Ashot Tsharakyan

Recent Trends in the Housing Market

Dissertation

Prague, June 2011

CERGE

Center for Economic Research and Graduate Education Charles University Prague

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Contents

Abstract

In my dissertation I focus on exploring the major aspects of real estate markets' development over the last fifteen years. The dissertation includes theoretical as well as empirical analysis of US and Czech real estate market and consists of 4 chapters. In the first chapter the aggregate welfare effects of housing price appreciation in the presence of binding constraints are analyzed. The additional beneficial effect of housing price appreciation in the form of relaxation of credit constraints and opportunity for better consumption smoothing is taken into account when calculating the welfare effects of housing price appreciation. The effects of housing price appreciation are analyzed using both a model with exogenous housing prices based on previous literature as well as a newly developed model with endogenous housing prices. The second chapter explores the aggregate welfare effects of housing price changes in a stochastic general equilibrium framework with heterogeneous agents. The household sector in this model consists of two types of households, namely credit constrained and unconstrained ones, which differ both with respect to their time preferences as well as the structure of assets they own. The model also includes multi-sector production side and several sources of exogenous stochastic shocks. The third chapter explores the effects of mortgage origination fees on housing price dynamics. It uses Metropolitan Statical Area level panel data for the period 1982-2003 and a demand/supply model of housing prices to show statistically significant negative effect of mortgage fees on housing prices. The last chapter studies the effects of gradual deregulation of regulated rents taking place in the Czech Republic since 2007 on tenure choice and price expectations of the households. For these purposes it uses Czech Household Budget Survey data, logit and probit regressions of tenure choice and present value model of renting versus owning.

Abstrakt

Tato dizertační práce se zabývá analýzou nejdůležitějších aspektů vývoje trhu bydlení za posledních 15 let. Práce obsahuje jak teoretickou, tak i empirickou část, kterážto je zaměřena na americký a český realitní trh, přičemž se celkově skládá ze čtyř částí. V první kapitole jsou analyzovány dopady růstu cen bydlení na společenský blahobyt, a to za tzv. aktivního kreditního/úvěrového omezení. Další kladné efekty růstu cen bydlení ve formě "změkčení" kreditního/úvěrového omezení a možnosti lepšího vyhlazení spotřeby jsou následně také vzaty v potaz, a to při kalkulaci dopadů na celkový blahobyt. Efekty růstu cen bydlení jsou analyzovány jak pomocí modelu s jejich exogenní determinací, který je podložen současnou relevantní literaturou, tak ale i pomocí nově vytvořeného modelu s determinací endogenní. Druhá kapitola se věnuje celkovým dopadům změn cen bydlení v rámci stochastického modelu všeobecné rovnováhy s heterogenními subjekty/agenty. Sektor domácností se zde skládá ze dvou typů domácností, a to s kreditním omezením a bez kreditního omezení. Tyto domácnosti se liší v jejich časových preferencích, jakož i ve struktuře portfolia jejich aktiv. Model taktéž obsahuje vícero výrobních sektorů a několik zdrojů stochastických šoků. Třetí kapitola řeší dopady hypotečních poplatků na dynamiku cen bydlení. Používá panelová data z Metropolitan Statistical Area za období 1982-2003 a poptávkově-nabídkový model cen bydlení, aby demonstrovala statisticky významný záporný dopad hypotečních poplatků na ceny bydlení. Poslední kapitola studuje dopady postupné deregulace nájemného v ČR od roku 2007 na výběr typu bydlení a cenová očekávání domácností. Za těmito účely používá data z rodinných účtů za ČR , logit-probit regrese výběru charakteru bydlení a model porovnávající současnou hodnotu nájemního vs. vlastního bydlení.

Introduction

The present thesis undertakes a thorough theoretical as well as empirical investigation of the major trends observed on real estate markets over the last one and a half decades. It concentrates several crucial aspects of the real estate market development, namely considerable changes in housing prices,the effect of financial market liberalization on housing prices and possible effects of regulated rent deregulation on home ownership decisions. Although the major part of the analysis refers to the US housing market, the last chapter of the present dissertation analyzes important issues on the Czech real estate market.

The first chapter explores the aggregate welfare effects of housing price appreciation under the presence of binding credit constraints. The importance of taking into account the presence of credit constraints in the calculation of welfare effects of housing price appreciation is based on the fact that for credit constrained homeowners, the positive shock in housing prices implies an additional beneficial effect due to an increase in housing equity and thus relaxation of credit constraints and an opportunity for better consumption smoothing. In this paper at first the credit constraint is incorporated into the model of Bajari et al (2005) with an exogenous housing price, and it is shown that housing price appreciation implies improvement in aggregate welfare. Next,the housing price is made endogenous and its appreciation is driven by a supply shock in the form of a change in building permit costs and demand shocks in the form of changes in income and interest rates. Both credit-constrained and unconstrained versions of endogenous price model are considered and welfare changes due to housing price appreciation driven by each of the shocks are derived for both versions. At the end, the model is calibrated according to shocks observed on the US housing market from 1995 to 2006 and aggregate welfare effects of housing price appreciation driven by observed combination of shocks are quantified. The welfare comparison are made between the steady states only. The results demonstrate that demand shocks dominated during that period and the aggregate welfare improved as a result of housing price appreciation.

The second chapter of this dissertation extends the the partial equilibrium analysis performed in the first chapter to the general equilibrium framework. In this paper the aggregate welfare effects of both positive as well as negative changes in housing prices are analyzed in the heterogeneous agent general equilibrium model with a multi-sector production side. The model includes two types of households, credit constrained and unconstrained households. Following Kiyotaki and Moore (1997), the credit unconstrained households are assumed to have lower time preference rate than the credit constrained ones. Also, they own capital, labor and land while credit constrained households own only labor and land. The production side of the economy includes an intermediate good production sector which uses capital and labor as inputs,a composite good production sector, a residential investment good production sector which use intermediate goods as input, and a housing production sector which combines residential investment goods and land to produce housing units. Sources of shock in this model are represented by a productivity shock in intermediate good production sector, which affects income, the productivity shock in the housing production sector driven by the tightening of building permit restrictions and changes in loan-to-value ratio, which reflect credit market shocks. In this paper both the change in composite good consumption, housing consumption and aggregate welfare in the new steady state compared to the initial steady state as well as the dynamics of those variables during transition for both types of households are calculated.

The third chapter of this dissertation investigates the effect of declining mortgage fees observed in the 1990s and first half of the 2000s on housing price dynamics. First, mortgage market deregulation and mortgage innovation are identified as the main drivers of the observed mortgage fee dynamics, and it is argued that they were caused by reasons exogenous to the housing market. Based on this, the effect of mortgage fees on housing prices is quantified, using MSA level panel data for years 1982-2003 and the demand/supply model of housing prices. The results indicate the presence of a robust and statistically significant negative effect of changes in mortgage fees on housing prices. A lagged effect of mortgage fees on housing prices is also found.

In the last chapter of my dissertation, the implications of gradual deregulation of regulated rents taking place in the Czech Republic since 2007 are explored. In this analysis, a series of annual cross-sectional household consumption surveys from 2005 to 2008 is used. According to the law governing the deregulation process, the regulated rent appreciation depends explicitly on the price of real estate. The fact that only about 20% of the sample is replaced each year, allows to follow corresponding households over subsequent years, including their tenure choice. In the first part of the paper, the effect of regulated rent appreciation on tenure choice is studied using probit and logit regressions and two-year adjacent panels formed from the survey data. It is shown that regulated rent appreciation has a statistically significant and a robust positive effect on the probability of owning by regulated renters and a negative effect on the probability of owning for market renters. In the second part, the deregulation formula and a present-value model are employed to deduce an expected real estate price growth rate distribution. It is shown that the net present value of buying property vs. renting is an increasing function of the real estate price appreciation. The appreciation, which makes the net present value equal to zero, is a lower bound for households that switched from renting a regulated apartment to owning one and a lower bound for households that did not switch.

1 Chapter 1

Welfare effects of housing price appreciation in an economy with binding credit constraints

(with Martin Janíčko)

Abstract

This paper analyzes the effects of recent housing price appreciation on aggregate welfare. It generalizes previously available results by considering credit constraints together with endogeneity of housing prices. First, housing price appreciation implies improvement in aggregate welfare in a model with an exogenous housing price and credit constraints. Then, the housing price is endogenized by modelling the supply side of the housing market. In this model, housing price appreciation is caused by supply and demand shocks. The supply shock originates from a change in building permit costs. The demand shifts are generated by changes in household income and interest rates. Both credit-constrained and unconstrained versions of this model are considered. Finally, the combination of observed demand and supply shocks is used to quantify aggregate welfare effects on the US housing market from 1995 to 2006. The results demonstrate that demand shocks dominated during that period and the aggregate welfare improved as a result of housing price appreciation.

KEY WORDS: housing price appreciation, aggregate welfare, binding credit constraints, endogenous housing price, demand and supply side shocks
JEL CLASSIFICATION: R2, R20, R21, R31

1.1 Introduction

In the second half of the 1990s first half of the 2000s a considerable increase in housing prices was observed in the majority of developed countries. Particularly in the United States housing prices rose at a rate exceeding growth rate of income and all other asset prices during the last decade (Bajari et al (2005), Li and Yao(2004)). Between 1986 and 1994, the increase in housing prices was 22.1% as opposed to 41.9% for the period from 1996 to 2004, using the constant-quality housing price index published by the US Census Bureau (see Figure 1).[1] This has stimulated research on the effects of housing price appreciation, particularly its link with monetary policy, its role in the business cycle and most importantly, its effects on consumption and consumer welfare (see, for example, Iacoviello and Minetti(2003), Iacoviello(2004), Li and Yao(2004), Campbell and Cocco(2005), Bajari et al(2005)).

Some papers have studied the effects of the increase in housing prices on the consumption and welfare of separate groups such as young renters, young homeowners and old homeowners. For example, Campbell and Cocco (2005) use UK micro-level data on real non-durable consumption growth and real housing price growth together with a life-cycle model to demonstrate a positive effect of an increase in the growth rate of housing prices on the growth rate of consumption. This effect is especially strong and significant for old homeowners and still quite significant but smaller in magnitude for young homeowners. Li and Yao (2004) also employ a life-cycle model of housing tenure choice to explore the effects of housing price shocks on household consumption and welfare. They find that for the homeowners less than 40 years old, a permanent increase in housing prices implies welfare losses while in the case of older homeowners, it implies an increase in their real non-durable consumption as well as welfare.

