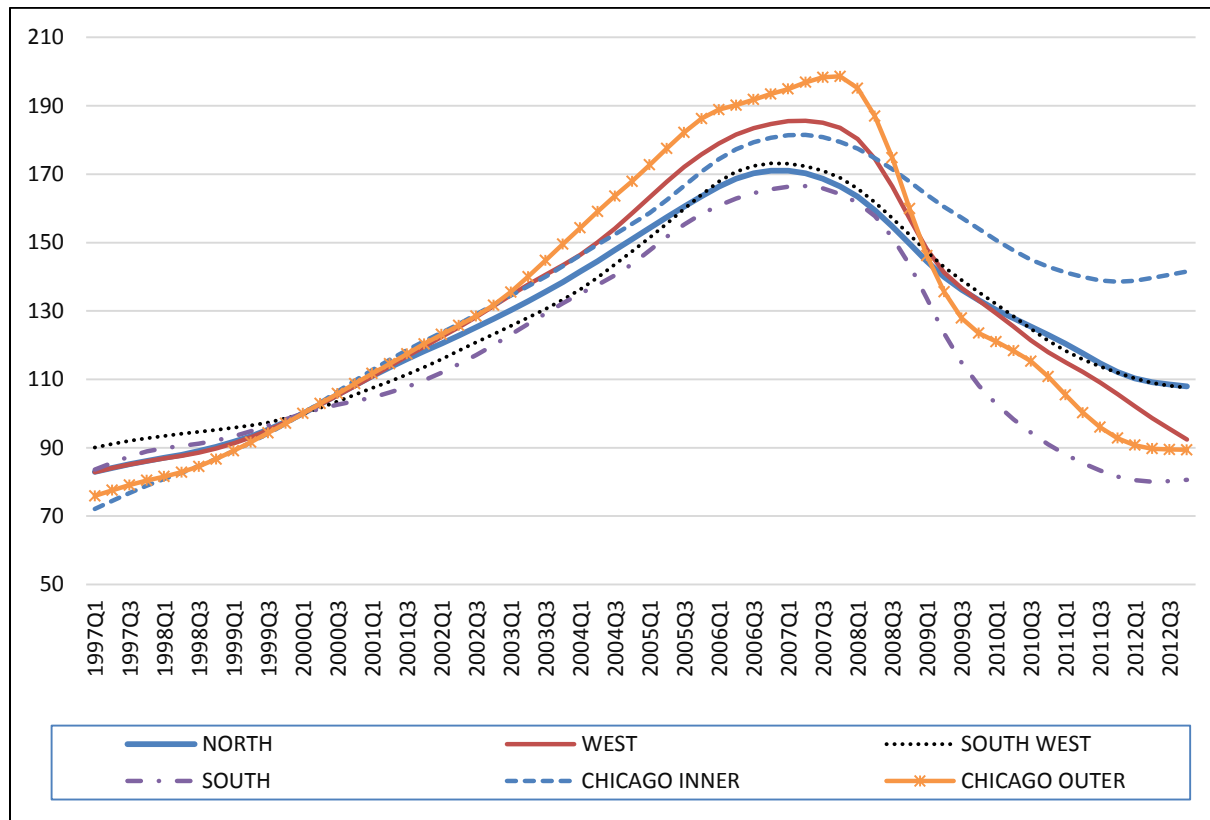


Figure 2. House Price Index in Cook County by Region, 1997-2012.