Bajari et al. (2005) study the aggregate effects of housing price changes on consumer welfare. They develop a new approach to measuring the changes in consumer welfare due to

[1] Similar observation can be made using other housing price measures ,e.g., the average purchasing price of housing from the Federal Housing Finance Board. It increased by 28.4% in the period 1986-1994 and by 68.9% from 1996 to 2004.

changes in the prices of owner-occupied housing. This approach defines welfare adjustment as the transfer in the form of income required to keep expected discounted utility constant, given the change in housing prices. The authors claim that this measure is more accurate than the user cost employed in earlier studies. The reason is that the user cost (defined as the marginal rate of substitution between housing and non-durable consumption) is entirely static while the welfare adjustment is a dynamic measure. In addition, user costs fail to take into account the role of housing as an investment good. Using their measure of welfare adjustment, the authors show that there is no change in aggregate welfare due to an increase in the price of the existing stock of housing. This result is based on a simple market clearing condition, which implies that the losses of buyers are exactly compensated by the gains of sellers. This conclusion holds for both a deterministic version of the model where current states convey no information about future states, as well as for a stochastic one, where the state follows a first-order Markov chain.

Bajari et al. (2005) abstract from rental markets and binding credit or borrowing constraints. However, for households subject to binding credit constraints, housing appreciation implies two kinds of effects: i) an increase in lifetime housing costs because of the necessity to buy a larger house in the future; ii) a benefit due to a relaxation of credit constraints (because of increased housing equity) and thus the opportunity for better consumption smoothing. Thus, by abstracting from credit constraints, Bajari et al (2005) ignore the additional effects, which housing price appreciation has on credit-constrained households. Empirically, one can evaluate the importance of credit constraints from the fact that over 65% of owner occupied housing in the US is mortgage-financed (according to the American Housing Survey). Also, credit constraints are binding in the US economy since the maximum allowed loan-to-value ratio (LTV) for conventional mortgages in the second half of the 1990's and the beginning of the 2000's was equal to 80%[2] (see Tsakaronis and Zhu (2004)) and average actual LTV

[2]Maximum LTV in this context refers only to conventional (prime) single family mortgages. During the last decade, a rapidly growing sub-prime lending market has appeared in the US. Sub-prime mortgages usually have higher LTVs than conventional ones, since they are given to households unable to meet the usual down payment requirements. Sub-prime loans are not considered here.

for years 1995-2004 fluctuated between 75.1 and 79.9% (according to the Monthly Interest Survey of Federal Housing Finance Board). From the modeling perspective, Ortalo-Magne and Rady(2005) identify the crucial role of capital gains and losses experienced by credit-constrained individuals in explaining housing market fluctuations.

In the first part of this paper, the aggregate welfare effects of housing price appreciation are studied in a model analogous to Bajari et al. (2005) but with households subject to binding credit constraints. Two major forms of credit constraint have been used in the previous literature. One of the most widely used models of credit constraints is that of Kiyotaki and Moore (1997). The authors study how credit constraints interact with aggregate economic activity over the business cycle. In this model, borrowing is restricted so that the repayment of a loan in the next period does not exceed the next period's value of the asset serving as collateral. Similar borrowing constraints are used by Iacaviello and Minneti(2003) and Iacoviello (2004). A more efficient form of credit constraint, called a margin clause, is considered in Mendoza and Durdu (2004). They employ collateral constraints under which the borrowing of a small open economy cannot exceed a fraction of the current market value of the economy's equity holdings. This type of contract is more effective and is widely used in international capital markets by investment banks and other lenders as a mechanism to manage default risk. In contrast to the Kiyotaki-Moore constraint, the custody of collateral assets is transferred at the time of entering into a credit contract (in the Kiyotaki Moore model it is transferred only in the next period, which is why it limits borrowing to the value of the asset in that period). Moreover, there is more flexibility and less risk for lenders since they can automatically make up shortfalls in the value of the collateral asset by liquidating it as soon as the price changes so that the value of the collateral is exactly equal to the debt.

The presented results show that in an economy with binding credit constraints, housing price appreciation implies an improvement in aggregate welfare. In a model with the Kiyotaki-Moore type constraint, this result holds only with the additional assumption that housing prices follow a random walk. In the model with a margin clause this result is observed even in the simplest deterministic version. This is due to the fact that the margin clause constraint is immediately affected by the housing price appreciation as the current price enters this constraint. However, if a Kiyotaki-Moore constraint is used, the next period's price enters the constraint and it is not necessarily affected by the change in current price.

In Bajari et al. (2005), the housing prices are exogenous. In contrast, I allow housing price to be determined by the equilibrium in the housing market and to change due to supply-side and demand-side shocks. Modeling of the supply side shock follows primarily Glaeser and Guyourko (2005). They show that the increase in housing prices since the 70s mainly reflects an increasing difficulty to obtain regulatory approval for building houses. This can be explained by changing judicial tastes, decreasing ability to bribe regulators, and stricter formal procedures. Similarly, in my model an endogenous supply shock is generated by an increase in building permit costs. Besides analyzing the consequences of housing price appreciation driven by supply-side shocks, the theoretical model is used to explore the consequences of housing price appreciation driven by demand-side shocks. Inspection of the US data allows one to identify changes in income and interest rates as the most important demand-side shocks observed during 1995-2006. The effects of demand and supply-side shocks are analyzed for both credit constrained and unconstrained versions of the model.

The results of the endogenous price model demonstrate that the final welfare effect of housing price appreciation depends on its source. Housing price appreciation driven by negative supply-side shocks such as increase in building permit costs leads to welfare loss, while housing price appreciation driven by positive demand-side shocks such as increases in income or decreases in interest rates implies a welfare gain. Comparison of welfare adjustments in a constrained and unconstrained model resulting from change in the building permit costs reveals that the relationship between them depends on the relative weight of housing in the utility function (under Cobb-Douglas form of preferences). Finally, the credit-constrained and unconstrained models are calibrated using a combination of actual demand and supply shocks in the US housing market during 1995-2006. The result demonstrates that housing price appreciation leads to an improvement in aggregate welfare.

The rest of the paper is organized as follows. Section 1.2 describes and solves the proposed model with households facing credit constraints and interprets the results. Section 1.3 builds and solves the model with an endogenous housing prices in both credit-constrained and unconstrained versions in which the changes in the housing price are driven by supply side shocks. Section 1.4 interprets and compares the results of credit constrained and unconstrained models. Section 1.5 analyzes the welfare implications of housing price appreciation driven by demand side shocks. Section 1.6 determines the change in aggregate welfare due to housing price appreciation driven jointly by the supply side and demand side shocks. Section 1.7 concludes the paper.

1.2 Model with Exogenous Housing Price and Credit Constraints

1.2.1 Model Definition and Solution

Consider an economy subject to credit constraints in which there are two goods: a composite consumption good c and housing h with a relative price q which is deterministic and exogenous as in the benchmark model. Also, there are risk-free assets in the form of bonds b. Households choose how many bonds to carry into the next period b_{t+1} (b_{t+1} can be either positive or negative. In the latter case households are borrowers), how much housing consumption to carry into next period h_{t+1}, and how much to consume now c_t. A household's investment into housing is denoted by x_t, and the investment in the risk-free asset (saving) is denoted by s_t. Households have real income y_t .The interest rate paid for borrowing or received for investment in bonds is exogenous and given by i_t. Adjustment of the housing stock implies transaction costs, which enter into the budget constraint as a separate expenditure ($f1\{x_t \neq 0\}$). In this version of the model, I abstract from depreciation of housing and new construction and assume that there is a fixed stock of housing traded between the agents.

Households are credit-constrained in the sense that they can borrow only up to a certain amount to finance their housing investment. Under margin clause constraint (Mendoza and Durdu(2004)), households can borrow only up to some fraction of their current wealth. In the present model, a household's current wealth consists of the current value of its housing stock which can be used as a collateral. Thus the credit constraint takes the form $b_{t+1} \geq -mq_t h_{t+1}$ i.e. households can borrow only up to a fraction $m < 1$ of the total value of their existing housing stock. When solving for the welfare adjustment, the credit constraint is used with strict equality. This means that credit constrained households are those who have to borrow up to the maximum limit when financing housing purchase. On one hand it can be interpreted as the upper limit on the degree of being credit constrained but on the other hand it rules out the households who have enough cash to buy house without mortgage but find it more profitable in terms of net present value to finance housing purchase through mortgage. Such households would typically not borrow the maximum possible amount since this implies higher interest rate. Thus, only the households, who have enough savings for the low down payment and have to borrow the rest, are considered credit-constrained.

The problem of the household can be formulated in the following way:

$$V(h_t, b_t, q_t, y_t) = \max_{\{c_t, h_{t+1}, b_{t+1}\}} [u(c_t, h_t) + \beta V(h_{t+1}, b_{t+1}, q_{t+1}, y_{t+1})]; \tag{1}$$

s.t

$$c_t + q_t x_t + s_t + f1\{x_t \neq 0\} = y_t + i_t b_t; \tag{2}$$

$$b_{t+1} - b_t = s_t - \pi b_t; \tag{3}$$

$$h_{t+1} - h_t = x_t; \tag{4}$$

$$b_{t+1} \geq -mq_t h_{t+1}. \tag{5}$$

Besides the credit constraint discussed above, the optimization includes three additional constraints. One is the usual budget constraint. The second constraint says that real savings (investment into bonds) should be equal to the difference between holding of bonds for the next period and the current holding of bonds net of inflation. The third says that each period's investment in housing should be equal to the difference between the next period's housing stock and the current housing stock.

One can substitute (3) and (4) into (2) to simplify the maximization and obtain the following constraints:

$$c_t = y_t + i_t b_t - q_t(h_{t+1} - h_t) - (b_{t+1} - (1-\pi)b_t) - f1\{x_t \neq 0\}; \tag{6}$$

$$b_{t+1} \geq -mq_t h_{t+1}. \tag{7}$$

The maximization of (1) subject to (6) and (80) gives the following F.O.C. and Envelope conditions:

$$\frac{\partial u(c_t, h_t)}{\partial c_t} = \lambda_t; \tag{8}$$

$$-q_t\lambda_t + \beta\frac{\partial V(h_{t+1}, b_{t+1}, q_{t+1}, y_{t+1})}{\partial h_{t+1}} + \upsilon_t m q_t = 0; \tag{9}$$

$$-\lambda_t + \upsilon_t + \beta\frac{\partial V(h_{t+1}, b_{t+1}, q_{t+1}, y_{t+1})}{\partial b_{t+1}} = 0; \tag{10}$$

$$\frac{\partial V(h_t, b_t, q_t, y_t)}{\partial h_t} = \frac{\partial u(c_t, h_t)}{\partial c_t} + q_t\lambda_t; \tag{11}$$

$$\frac{\partial V(h_t, b_t, q_t, y_t)}{\partial b_t} = \lambda_t(i_t + 1 - \pi). \tag{12}$$

where υ is the multiplier for the credit constraint and λ is the multiplier for the budget constraint.

From this F.O.Cs. one can obtain Euler equations for the model:

$$\upsilon_t = \frac{\partial u(c_t, h_t)}{\partial c_t} - \beta\frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}}(i_{t+1} + 1 - \pi); \tag{13}$$

$$\begin{aligned} q_t\frac{\partial u(c_t, h_t)}{\partial c_t} &= \beta\frac{\partial u(c_{t+1}, h_{t+1})}{\partial h_{t+1}} + \beta\frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}}q_{t+1}(1-\delta) + \\ &\quad + mq_t\left(\frac{\partial u(c_t, h_t)}{\partial c_t} - \beta\frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}}(i_{t+1} + 1 - \pi\right). \end{aligned} \tag{14}$$

Equation (13) implies that credit constraint is binding or its multiplier is strictly positive if the following holds:

$$\frac{\frac{\partial u(c_t, h_t)}{\partial c_t}}{\beta\frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_t}} > i_{t+1} + 1 - \pi. \tag{15}$$

Thus credit constraint is binding if intertemporal marginal rate of substitution between consumption today and consumption tomorrow is higher than gross real interest rate.

Now the dynamic welfare adjustment first defined in Bajari et al.(2005) should be derived for an economy subject to credit constraints. In this paper, the analysis is focused on the case with binding credit constraint (condition that guarantees that it is binding is given above) and it is used with equality.[3] Let's define the welfare adjustment as compensation in the form of income necessary to keep a household's life-time utility unchanged or in other words to keep the value function constant given change in housing prices. This change in income is converted into utility terms by multiplying it by the marginal utility of wealth which is equal to the Lagrange multiplier of the budget constraint.The change in the value function due to a change in housing price can be defined as:

$$\Delta V_i = \frac{\partial V(h_t, b_t, q_t, y_t)}{\partial q_t} \Delta q. \tag{16}$$

After the household is compensated for the change in lifetime utility due to change in housing prices , the total change in value function is given by:

$$\Delta V_T = \frac{\partial V(h_t, b_t, q_t, y_t)}{\partial q_t} \Delta q + \frac{\partial V(h_t, b_t, q_t, y_t)}{\partial y_t} \Delta y. \tag{17}$$

where ΔV_T stands for the total change in the value function. From this equation Δy is derived such that change in the value function equals zero. Based on Bajari et al (2005), an envelope theorem and the first order approximation is applied. Taking derivatives yields:

$$\begin{aligned} \frac{\partial V(h_t, b_t, q_t, y_t)}{\partial q_t} &= \frac{\partial u(c_t, h_t)}{\partial c_t} \frac{\partial c_t}{\partial q_t} = \frac{\partial u(c_t, h_t)}{\partial c_t}(-x_t) + \\ &+ \frac{\partial u(c_t, h_t)}{\partial c_t} m h_{t+1} - \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}} (1 - \pi + i_{t+1}) m h_{t+1}; \end{aligned} \tag{18}$$

[3]The analysis in this paper is concentrated on the period from 1995 to 2004. For this period the assumption of credit constraint remaining constantly binding can be justified by the large increase in mortgage refinancing activity in the US. In particular the refinancing index, which is published by Mortgage Bankers Association of America and changes in which represent percent changes in mortgage re.nancing applications compared with the previous month, increased from 1.5 in 1995 to around 10 in 2004. One of the crucial reasons behind this increase was the desire of the consumers to extract housing equity built-up as a result of housing price appreciation. This refinancing could make non-binding constraints binding again.

$$\frac{\partial V(h_t, b_t, q_t, y_t)}{\partial y_t} = \frac{\partial u(c_t, h_t)}{\partial c_t}. \tag{19}$$

Thus in this economy, the effect of a price change on the value function consists of two effects, a direct one and an indirect one. When the housing price appreciates, there is a decrease in consumption due to more expensive investment into housing. This is the direct effect reflected in the first term in (18). On the other hand, due to the increase in price, the housing equity increases and borrowing constraint relaxes. This allows households to increase borrowing and, consequently, current consumption. This benefit, net of the cost of repaying the additional borrowing, in the next period is presented in parentheses in (18). This is an indirect effect.

Equating ΔV_T to zero and expressing Δy from the resulting equation yields the following formula for the individual welfare adjustment in this model:

$$\begin{aligned}\Delta y_t &= x_t \Delta q_t - m h_{t+1} \Delta q_t + \frac{\beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}}}{\frac{\partial u(c_t, h_t)}{\partial c_t}} (1 - \pi + i_{t+1}) m h_{t+1} \Delta q_t = x_t \Delta q_t - \\ &- \left(m h_{t+1} \Delta q_t - \frac{(1 - \pi + i_{t+1})}{\frac{\frac{\partial u(c_t, h_t)}{\partial c_t}}{\beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}}}} m h_{t+1} \Delta q_t \right).\end{aligned} \tag{20}$$

Taking into account equation (13) it can be seen that under the binding credit constraints the term in parentheses in the (20) is positive. Using the utility function of the form $u(c,h) = \frac{(c^{1-\omega} h^{\omega})^{1-\gamma}}{1-\gamma}$ based on Li and Yao (2004), the welfare adjustment can be presented in the following form

$$\Delta y_t = x_t \Delta q_t - \left(m h_{t+1} \Delta q_t - \beta \frac{(1 - \pi + i_{t+1})(1 + \mu)^{\omega - \omega\gamma}}{(1 + \sigma)^{\omega - \omega\gamma + \gamma}} m h_{t+1} \Delta q_t \right), \tag{21}$$

where μ stands for housing consumption growth rate and σ stands for composite good consumption growth rate.

Let me also discuss the result in case of using Kiyotaki-Moore constraint. This constraint limits the borrowing so that gross repayment next period does not exceed a fraction of next period's expected monetary value of the collateral asset. In terms of the present model it has the form $(1+i_{t+1})b_{t+1} \geq -mE_t q_{t+1} h_{t+1}$. The crucial difference between margin clause and this constraint is that the next period's price rather than this period's price enters into the credit constraint. If the housing price next period is not affected by the change in current price, the credit constraint will not be relaxed and consequently change in aggregate welfare will still be zero as in Bajari et al. (2005). However, several empirical papers have demonstrated that housing prices follow either random walk or AR(1) with high persistence. Using AR(1) assumption and applying the same procedure to the model with a Kiyotaki-Moore constraint, the following formula for the individual welfare adjustment can be derived:

$$\Delta y_t = x_t \Delta q_t - \frac{\rho m h_{t+1} \Delta q_t}{1+i_{t+1}} + \frac{(1-\pi+i_{t+1})\rho m h_{t+1} \Delta q_t}{\frac{\frac{\partial u(c_t,h_t)}{\partial c_t}}{\beta \frac{\partial u(c_{t+1},h_{t+1})}{\partial c_{t+1}}}(1+i_{t+1})}. \tag{22}$$

Here the positive effect on consumption due to relaxation of credit constraint is discounted by the gross interest rate since it can be realized only next period.

1.2.2 Interpretation and Quantification of the Welfare Adjustment

This section interprets and quantifies the final result. For convenience, here I restate the formula for individual welfare adjustment:

$$\Delta y_{j,t} = x_{j,t}\Delta q_t - \left(m h_{j,t+1} \Delta q_t - \beta \frac{(1-\pi+i_{t+1})(1+\mu)^{\omega-\omega\gamma}}{(1+\sigma)^{\omega-\omega\gamma+\gamma}} m h_{j,t+1} \Delta q_t \right) \text{ for household j.} \tag{23}$$

Comparing the result in (23) to that of Bajari et al (2005), two crucial differences can be noted. First, as it was shown above the term in parentheses in equation (23) is positive, which implies that for all households in the model economy the potential welfare loss is lower (welfare gain is higher) than in the benchmark paper since there is an additional beneficial effect of housing price appreciation on consumption. This effect comes in the form of relaxation of credit constraints which gives a better opportunity to smooth consumption. Second, homeowners do get a certain benefit from housing price appreciation even without participating in housing transactions (when $x_{j,t} = 0$), which is quite consistent with reality. For instance, older homeowners can leave larger bequests or invest more in retirement accounts even without selling their house. Younger homeowners can shift their investment to risky assets or increase consumption.

The aggregate welfare adjustment is equal to the sum of individual adjustments defined by (23). Using the assumption of investment only into existing housing stock and summing up, the first term of the expression vanishes ($\Sigma x_{j,t} = 0$), yielding the following expression for the aggregate welfare adjustment:

$$W_t = -(m\Sigma_j h_{j,t+1}\Delta q_t - \beta\frac{(1-\pi+i_{t+1})(1+\mu)^{\omega-\omega\gamma}}{(1+\sigma)^{\omega-\omega\gamma+\gamma}}m\Sigma_j h_{j,t+1}\Delta q_t) \qquad (24)$$

Since it was shown that the term in parentheses in (23) is positive, the total sum in (24) is negative. Thus, the aggregate welfare adjustment in this economy with exogenous housing prices and credit-constrained households is negative, implying that in the aggregate, less income is necessary to keep lifetime utility constant. That is, housing price appreciation in an economy subject to binding credit constraints actually implies an improvement in aggregate welfare. Everybody in the economy who possesses any housing stock is made better off due to the relaxation of binding credit constraints. The finding is consistent with the observation that in certain years characterized by housing price appreciation, developed countries experienced consumption growth or even a consumption boom (Campbell and Cocco(2004)).