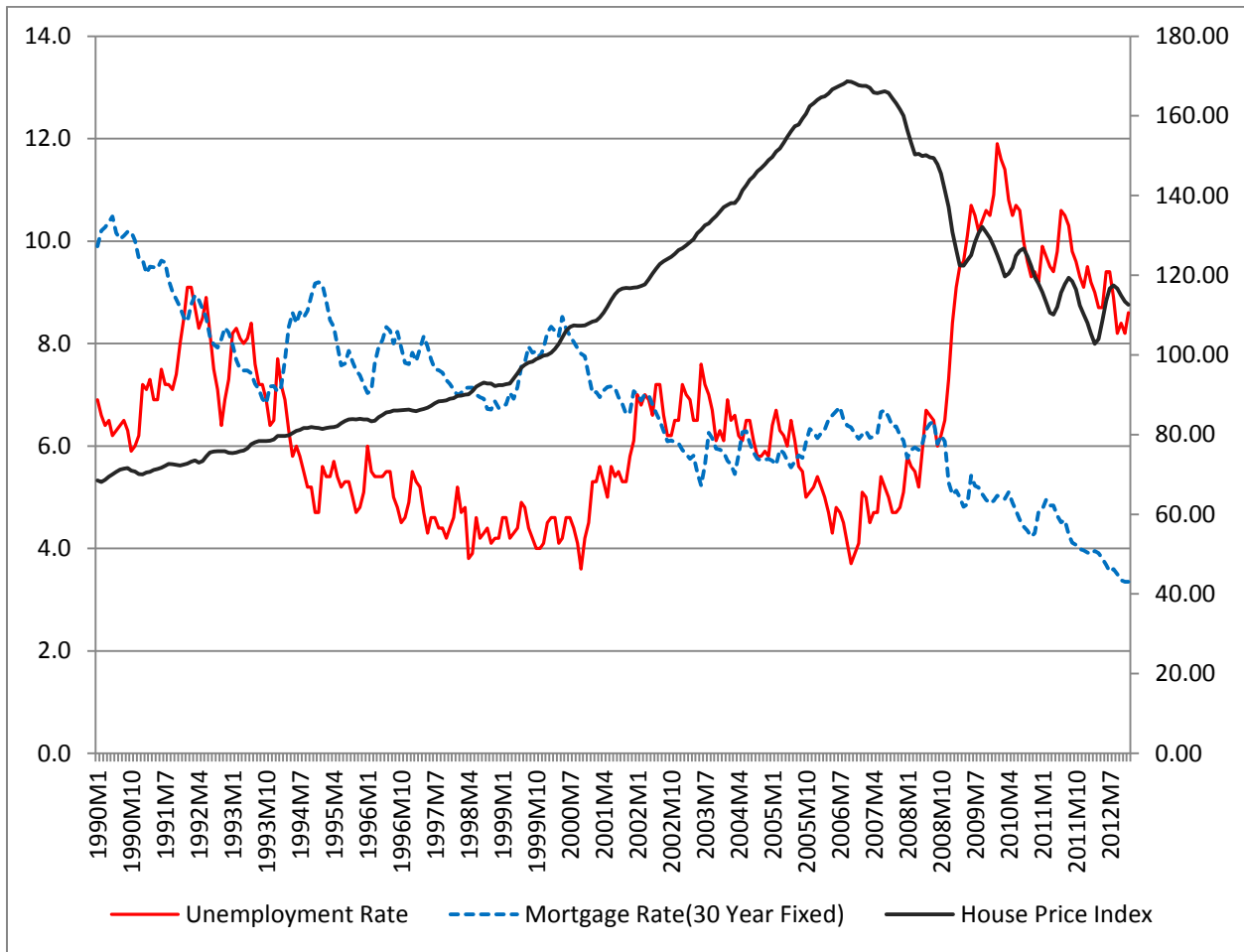


Figure 3. Case-Shiller House Price Index and Unemployment Rate for Chicago MSA and the 30-year Fixed Mortgage Rate, 1990-2012.



Figure 4. Total and Distressed Turnover Rates by Region, 2005-2011. Distressed sales include both foreclosed properties sold at auction and real estate owned transactions (i.e., sales of bank-owned properties that are in the possession of a lender as a result of foreclosure and an unsuccessful foreclosure auction).

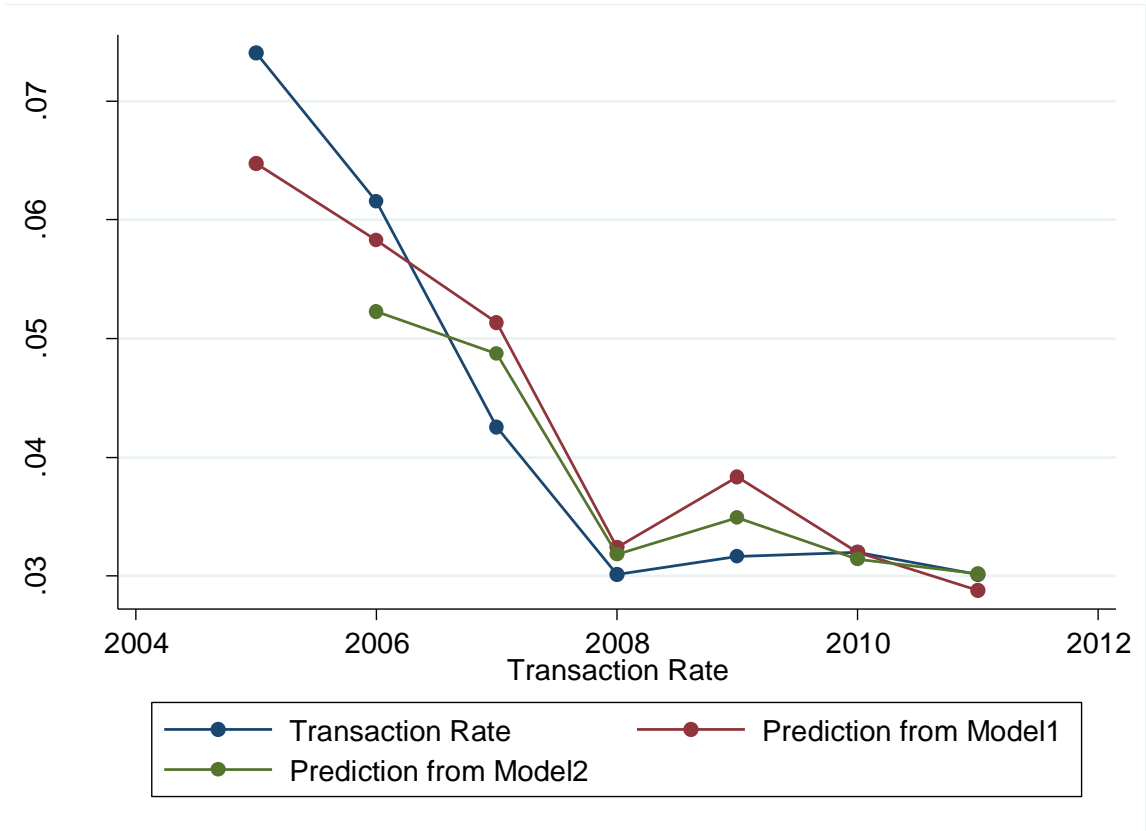


Figure 5. Predicted and Actual Turnover Rates, 2005-2011. Predicted turnover rates are from Models (1) and (2) in Table 3.

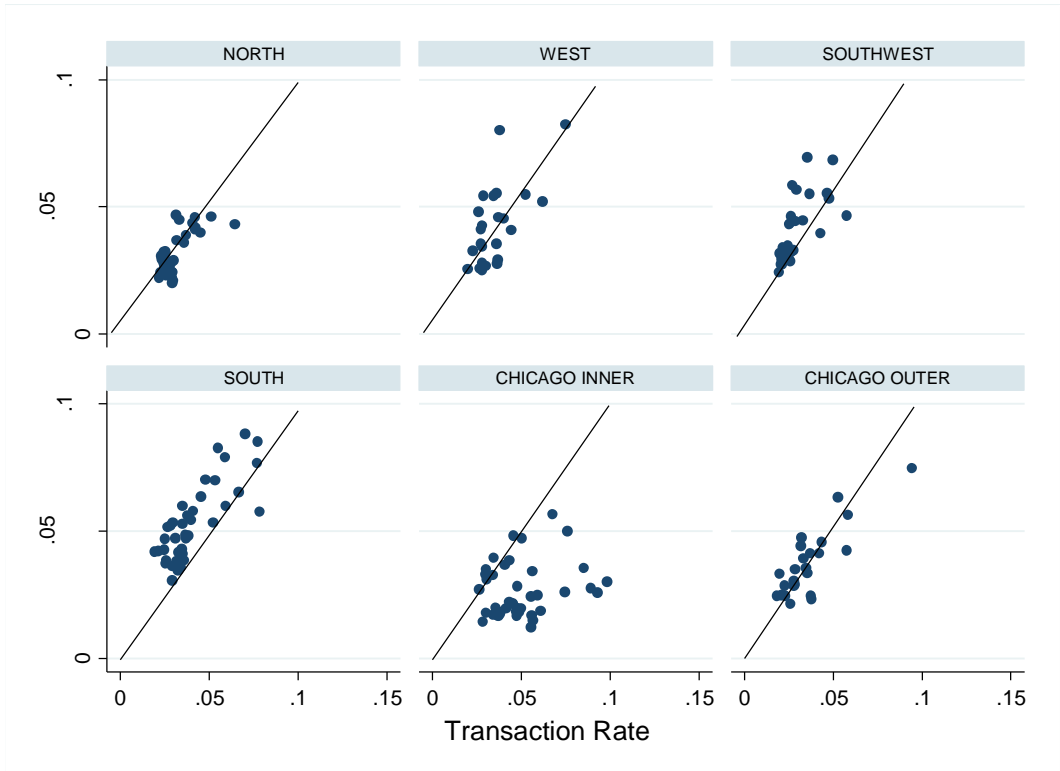


Figure 6. Predicted vs. Actual Turnover Rates by Region. Predicted turnover rates are from Model (2) in Table 3.