It is possible to quantify the result in (24) and compare it to the result of Bajari et al. (2005). The term $\Sigma_j h_{j,t+1}\Delta q_t$ can be interpreted as the change in the market value of the total housing stock, or in other words, the change in the aggregate nominal housing wealth. The data on aggregate nominal housing wealth in the US can be obtained from several studies (such as Case, Quigley and Shiller (2001), Nothaft (2004), etc). However, when using it to quantify the result of this model, it is important to take into account three observations. Firstly, the model does not have the explicit choice of renting the house. Consequently, only the change in the value of owner-occupied housing stock should be considered. Secondly, the effect of relaxing borrowing constraints reflected in (23) should in reality be experienced only by credit-constrained households who take a mortgage when purchasing a house. Finally, due to considering the case of binding credit constraints, this result is true for the households having mortgages with a maximum LTV (or close to it).

Based on these considerations, the yearly change in the nominal housing wealth in the US is multiplied by the share of owner-occupied housing in the total housing stock, by the share of mortgage-financed owner-occupied housing in the total owner occupied housing stock and also by the share of mortgages with LTV 70-80% (the average LTV in this group is 79%) in the total number of mortgages (see the appendix for the data sources used to calculate these shares). The resulting numbers are then divided by the total number of households in the US economy (taken from Current Population Report of US Department of Commerce) to obtain per household change in aggregate welfare (in 2003 dollars) in the model with credit-constrained households. The results are displayed in Figure 2. The figure displays the absolute value of welfare change in (24) so the numbers are positive.

The obtained results contrast sharply with those of Bajari et al. (2005), who found no effects of housing price appreciation on aggregate welfare in case of investing into existing housing stock. It turns out that when accounting for binding credit constraints, the housing price appreciation which occurred in the US between 1995 and 2006 improved aggregate welfare on average by around 1070 dollars per household a year or by about 12900 dollars per household in total.

1.3 Model with Endogenous Housing prices

1.3.1 Households

The basic assumptions about the household sector in this model are analogous to the assumptions in Section 1.2. The crucial difference is that the housing price is determined endogenously. To be more realistic, this version takes into account physical depreciation of housing and assume that it occurs with a constant rate δ.

The household problem in the economy with endogenous housing price and credit constraints can be formulated as follows:

$$V(h_t, b_t, y_t) = \max_{\{c_t, h_{t+1}, b_{t+1}\}} [u(c_t, h_t) + \beta V(h_{t+1}, b_{t+1}, y_{t+1})]; \tag{25}$$

s.t

$$c_t + q_t x_t + s_t + f1\{x_t \neq 0\} = y_t + i_t b_t; \tag{26}$$

$$b_{t+1} - b_t = s_t - \pi b_t; \tag{27}$$

$$h_{t+1} - h_t = x_{d,t} - \delta h_t; \tag{28}$$

$$b_{t+1} \geq -m q_t h_{t+1}, \tag{29}$$

where subscript d denotes a variable belonging to the demand side of the housing market. The Euler equations for this model are given by:

$$v_t = \frac{\partial u(c_t, h_t)}{\partial c_t} - \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}} (i_{t+1} + 1 - \pi); \tag{30}$$

$$\begin{aligned} q_t \frac{\partial u(c_t, h_t)}{\partial c_t} &= \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial h_{t+1}} + \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}} q_{t+1}(1-\delta) + \\ &+ m q_t \left(\frac{\partial u(c_t, h_t)}{\partial c_t} - \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}} (i_{t+1} + 1 - \pi \right). \end{aligned} \tag{31}$$

In the unconstrained version of the endogenous price model households are not subject to a credit constraint, so it is absent from their optimization problem. The rest of the problem is the same. Euler equations for this model are given by:

$$\frac{\partial u(c_t, h_t)}{\partial c_t} = \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}} (i_{t+1} + 1 - \pi); \tag{32}$$

$$q_t \frac{\partial u(c_t, h_t)}{\partial c_t} = \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial h_{t+1}} + \beta \frac{\partial u(c_{t+1}, h_{t+1})}{\partial c_{t+1}} q_{t+1}(1-\delta). \tag{33}$$

1.3.2 Construction Firms

The supply side of the market is identical for both credit constrained and unconstrained versions of the model economy. In modeling the production of new housing, I rely primarily on Amin and Capozza(1993)). Let's assume that there is a perfectly competitive sector of construction firms that supply units to the housing market. The representative firm acts to maximize its profits taking the housing price as given. It has a production function given by $X_{s,t} = G(K_t, L_t) = K_t^{\alpha} L_t^{1-\alpha}$, where K_t is the amount of capital used, L_t is the amount land used and $\alpha < 1$. It is assumed that firms face constant returns to scale technology, which implies a linear cost function with constant marginal cost, denoted by d. Output per unit of land is given by $x_{s,t} = g(k_t) = \frac{X_{s,t}}{L_t} = \left(\frac{K_t}{L_t}\right)^{\alpha} = (k_t)^{\alpha}$. Under these assumptions, the total cost of production is given by dk. Construction firms need to obtain a permit from the zoning authority, a process that involves costs. The cost of each permit is given by n, which includes both cash expenditures needed to obtain the building permit as well as the cost of time necessary to obtain the building permit (in monetary terms). In the real US economy, regulation costs can vary either according to the value of the building project or according to the square footage of the constructed housing unit. Both the demand as well as the supply side of the model economy are calibrated in terms of the average housing unit, which will be defined later. Consequently, the dollar value of the building permit cost is set according to the square footage of this typical unit. Under such calibration, one building permit is necessary to build one unit of output, that is, one average housing unit. Such an assumption is further justified by the fact that the entire US Census Bureau data on building permits is reported in terms of new privately owned housing units authorized in permit-issuing places, rather than in terms of number of obtained building permits per se.

With these assumptions, the maximization problem of a construction firm is given by

$$\max_{k_t} \Pi_t = q_t x_{s,t} - dk_t - nx_{s,t}; \tag{34}$$

s.t

$$x_{s,t} = (k_t)^{\alpha}. \tag{35}$$

From maximization one can get the optimal amount of input used by construction firm, which is

$$k_t = \left(\frac{\alpha q_t - \alpha n}{d}\right)^{(1/(1-\alpha))}. \tag{36}$$

This gives the optimal amount of capital to land ratio chosen by the representative firm.

Substituting back into the production function, yields the amount of housing produced per unit of land:

$$x_{s,t} = g(k_t) = \left(\frac{\alpha q_t - \alpha n}{d}\right)^{(1/(1-\alpha))}. \tag{37}$$

Moreover, since in equilibrium all the firms act in the same way, multiplication of (37) by the aggregate stock of land gives the aggregate supply of new housing produced.

1.3.3 Definition of Equilibrium

Let's define the aggregate supply of land as $\bar{L}$. It is reasonable to assume that the supply of land is fixed in the short run. However, this doesn't imply that supply of new housing is fixed as well . It can increase if more housing is produced per unit of land. Let's assume that there is an exogenous output of composite consumption good, given by Y_t. The supply side of the consumption good market is not modelled explicitly, since the analysis is focused on the housing market. Also, the model with credit constraints is analyzed in the situation where the credit constraint is binding. This implies that all households are net borrowers, with the amount of borrowing determined endogenously depending on the amount of housing consumption chosen. The equilibrium in the credit market is not modelled here since the analysis is not focused on the behavior of the interest rate. It is assumed instead that there is an exogenously given supply of funds borrowed by banks denoted by B_t, which is coming from abroad.

The equilibrium consists of prices $\{q_t\}_{t=0}^{\infty}$, interest rates i_t, allocations $\{c_t, h_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ by households and the profit maximizing input demand of firms k_t, such that:

1) given prices, households solve their optimization problem (conditions (30)-(31) for the credit constrained economy and (32)-(33) for unconstrained economy) and firms maximize their profits (condition (36));

2) Markets clear

i) $x_{d,t} = g(k_t)\bar{L}$ (housing market)

ii) $c_t = Y_t$ (goods market)

iii)$b_{t+1} = B_t$ (for credit-constrained economy) (bond market)

$b_{t+1} = 0$ (for unconstrained economy) (bond market).

The last condition comes from the fact that in a standard unconstrained representative agent asset pricing model in equilibrium, lending should compensate borrowing.

1.4 Characterization of the Welfare Adjustment:Supply Side Shocks

1.4.1 Welfare Adjustment Derivation

In this section the formula for welfare adjustment due to an endogenous housing price appreciation for an economy in a steady state is derived. The full derivation of steady state for both credit-constrained and unconstrained versions of the model is given in the appendix. The same utility function as in Section 1.2 is used here.

Suppose that the economy is in a steady state when building permit costs reflected in n increase. It is evident from (36) that this shifts down the profit-maximizing level of input and reduces the profit-maximizing output of the competitive firms per unit of land used. Consequently, the aggregate supply of new residential housing decreases and housing price appreciates (the expression for the response of housing price to the change in building permit costs is derived in the appendix). Similar to Section 1.2, the welfare adjustment is defined as the change in income necessary to keep lifetime utility constant when n changes. The change in value function resulting from the change in n is given by

$$\Delta V = \frac{\partial V(h^{ss}, b^{ss}, y^{ss})}{\partial n} \Delta n + \frac{\partial V(h^{ss}_{,} b^{ss}, y^{ss})}{\partial y} \Delta y, \tag{38}$$

where superscript ss denotes steady state values.

Using the utility form defined above, calculating the corresponding derivatives, substituting them to the last equation, equating ΔV to zero and expressing Δy from the resulting equation yields the following formulas for the welfare adjustments:

$$\Delta y_t = \Delta n\omega \frac{\alpha}{q^{ss} - n(1-\alpha)} \left(\frac{B(y^{ss} - f1\{x^{ss} \neq 0\})}{\beta(1-\omega)D} \right) \text{ for the model with credit constraints;} \tag{39}$$

$$\Delta y_t = \Delta n\omega \frac{\alpha}{q^{ss} - n(1-\alpha)} (i^{ss} + \delta - \pi) \left(\frac{y^{ss} - f1\{x^{ss} \neq 0\}}{A} \right) \text{ for the unconstrained model;} \tag{40}$$

where A,B and D are constants defined in the appendix.

1.4.2 Interpretation and Comparison

In this section the welfare adjustments in the models with endogenous housing prices driven by supply-side shocks are signed and compared.