Table 1. Mean Demographic and Economic Variables and Changes from 2005 to 2011.

	North			West			Southwest			South			Chicago Inner			Chicago Outer		
	2005	2011	Change	2005	2011	Change	2005	2011	Change	2005	2011	Change	2005	2011	Change	2005	2011	Change
Share of Households																		
Male	0.59	0.55	-0.04	0.50	0.48	-0.03	0.55	0.51	-0.04	0.42	0.40	-0.03	0.52	0.50	-0.02	0.52	0.51	-0.01
Black	0.03	0.04	0.00	0.34	0.33	-0.01	0.17	0.19	0.02	0.66	0.69	0.03	0.19	0.20	0.00	0.20	0.20	0.00
Hispanic	0.12	0.13	0.01	0.19	0.22	0.04	0.09	0.12	0.04	0.14	0.14	0.00	0.19	0.17	-0.02	0.40	0.42	0.02
White and Asian	0.85	0.84	-0.01	0.48	0.45	-0.03	0.74	0.69	-0.05	0.20	0.17	-0.03	0.62	0.63	0.02	0.40	0.38	-0.02
High-School Graduate	0.90	0.91	0.01	0.79	0.83	0.04	0.89	0.90	0.01	0.79	0.82	0.02	0.83	0.87	0.05	0.72	0.73	0.01
College Graduate	0.45	0.48	0.03	0.24	0.25	0.01	0.27	0.29	0.02	0.18	0.20	0.03	0.47	0.54	0.07	0.15	0.17	0.02
Married	0.50	0.50	0.00	0.41	0.37	-0.04	0.51	0.47	-0.04	0.32	0.26	-0.06	0.27	0.25	-0.02	0.38	0.32	-0.06
Age < 27	0.04	0.04	0.00	0.06	0.05	-0.01	0.04	0.03	-0.01	0.07	0.03	-0.03	0.12	0.12	0.00	0.08	0.07	-0.02
Age 27-34	0.14	0.12	-0.01	0.13	0.14	0.00	0.11	0.12	0.01	0.13	0.11	-0.02	0.22	0.24	0.02	0.16	0.16	0.00
Age 35-44	0.22	0.18	-0.04	0.23	0.22	-0.01	0.23	0.18	-0.05	0.20	0.19	-0.01	0.21	0.21	0.00	0.22	0.20	-0.02
Age 45-54	0.23	0.22	-0.01	0.24	0.19	-0.05	0.23	0.24	0.01	0.20	0.21	0.01	0.18	0.15	-0.02	0.20	0.21	0.00
Age 55-64	0.16	0.19	0.03	0.15	0.19	0.04	0.18	0.20	0.02	0.17	0.21	0.04	0.13	0.14	0.01	0.14	0.19	0.05
Age 65-74	0.09	0.12	0.03	0.09	0.12	0.02	0.11	0.11	0.00	0.13	0.13	0.00	0.07	0.08	0.01	0.09	0.08	-0.01
Age > 74	0.11	0.11	0.00	0.10	0.10	0.00	0.11	0.13	0.02	0.11	0.12	0.00	0.07	0.06	-0.01	0.10	0.09	-0.01
% in Lowest Income Quartile	0.17	0.26	0.09	0.28	0.37	0.08	0.20	0.26	0.07	0.39	0.44	0.06	0.34	0.40	0.06	0.36	0.47	0.11
% in Highest Income Quartile	0.37	0.33	-0.05	0.20	0.19	-0.01	0.30	0.27	-0.03	0.14	0.12	-0.02	0.24	0.24	0.00	0.16	0.12	-0.04
Other																		
Unemployment Rate	0.03	0.05	0.02	0.04	0.06	0.02	0.04	0.06	0.02	0.07	0.08	0.01	0.05	0.06	0.01	0.04	0.09	0.04
Fulltime Worker Rate	0.66	0.60	-0.05	0.60	0.57	-0.02	0.61	0.58	-0.03	0.52	0.50	-0.02	0.66	0.66	0.00	0.63	0.54	-0.08
Persons in Household	2.41	2.36	-0.05	2.48	2.39	-0.08	2.56	2.43	-0.13	2.47	2.19	-0.28	1.93	1.85	-0.08	2.62	2.43	-0.19
Turnover Rate	0.06	0.03	-0.04	0.07	0.03	-0.04	0.06	0.02	-0.04	0.08	0.03	-0.05	0.09	0.04	-0.05	0.08	0.03	-0.05
Distressed Sales Rate	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01

Note: Entries are means. The full-time worker rate uses a definition of 35 or more hours a week.