The result in an economy with an endogenous housing price but without credit constraints is given by:

$$\Delta y_t = \Delta n\omega \frac{\alpha}{q^{ss} - n(1-\alpha)} (i^{ss} + \delta - \pi) \left(\frac{y^{ss} - f1\{x^{ss} \neq 0\}}{A} \right), \tag{41}$$

where $A = (1-\omega)i^{ss} + \omega\pi + \delta - \pi$ and $\alpha < 1$.

The details of calibrating parameters π, i^{ss} and δ as well as the parameter values and the sources of calibration are given in data appendix. Using the assumed values and setting $\omega = 0.56$ (justification for this is given later in the section) gives $A = 0.0338$, which implies that the 5th term in the product in (38) is positive. Also, the 4th term is positive. The 3rd term is positive since it reflects the effect of change in regulation costs on housing prices, which must be strictly positive. The change in n is positive by assumption. Consequently the individual welfare adjustment in this model is positive. Thus, in an economy with endogenous housing prices where households are not credit-constrained, the housing price appreciation driven by negative supply side shock leads to a welfare loss.[4]

In a model with both credit constraints and endogenous housing prices, the welfare adjustment is given by

[4] According to my definition positive Δy means welfare loss since people need more income to keep them indifferent between old and new prices.

$$\Delta y_t = \Delta n\omega \frac{\alpha}{q^{ss} - n(1-\alpha)} \left(\frac{B(y^{ss} - f1\{x^{ss} \neq 0\})}{\beta(1-\omega)D} \right), \tag{42}$$

where $B = 1 - \beta(1-\delta) - m(1 - \beta(i^{ss} + 1 - \pi))$ and $D = \frac{1-\omega}{\omega\beta} B - m\pi + i^{ss}m + \delta$.

Looking at (55) (in the appendix) which defines the steady state housing stock in the credit-constrained economy, it is easy to see that $D > 0$ is necessary for having positive steady state housing stock. Also, (54) (in the appendix) implies that positive consumption in the steady state requires $B > 0$ if $\omega < 1$(since it is an exponent of housing in the Cobb-Douglas utility function). Consequently, in this economy the welfare adjustment is positive. Thus, when endogenous housing price appreciation is driven by negative supply shocks and preferences are of Cobb-Douglas form, agents experience a welfare loss both with and without credit constraints.

One can compare the last two formulas for welfare adjustments to establish whether credit constraints alleviate or exacerbate the welfare loss from a negative supply shock. For simplicity let's abstract from fixed transaction costs; that is, let's assume that $f1\{x^{ss} \neq 0\} = 0$. Also, to make a fair comparison, let's ignore the possible difference between the income of credit-constrained and unconstrained households and assume the same income for both economies.[5] Examining (39) and (40), it is evident that for comparing those two results one should compare the terms $\frac{i^{ss}+\delta-\pi}{A}$ and $\frac{B}{\beta(1-\omega)D}$. For the credit-constrained economy $i^{ss} = 0,057$, the level of the average effective interest rate on mortgages in the US in 2004 (obtained from Monthly Interest Rate Survey of Federal Housing Finance Board). Also, it is important to recall that here an economy with binding credit constraints is considered. In this case the Lagrange multiplier of the credit constraint is positive, that is $\upsilon^{ss} > 0$. This fact creates differences in discount rates between credit-constrained and unconstrained households. Mathematically, the discount rate for the economy with binding credit constraints is given by

[5] In case of accounting for potential differences in the incomes of credit constrained and unconstrained households, as I did in earlier drafts of the paper, the results of comparison are practically the same as in this draft.

$$\beta' = \frac{1-\frac{v^{ss}}{\frac{\partial u(c^{ss},h^{ss})}{\partial c}}}{i^{ss}+1-\pi},$$

while the discount rate for the economy without credit constraints is given by

$$\beta' = \frac{1}{i^{ss}+1-\pi}.$$

Looking at the last two expressions and taking into account that $\upsilon_{ss} > 0$ and that the interest rate is higher in the economy with binding credit constraints, it is evident that the discount factor in this economy should be lower than the discount factor in the unconstrained economy. Thus, for the economy with binding credit constraints I set $\beta = 0.96$, which is lower than the conventional 0.98-0.99. Finally $m = 0,8$ based on Tsakaronis and Zhu (2004). Using all these values a sensitivity analysis is performed by computing both terms mentioned above for values of preference parameter ω ranging from 0.1 to 0.9 where ω is the exponent of housing in the Cobb-Douglas utility function. The results are presented in Table 1.

The table demonstrates that the welfare adjustment caused by a housing price appreciation due to an increase in regulation costs is lower in a credit-constrained economy than in an unconstrained economy for all $\omega \leq 0.5$ but is higher in the credit-constrained economy than in the unconstrained economy for all $\omega \geq 0.6$. Thus, the relationship between the welfare changes in credit-constrained and unconstrained models depends on the relative weight of housing in the agent's utility function. Since credit-constrained households intuitively have a lower housing stock than unconstrained ones, the marginal utility of housing for them is higher. Consequently, when housing consumption has a relatively high weight in the utility function, credit-constrained households lose more from a decrease in their steady state housing stock which has higher marginal utility for them, than unconstrained households.

It is possible to calculate ω using shares of housing and non-durable consumption in average annual expenditures in the US economy. According to the Consumer Expenditures Survey published by the Bureau of Labor Statistics, the share of housing in the expenditures in 2004 was equal to 32.1% and the share of non-durable consumption (aggregated from separate components given in the Consumption Expenditure Survey) was equal to 49%. On the other hand in my model the dollar value of one-period expenditures on composite good (non-durable consumption) is given by c^{ss} (since the price of consumption is normalized at 1) and the dollar value of one-period expenditures on housing is given by $\delta q^{ss}h^{ss}$ (since during one period households consume value of the depreciated housing stock). Looking at the steady state allocations in the appendix it is easy to see that in both credit-constrained and unconstrained versions of the economy the ratio $\frac{c^{ss}}{\delta q^{ss}h^{ss}}$ is a function of ω only and the other already calibrated parameters. On the other hand, mathematically it is true that

$$\frac{c^{ss}}{\delta q^{ss}h^{ss}} = \frac{\frac{c^{ss}}{Expenditures}}{\frac{\delta q^{ss}h^{ss}}{Expenditures}} = \frac{0.49}{0.321}. \tag{43}$$

Thus, ω can be calculated from this equation. For defining the plausible range of values for ω, at first all the households in the actual economy are treated as unconstrained and ω is calculated from the above equation using steady state allocations of the unconstrained model . Then all the households are treated as credit-constrained and ω is calculated using allocations from the credit-constrained model.

The unconstrained model gives

$$\frac{c^{ss}}{\delta q^{ss}h^{ss}} = \frac{(1-\omega)(i^{ss}+\delta-\pi)}{\omega\delta} = \frac{0.49}{0.321}, \tag{44}$$

from which $\omega = 0.56$.

Constrained model gives

$$\frac{c^{ss}}{\delta q^{ss}h^{ss}} = \frac{B(1-\omega)}{\omega\beta\delta} = \frac{0.49}{0.321}, \tag{45}$$

from which $\omega = 0.64$.

Since there are both types of households in the actual economy, the true value of ω should be between 0.56 and 0.64. In the case of $\omega = 0.56$, the adjustment in the constrained model is only marginally higher than that in the unconstrained economy since $\frac{i^{ss}+\delta-\pi}{A} = 1,33380$ and $\frac{B}{\beta(1-\omega)D} = 1.37297$, while in the case of $\omega = 0.64$, the credit-constrained households clearly loose more from a negative supply shock since $\frac{i^{ss}+\delta-\pi}{A} = 1.672835$ and $\frac{B}{\beta(1-\omega)D} = 2.00179$.

1.5 Characterization of Welfare Adjustment: Demand Side Shocks

1.5.1 Shifts in Income as the Reason for Housing Price Appreciation

In general, changes in income constitute the most natural demand-side shock in any market including the housing market. Consequently, when searching for demand-side shocks affecting housing prices, I first look at the dynamics of income in the US during the years of housing price appreciation. Annual figures for median household income in the US, obtained from the Current Population Survey of US Census Bureau are presented in Figure 3 together with the constant-quality housing price index displayed previously in Figure 1.

The graph clearly shows that the years of substantial housing price appreciation were characterized by a considerable upward shift in the median household income which, after staying nearly constant in the first half of the 90s, began to grow rapidly in the second half. Calculating the growth rate of income from US Census Bureau data indicates that in 1988-1994, median household income increased by only 17.7%, while in 1995-2001 it grew by 24.5%. Empirical evidence would thus suggest that changes in income were an important demand-side driver of housing price appreciation in the last decade.

Let's denote by Δy_{new} the new change in income that is the welfare adjustment and by Δy_{old} the initial change in income that is the shock. The welfare adjustment is derived from the following equation:

$$\Delta V = \frac{\partial V(h^{ss}, b^{ss}, y^{ss})}{\partial c} \frac{\partial c^{ss}}{\partial y} \Delta y_{old} + \frac{\partial V(h^{ss}_{,} b^{ss}, y^{ss})}{\partial h} \left(\frac{\partial h^{ss}}{\partial y} + \frac{\partial h^{ss}}{\partial q} \frac{\partial q^{ss}}{\partial y} \right) \Delta y_{old} + \frac{\partial V}{\partial y} \Delta y_{new}. \tag{46}$$

Equating ΔV to 0, using the steady state derived in the appendix, and expressing Δy_{new} from the resulting equation yields the following formulas for the welfare adjustments:

$$\Delta y_{new} = -\frac{B(1-\omega)}{\omega \beta D} \Delta y_{old} - \frac{B}{\beta} \left(\frac{1}{D} - \frac{y^{ss} - f1\{x^{ss} \neq 0\}}{Dq^{ss}} \frac{\partial q}{\partial y} \right) \Delta y_{old} \tag{47}$$

for constrained model,

where

$\frac{\partial q}{\partial y} = \frac{J\delta d^{(\alpha/(1-\alpha))}}{q^{ss}\bar{L}D\frac{\alpha^2}{1-\alpha}(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}-1}+\bar{L}D(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}}} > 0;$

and,

$$\Delta y_{new} = -\frac{(1-\omega)(i^{ss}+\delta-\pi)}{A}\Delta y_{old} - (i^{ss}+\delta-\pi)\left(\frac{\omega}{A} - \frac{y^{ss} - f1\{x^{ss} \neq 0\}}{Aq^{ss}}\frac{\partial q}{\partial y}\right)\Delta y_{old} \quad (48)$$

for unconstrained model,

where

$\frac{\partial q}{\partial y} = \frac{J\delta\omega d^{(\alpha/(1-\alpha))}}{Aq^{ss}\bar{L}\frac{\alpha^2}{1-\alpha}(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}-1}+A\bar{L}(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}}} > 0.$

The equation reflecting the response of housing prices to changes in income was obtained as in previous cases by applying an implicit function theorem to the housing market clearing condition derived in the appendix. The second terms in the welfare adjustments given above are the final changes in housing stock due to interaction of the income and substitution effects.