Table 2. Lock-in and Loan-to-Value Ratios in Cook County by Region, 2005 and 2011.

	North			West			Southwest			South			Chicago Inner			Chicago Outer		
	2005	2011	Δ	2005	2011	Δ	2005	2011	Δ	2005	2011	Δ	2005	2011	Δ	2005	2011	Δ
Lockin	0.15	0.06	-0.08	0.11	0.02	-0.09	0.11	0.03	-0.08	0.08	0.01	-0.07	0.11	0.07	-0.05	0.1	0.02	-0.08
LTV																		
LTV < 0.9	0.97	0.81	-0.16	0.95	0.64	-0.31	0.95	0.71	-0.24	0.92	0.53	-0.38	0.96	0.87	-0.09	0.94	0.59	-0.35
LTV 0.9 to 1.15	0.02	0.12	0.1	0.04	0.15	0.11	0.04	0.14	0.09	0.06	0.1	0.04	0.03	0.08	0.05	0.04	0.1	0.06
LTV > 1.15	0.01	0.07	0.06	0.01	0.21	0.2	0.01	0.16	0.15	0.02	0.37	0.35	0.01	0.05	0.04	0.02	0.3	0.29

Note: Lock-in variable measures the percent of borrowers with a non-assumable fixed-rate mortgage with an LTV < 0.90 and a coupon rate below market.

Table 3. Logit Estimates of the Odds of Moving

Variable Name	Model (1)		Model (2)	
LTV 0.90 to 1.15	-2.18	-4.45	-1.37	-3.16
LTV > 1.15	-0.88	-3.22	-0.98	-4.36
Lock-in	-3.84	-9.06	-3.53	-9.45
Unemployment	-0.07	-0.07		
Δ Unemployment			-2.21	-3.07
Married	0.81	0.89	0.77	0.84
Income q1	-1.84	-2.63	-0.07	-0.08
Income q4	2.57	2.50	3.25	3.29
Full-time Worker Rate	-0.79	-1.21		
Δ Full-time Worker Rate			-0.13	-0.34
Male	1.10	1.49	0.85	1.25
Black	1.59	1.28	1.67	1.29
Hispanic	0.07	0.07	0.45	0.47
High School Grad	-2.02	-2.37	-1.50	-1.72
College Grad	-2.36	-3.25	-1.24	-1.66
Age 27-34	-3.15	-2.13	-2.42	-1.57
Age 35-44	-3.33	-2.37	-1.47	-1.01
Age 45-54	-4.13	-3.01	-1.67	-1.13
Age 55-64	-3.75	-2.50	-1.50	-1.02
Age 65-74	-5.10	-2.92	-2.38	-1.46
Age 74+	-3.17	-1.67	0.29	0.16
Size	-0.01	-0.03	-0.06	-0.29
Constant	2.32	1.32	-1.67	-0.96
Observations		231		198
R-square		0.738		0.683

Note: Logit estimates with t-statistics. Dependent variable is logarithm of the odds of moving. Model (1) is estimated for 33 PUMAs over the sample period 2005 to 2011. Model (2) is estimated over the sample period 2006 to 2011.

Table 4. Parameterization of Model

	2011Q1						Updated to 2012Q4					
	North	West	Southwest	South	Chicago Inner	Chicago Outer	North	West	Southwest	South	Chicago Inner	Chicago Outer
Change in House Price							-0.038	-0.126	-0.039	-0.012	0.022	-0.037
Turnover Rate	0.029	0.031	0.024	0.028	0.044	0.031	0.032	0.032	0.026	0.027	0.053	0.033
Lock-in	0.064	0.021	0.029	0.007	0.067	0.017	0.013	0.006	0.009	0.003	0.014	0.004
LTV												
LTV < 0.9	0.73	0.64	0.71	0.53	0.87	0.60	0.73	0.61	0.69	0.50	0.86	0.60
LTV 0.9 to 1.15	0.12	0.15	0.14	0.10	0.08	0.10	0.13	0.14	0.13	0.11	0.09	0.12
LTV > 115	0.15	0.21	0.16	0.37	0.05	0.30	0.14	0.25	0.18	0.39	0.05	0.28

Note: Turnover rate in 2012Q4 is the actual annual rate for 2012. Lock-in and LTV were updated to 2012Q4 using and a 1 percentage point decline in the mortgage rate and actual house price changes from 2011Q1 to 2012Q4 (see table), respectively.

Table 6. Extreme LTV Distributions for Cook County Regions vs. Case-Shiller Metro Areas

Region	CS Metros	Percentages of Borrowers	
		LTV < 0.8	LTV > 1.4
Chicago Inner		73	3
	New York	67	6
	Portland	66	4
	San Francisco	63	10
North	Los Angeles	60	9
		57	7
	Denver	55	5
	Boston	55	7
	Atlanta	55	10
	Washington D.C.	54	11
	San Diego	53	10
	Cleveland	52	10
Southwest	Dallas	51	6
		49	12
	Seattle	49	12
	Minneapolis	48	11
	Charlotte	44	8
	Miami	48	23
	Tampa	45	22
Chicago Outer	Detroit	44	25
	Phoenix	43	20
		40	24
	West	41	17
	South	27	38
	Las Vegas	26	37

Source: Chicago regions calculated by the authors. MSA data from Zillow. Available at: website www.zillow.com.

Table 5. Policy Simulation of a One-Time Increase of Either 10 or 50% in House Prices in Year t

	Region					
	North	West	Southwest	South	Chicago Inner	Chicago Outer
Initial LTV and Turnover Rate						
Turnover Rate	0.032	0.032	0.026	0.027	0.053	0.033
LTV						
LTV < 90	0.73	0.61	0.69	0.50	0.86	0.61
LTV 90 to 115	0.13	0.14	0.13	0.11	0.09	0.12
LTV > 115	0.14	0.25	0.18	0.39	0.05	0.28
One-Time 10% Increase in House Prices						
Turnover Rate and LTV in t+1						
Turnover Rate	0.033	0.034	0.027	0.028	0.055	0.035
LTV						
LTV < 90	0.79	0.67	0.75	0.55	0.91	0.66
LTV 90 to 115	0.13	0.16	0.13	0.12	0.07	0.13
LTV > 115	0.08	0.17	0.12	0.33	0.02	0.21
One-Time 50% Increase in House Price						
Turnover Rate and LTV in t+1						
Turnover Rate	0.040	0.042	0.033	0.033	0.061	0.041
LTV						
LTV < 90	0.94	0.87	0.90	0.71	0.98	0.82
LTV 90 to 115	0.04	0.08	0.07	0.15	0.01	0.09
LTV > 115	0.02	0.05	0.03	0.14	0.01	0.09

Table 7. Simulation of a One-Time Increase of Either 10 or 50% in House Prices in Year t+1 and 1% Annual Increase in Mortgage Rates in Years t+2 through t+4

Policy Year	Mortgage Rate	10% Increase in House Price at End of Year t						50% Increase in House Price at End of Year t					
		North	West	Southwest	South	Chicago Inner	Chicago Outer	North	West	Southwest	South	Chicago Inner	Chicago Outer
Turnover Rate													
t+0	0.037	0.032	0.032	0.026	0.027	0.053	0.033	0.032	0.032	0.026	0.027	0.053	0.033
t+1	0.037	0.033	0.034	0.027	0.028	0.055	0.035	0.040	0.042	0.033	0.033	0.061	0.041
t+2	0.047	0.024	0.028	0.022	0.026	0.040	0.029	0.027	0.032	0.024	0.029	0.043	0.031
t+3	0.057	0.016	0.020	0.015	0.023	0.026	0.021	0.015	0.019	0.015	0.022	0.027	0.019
t+4	0.067	0.009	0.012	0.009	0.016	0.014	0.013	0.008	0.009	0.007	0.012	0.015	0.010
Memo													
Lock-in													
t+0	0.037	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00
t+1	0.037	0.01	0.01	0.01	0.00	0.02	0.00	0.02	0.09	0.01	0.00	0.02	0.00
t+2	0.047	0.11	0.07	0.08	0.03	0.10	0.06	0.13	0.09	0.10	0.04	0.11	0.09
t+3	0.057	0.23	0.17	0.18	0.07	0.23	0.16	0.29	0.23	0.24	0.12	0.24	0.22
t+4	0.067	0.38	0.31	0.34	0.18	0.40	0.28	0.47	0.46	0.44	0.30	0.41	0.40