At this moment the sign of the last two results is ambiguous since the second term in both expressions is not necessarily negative. Intuitively it should be negative since in the case of housing, the income effect usually dominates the substitution effect. These results are quantified in Section 1.6.

1.5.2 Changes in the Interest Rates as the Reason for Housing Price Appreciation

A decrease in mortgage interest rates and nominal interest rates on bonds generates an increase in the housing demand for both credit-constrained and unconstrained households. For the credit-constrained households who are net borrowers, a decrease in the mortgage rate implies lower current payments for their mortgages. This increases their disposable income, which in turn means that they can increase housing consumption and/or consumption of the composite good. For the unconstrained households, housing and bonds can be viewed as alternative investment opportunities or assets. Consequently, a decline in the interest rates on bonds makes housing a more attractive investment relative to bonds and the investment is shifted towards housing, thus further raising housing demand.

At this point, one should ask what happened to the nominal interest rates on bonds and mortgage interest rates in the real economy in the 1990s. The evolution of the average effective interest rates on mortgages and long term government bond yields in the US from 1986 to 2006 is summarized in Figure 4. The figure clearly demonstrate a downward trend in the interest rates in 1995-2006. It thus appears quite important to study the welfare implications of housing price appreciation driven by a decrease in interest rates.

The welfare adjustment, defined as in the previous section, is derived from the following equation:

$$\Delta V = \frac{\partial V(h^{ss},b^{ss},y^{ss})}{\partial c} \frac{\partial c^{ss}}{\partial i} \Delta i + \frac{\partial V(h^{ss}_{,}b^{ss},y^{ss})}{\partial h} \left(\frac{\partial h^{ss}}{\partial i} + \frac{\partial h^{ss}}{\partial q} \frac{\partial q^{ss}}{\partial i} \right) \Delta i + \frac{\partial V}{\partial y} \Delta y = 0.$$

In the model with credit constraints, welfare adjustment is given by:

$$\Delta y = (y^{ss} - f1\{x^{ss} \neq 0\}) \left(\frac{1-\omega}{\omega\beta}(1-\beta)(m-m^2) + \frac{Bm}{\beta\omega D^2} - \frac{Bm}{\beta\omega D} \left(\frac{(q^{ss}-n)(1-\alpha)}{D(q^{ss}-n(1-\alpha))} \right) \right) \Delta i. \tag{49}$$

In the unconstrained model it is given by:

$$\Delta y = (y^{ss} - f1\{x^{ss} \neq 0\}) \left(\begin{array}{c} -\frac{\omega(1-\omega)\delta}{A^2} + \frac{(i^{ss}+\delta-\pi)\omega(1-\omega)}{A^2} - \\ -\frac{\omega(i^{ss}+\delta-\pi)}{A} \left(\frac{(1-\omega)(q^{ss}-n)(1-\alpha)}{A(q^{ss}-n(1-\alpha))} \right) \end{array} \right) \Delta i. \tag{50}$$

1.6 US Economy in 1995-2006: Actual Aggregate Welfare Adjustment

In the previous sections, welfare adjustments in the model economy were derived for different supply and demand side shocks. In this section the aggregate welfare adjustment resulting from housing price appreciation driven by the combination of shocks observed in US housing market from 1995 to 2006 is computed.

According to the US Census Bureau in 2006 1,645,900 single-family housing units with an average area of 2,469 square feet per unit and 325,000 units in buildings with two units or more with an average area of 1,418 square feet per unit were built. Thus, in total 4521150000 square feet of housing were built in the US in 2006. Dividing the total number of square feet produced by the total number of housing units produced yields that the area of an average housing unit was 2,295 square feet. Building permit cost is calculated according to the Craftsman's National Construction Estimator taking into account square footage of the housing unit and US average construction cost per square foot and as a result is set to n =13160. Using the report of the National Association of Realtors on the land use, which says that in 2000 (the most recent available estimate) 658,000 acres of land were used for residential construction, I set $\bar{L} = 658,000$. Finally, with this information it is possible to calculate the amount of output per unit of land in the real economy, which is equal to 5,428.41 square feet or 2.79 housing units.

With this information in hand, the construction cost per housing unit given by parameter d can be calculated. Using (37), which defines the output per unit of land, and solving it for d yields

$$d = \left(\frac{(\alpha q^{ss} - \alpha n)^{(\alpha/(1-\alpha))}}{x_{s,t}}\right)^{((1-\alpha)/\alpha)}.$$

According to the Monthly Interest Rate Survey of Federal Housing Finance Board, the average purchase price of housing in the US in 2004 was 262,000 dollars. Also based on the National Association of Realtors' data on capital income and land income shares in the housing construction industry, I set $\alpha = 0.4$. Finally, according to the calculation above, $x_{s,t} = 2.79$. Substituting all parameters into the last equation gives $d = 22,386$ per one housing unit.

At this point it is necessary to specify the structure of the population or, in other words, the number of credit-constrained and unconstrained households. One can evaluate the degree of being credit-constrained by the current wealth or the accumulated wealth of the household. Even better indicator from this point of view can be the net worth of the household, that is, the value of the household's assets net of liabilities. The 2006 Survey of Consumer Finance by the Federal Reserve System reports the average net worth of American households according to the age of the household head (Table 2). Based on this data it is straightforward that households headed by individuals of the lowest two age groups are the most likely to be constrained. However, households headed by individuals of the age 35-44 have considerably higher net worth than do younger households. Moreover, according to the US Census Bureau, households headed by individuals aged 35-44 have the second highest median income in the US economy. Consequently,in my research two alternative variants of parametrization are considered. Under the first one, households headed by individuals aged 35-44 are assumed to be credit-constrained; under the second one they are considered unconstrained. Using the Current Population Report of the US Department of Commerce, I set $J_c = 44784339$ and $J_{uc} = 62888650$ for the first case and $J_c = 21737795$ and $J_{uc} = 85935104$ for the second case, where J_c and J_{uc} is the number of credit-constrained and unconstrained households respectively.

Now let's calculate an implied cumulative welfare adjustment for the actual US economy. According to the constant-quality housing price index of the US Census Bureau, housing prices net of inflation increased by 43.7% between 1995 and 2006 (adjustment for inflation was done by subtracting change in CPI-U from total change in constant-quality housing price index). Also, median household income in the US increased by 30.1% between 1995 and 2006. Finally, the interest rate on long-term government bonds declined from 6.58 to 4.2 % (by 36.2%) during this period while the effective interest rate on mortgages declined from 8 to 5.7% (by 28.7%). The only unobservable is the change in the building permit cost or the supply-side shock. The idea is to calculate the elasticity of housing prices with respect to income and interest rates in both a constrained and an unconstrained economy and then to compute the total response of housing prices to demand side shocks. The supply-side shock or change in building permit costs can be computed so as to match the residual change in prices in the US economy.

To compute the response of housing prices to changes in demand side factors, the following formulas are used:

$$\varepsilon_{qy,c} = \frac{J\delta d^{(\alpha/(1-\alpha))}}{q^{ss}\bar{L}D\frac{\alpha^2}{1-\alpha}(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}-1}+\bar{L}D(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}}}\frac{y^{ss}}{q^{ss}};$$

$$\varepsilon_{qy,uc} = \frac{J\delta\omega d^{(\alpha/(1-\alpha))}}{Aq^{ss}\bar{L}\frac{\alpha^2}{1-\alpha}(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}-1}+A\bar{L}(\alpha q^{ss}-\alpha n)^{\frac{\alpha}{1-\alpha}}}\frac{y^{ss}}{q^{ss}};$$

$$\varepsilon_{qi,c} = \frac{m(1-\alpha)i^{ss}(q^{ss}-n)}{\omega D(q^{ss}-n(1-\alpha))};$$

$$\varepsilon_{qi,uc} = \frac{(1-\omega)(1-\alpha)i^{ss}(q^{ss}-n)}{A(q^{ss}-n(1-\alpha))};$$

where $\varepsilon_{qy,c}$ is the elasticity of housing prices with respect to income in the constrained economy, $\varepsilon_{qy,uc}$ is the elasticity of housing prices with respect to income in the unconstrained economy , $\varepsilon_{qi,c}$ is the elasticity of prices with respect to interest rate in the constrained economy and $\varepsilon_{qi,uc}$ is the elasticity of prices with respect to interest rate in the unconstrained economy. These elasticities are computed for each of the variants of parametrization mentioned above and for each of the values of ω calculated in Section 1.5. The results are displayed in Table 3.

From the table it is evident that if assuming that households headed by individuals in the age group 35-44 are not constrained, the model-implied elasticities with respect to income changes are quite high in the unconstrained economy. Given the elasticities with respect to the other shocks, under such calibration the model-implied change in housing price due to actual changes in income and interest rates overshoots the actual quality-adjusted change in housing prices. Thus, the case with $J_c = 44784339$ and $J_{uc} = 62888650$ is used in what follows. Also, Also $\omega = 0.583$, which is calculated from estimates of for credit constrained and unconstrained co housing the weights corresponding to calibrated number of credit constrained and unconstrained households in the economy. In this case housing prices change in total by 38.7% due to a change in demand-side factors. Since between 1995 and 2004 housing prices changed by 43.7%, the change in housing price due to supply shock should have been equal to 5%. Now let's use the elasticity of housing prices with respect to regulation cost, which is given by the following formula:

$$\varepsilon_{qs} = \frac{\alpha n}{q^{ss}-n(1-\alpha)}.$$

Calculating this formula yields that $\varepsilon_{qs} = 0.185$. This implies that the building permit cost should have increased by 71.8 % to match the actual change in housing price. Since the new building permit cost is equal to 13,160 dollars, the old one will be given by 7,660, which implies the change of building permit cost of 5,500 dollars. Now we will use all the changes of variables in units but not in percents to calculate the dollar value of welfare adjustment resulting from housing price appreciation driven by all factors jointly. Thus $\Delta n = 5500, \Delta y_{old} = 14125$, $\Delta i_c = -1.95$ and $\Delta i_{uc} = -2.38$.Based on Global Property Guide we set transaction costs to the 9.07% of housing price. Using all of the above information each of the welfare adjustments derived previously is calculated for both credit-constrained as well as unconstrained versions of the model. The results are summarized in Table 4. According to prior expectations housing price appreciation driven by negative supply shock (building permit costs) results in welfare loss(positive Δy) while housing price appreciation driven by positive demand shock(income and interest rates) results in welfare improvement(negative Δy).

Given these results it is easy to calculate the cumulative aggregate welfare change in the actual US economy in 1995-2006. To make my result more informative the final cumulative welfare adjustment per household is expressed in terms of mean income in the US in 2006.

Under such measurement the total aggregate welfare adjustment is given by:

$$\Delta Y_{aggregate} = \frac{J_c}{J_c + J_{uc}} \frac{(\Delta y_{s,c} + \Delta y_{y,c} + \Delta y_{i,c})}{y_{mean}} + \frac{J_{uc}}{J_c + J_{uc}} \frac{(\Delta y_{s,uc} + \Delta y_{y,uc} + \Delta y_{i,uc})}{y_{mean}} = -0.278. \tag{51}$$

In this formula $\Delta y_{s,c}$ is welfare adjustment in the constrained economy due to housing price appreciation caused by supply shock, $\Delta y_{s,uc}$ is welfare adjustment in the unconstrained economy due to housing price appreciation caused by to supply shock in the unconstrained economy, $\Delta y_{y,c}$ is welfare adjustment in the constrained economy due to housing price appreciation caused by income shock, $\Delta y_{y,uc}$ is welfare adjustment in the unconstrained economy due to housing price appreciation caused by income shock, $\Delta y_{i,c}$ is welfare adjustment in the constrained economy due to housing price appreciation caused by interest rate shock , $\Delta y_{i,uc}$ is welfare adjustment in the unconstrained economy due to housing price appreciation caused by interest rate shock in the unconstrained economy. Since the sign of the adjustment is negative the result implies the improvement in aggregate welfare. Thus, the housing price appreciation which took place in the US economy between 1995 and 2006 and which was driven by an observed combination of demand and supply side shocks improved the aggregate welfare per household by 28% of mean household income in 2006.

1.7 Summary

This paper explores the aggregate welfare effects of housing price appreciation in a general model with binding credit constraints and endogenous housing prices. First, the model with exogenous housing prices but with households subject to binding credit constraints is considered. It is demonstrated that in an economy with binding credit constraints housing price appreciation leads to an improvement in aggregate welfare. The result is due to the fact that the credit-constrained model takes into account the welfare improving effect of the housing price appreciation, which implies relaxation of binding credit constraints. This effect is ignored in the previous models where households are assumed to be unconstrained.

A model with endogenous housing prices, in which housing price appreciation is driven by supply and demand side shocks, is analyzed for both credit-constrained and unconstrained households. The supply side shocks are driven by the increases in building permit cost. Changes in income and interest rates are the demand side drivers. The relationship between welfare adjustments in the two modelling alternatives depends on the relative weight given to housing in the agent's utility function. The theoretical models are calibrated to calculate the actual welfare adjustment resulting from the combination of all considered shocks in the US housing market in 1995-2006. It is shown that the housing price appreciation from 1995 to 2006 led to per household improvement in the aggregate welfare by an amount equivalent to approximately 28% of mean household income in 2006.

1.8 Appendix

1.Derivation of the steady state in the endogenous housing price model with credit constraints.

The steady state in the model with binding credit constraints should satisfy the following conditions:

$h_{t+1} = h_t = h^{ss}$,

$c_{t+1} = c_t = c^{ss}$,

$b_{t+1} = b_t = b^{ss}$,

$b^{ss} = -mq^{ss}h^{ss}$,

$s^{ss} = b^{ss} - (1-\pi)b^{ss} = \pi b^{ss}$,

$x^{ss} = h^{ss} - (1-\delta)h^{ss} = \delta h^{ss}$.

Using the last 3 conditions, (26) in the steady state can be rewritten as

$c^{ss} = y^{ss} - i^{ss}mq^{ss}h^{ss} - f1\{x^{ss} \neq 0\} - q^{ss}\delta h^{ss} + \pi m q^{ss}h^{ss}$.

Rewriting (30) and (31) in the steady state and rearranging yields

$$\upsilon_t = \frac{\partial u(c^{ss}, h^{ss})}{\partial c} - \beta\frac{\partial u(c^{ss}, h^{ss})}{\partial c}(i^{ss} + 1 - \pi), \tag{52}$$

$$q^{ss} = \beta\frac{\frac{\partial u(c^{ss},h^{ss})}{\partial h}}{\frac{\partial u(c^{ss},h^{ss})}{\partial c}} + \beta q^{ss}(1-\delta) + mq^{ss}\left(1 - \beta(i^{ss} + 1 - \pi)\right) \tag{53}$$

.

Using the utility form defined in Section 1.2 in the last equation and rearranging the resulting equation yields

$$c^{ss} = B\frac{1-\omega}{\omega\beta}h^{ss}q^{ss}. \tag{54}$$

where $B = 1 - \beta(1-\delta) - m(1 - \beta(i^{ss} + 1 - \pi)$

Substituting (54) into the steady state budget constraint and rearranging the steady state level of housing stock is obtained:

$$h^{ss} = \frac{y^{ss} - f1\{x^{ss} \neq 0\}}{Dq^{ss}}, \tag{55}$$

where $D = B\frac{1-\omega}{\omega\beta} - mi^{ss} + m\pi + \delta$.

The steady state level of consumption can be obtained by substituting (55)back to (54):

$$c^{ss} = B\frac{(1-\omega)(y^{ss} - f1\{x^{ss} \neq 0\})}{\omega\beta D}. \tag{56}$$

All the other endogenous variables can now be determined from various conditions. The results are given by the following:

$x^{ss} = \delta\frac{y^{ss}-f1\{x^{ss}\neq 0\}}{Dq^{ss}}$;

$b^{ss} = -m\frac{y^{ss}-f1\{x^{ss}\neq 0\}}{D}$;

$v^{ss} = (1-\omega)\left(\frac{y^{ss}-f1\{x\neq 0\}}{D}B\frac{1-\omega}{\omega\beta}\right)^{-\gamma}\left(\frac{\omega\beta}{q^{ss}B(1-\omega)}\right)^{w(1-\gamma)}(1-\beta(i^{ss}+1-\pi)$.

Finally q^{ss} can be determined endogenously from the market clearing condition by equating demand and supply:

$$J\delta\frac{(y^{ss} - f1\{x^{ss} \neq 0\})}{Dq^{ss}} = \left(\frac{\alpha q^{ss} - \alpha n}{d}\right)^{(\alpha/(1-\alpha))}\bar{L}. \tag{57}$$

The response of housing prices to different shocks should be determined from the market clearing condition. It is not possible to explicitly solve (57) for the housing price. But (57) represents an implicit function of q^{ss} in terms of model parameters only. For determining the response of housing prices to different shocks, an implicit function theorem is applied to (57). Let me demonstrate it here for a supply side shock. Rearranging (57) and assuming that D is not equal to 0 yields

$d^{(\alpha/(1-\alpha))}J\delta(y^{ss} - f1\{x^{ss} \neq 0\}) - (Dq^{ss}\bar{L}(\alpha q^{ss} - \alpha n)^{(\alpha/(1-\alpha))}) = 0.$

This is an implicit function which defines how the equilibrium price depends on building permit costs (parameter n). To determine how the equilibrium price changes in response to an increase in building permit cost, the implicit function theorem is applied to this equation, yielding:

$$\frac{dq}{dn} = -\frac{\frac{\partial(d^{(\alpha/(1-\alpha))}J\delta(y^{ss}-f1\{x^{ss}\neq 0\})-(Dq^{ss}\bar{L}(\alpha q^{ss}-\alpha n)^{(\alpha/(1-\alpha))}))}{\partial n}}{\frac{\partial(d^{(\alpha/(1-\alpha))}J\delta(y^{ss}-f1\{x^{ss}\neq 0\})-(Dq^{ss}\bar{L}(\alpha q^{ss}-\alpha n)^{(\alpha/(1-\alpha))}))}{\partial q}} = \frac{\alpha q^{ss}}{q^{ss}-n(1-\alpha)} > 0. \tag{58}$$

This is positive since the numerator is positive and the denominator should be positive (cost of building permit multiplied by a number strictly less than one cannot exceed housing price). The formulas for the responses of housing price to changes in income and interest rates are derived in a similar way from the market clearing condition.

2. Derivation of the steady state in the unconstrained model.

Applying the same procedure as above, one can derive the following conditions describing the steady state:

$$h^{ss} = \frac{\omega(y^{ss} - f1\{x^{ss} \neq 0\})}{Aq^{ss}}, \tag{59}$$

where $A = (1-\omega)i^{ss} + \omega\pi + \delta - \pi$,

$$c^{ss} = \frac{(1-\omega)(i^{ss} + \delta - \pi))(y^{ss} - f1\{x^{ss} \neq 0\})}{A}, \tag{60}$$

$$x^{ss} = \delta\frac{\omega(y^{ss} - f1\{x^{ss} \neq 0\})}{Aq^{ss}} \tag{61}$$

The market clearing condition is given by

$J\delta\frac{\omega(y^{ss}-f1\{x^{ss}\neq 0\})}{Aq^{ss}} = \left(\frac{\alpha q^{ss}-\alpha n}{d}\right)^{(\alpha/(1-\alpha))}\bar{L}.$

The response of housing price in the unconstrained model to different shocks is derived in a similar way as previously from this market clearing condition.

3.Data

When quantifying the result in (18), I use the American Housing Survey of the US Census Bureau, which reports the total number of housing units, the total number of the owner occupied housing units and the total number of mortgage-financed owner occupied housing units in the US. Given this information one can calculate the share of owner occupied housing stock in the total housing stock and share of mortgage-financed owner occupied housing stock in the total owner occupied housing stock. The data from the Monthly Interest Rate Survey of Federal Housing Finance Board, which reports the proportions of mortgages with different LTV in the total number of mortgages, is also used in computation of (18).

When calibrating the endogenous price model, the IMF International Financial Statistics is used to set the values for inflation rate and nominal interest rate in the unconstrained economy. The nominal interest rate is approximated by long-term (10 years) government bond yield and is set to $i = 0.042$. Inflation is set to $\pi = 0.02$. The depreciation rate δ is calibrated from several studies. Earlier studies such as Margolis(1982) and Malpezi and Ozane(1987) have estimated gross depreciation rate of 2% for the housing stock in the USA. Also, in the end of the 1980s and beginning of the 1990s, the Congress raised the depreciation period for housing in the US to 27.5 years, which implies a yearly depreciation rate of around 3.5%. Based on this range of estimates, I set $\delta = 0.025$.

In this research the constant-quality housing price index published by the US Census Bureau is used as the main housing price measure (Figure 1). The data of the US Census Bureau on median household income (Figure 3) and new residential construction is also used. The data of the Federal Housing Finance Board on average LTV as well as average effective interest rate on mortgages (Figure 4) is employed. Finally, the dynamics of long term bond yields (Figure 4) is taken from IMF International Financial Statistics and the amount of land used in residential construction during a year is taken from the report of National Association of Realtors.

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1.9 Figures

Figure 1: Dynamics of constant-quality housing prices in the US

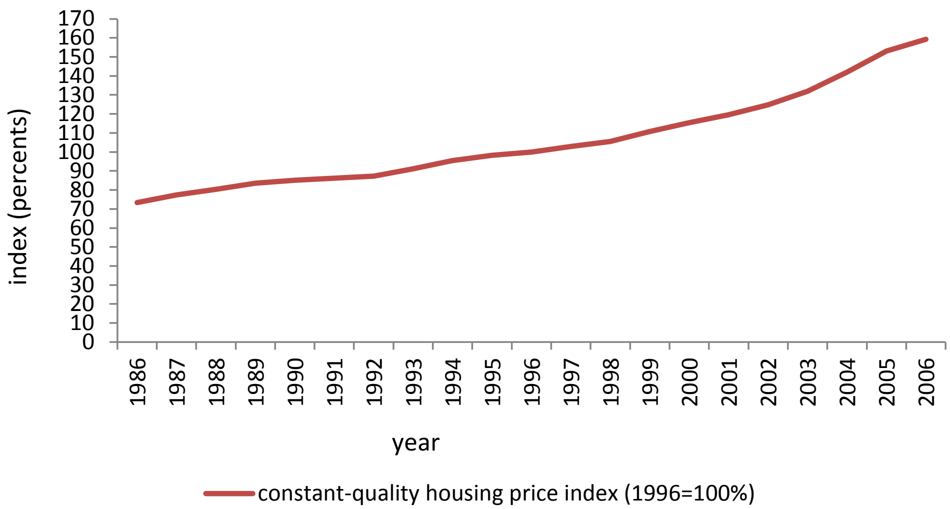


Figure 2: Welfare adjustment in the economy with exogenous housing price and binding constraint

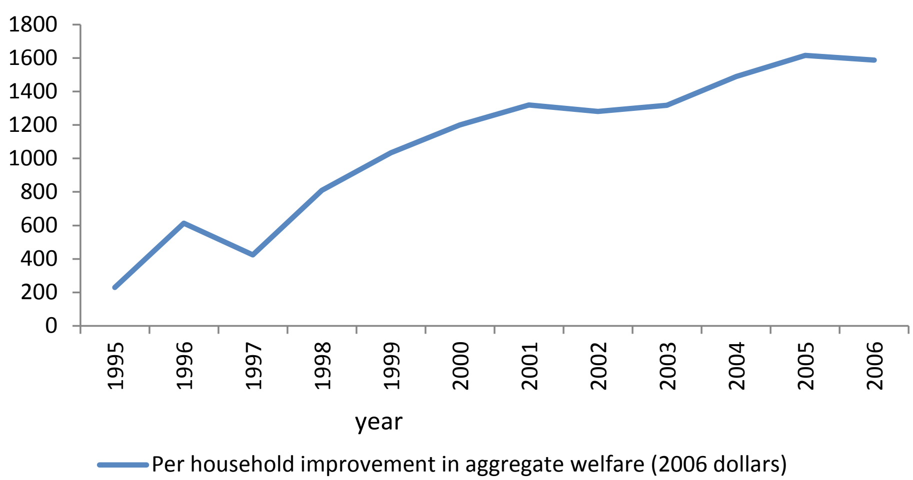


Figure 3: Joint dynamics of household income and housing prices in the US

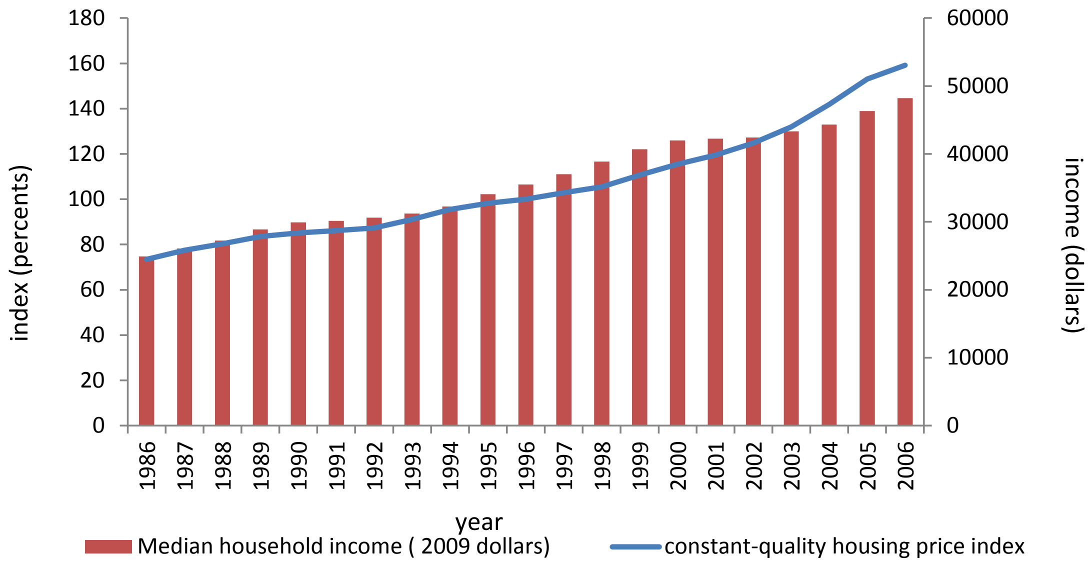
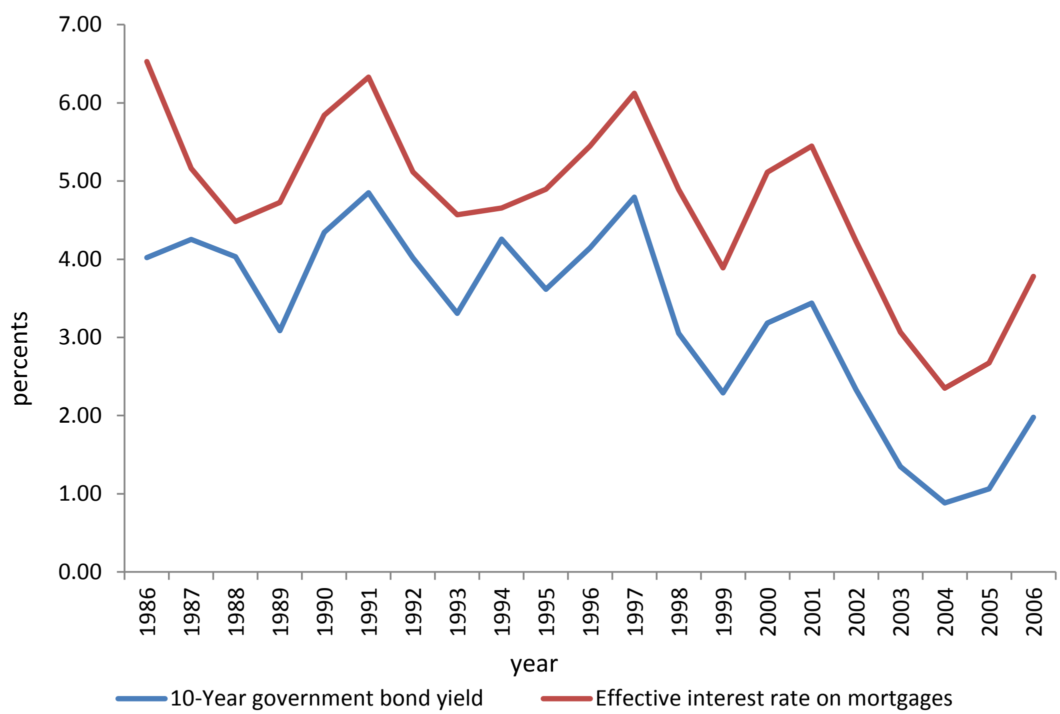


Figure 4: Dynamics of constant-quality housing prices in the US



1.10 Tables

Table 1: Comparison of welfare adjustments in the credit constrained and unconstrained models (supply side shocks)

	Unconstrained	Constrained
ω	$\frac{i^{ss}+\delta-\pi}{A}$	$\frac{B}{\beta(1-\omega)D}$
0.1	1.04678	0.121252
0.2	1.098154	0.274385
0.3	1.154829	0.473092
0.4	1.217672	0.740199
0.5	1.287749	1.116798
0.6	1.366385	1.685037
0.7	1.455248	2.636675
0.8	1.556474	4.546914
0.9	1.672835	8.291815

Table 2: Net Worth of the US households by age of head

Age of household head	Mean net worth in constant 2004 dollars
Under 35	73500
35-44	299200
45-54	542700
55-64	843800
65-74	690900
75 and over	528100

Table 3: Comparison of welfare adjustments in the credit constrained and unconstrained models (supply side shocks)

Elasticity	Parametrization 1	Parametrization 2	Parametrization 3	Parametrization 4
$\epsilon_{qy,c}$	0.389	0.472	0.526	0.678
$\epsilon_{qy,uc}$	0.264	0.382	0.188	0.281
$\epsilon_{qi,c}$	0.235	0.264	0.235	0.264
$\epsilon_{qy,uc}$	0.357	0.38	0.357	0.38

where
$\epsilon_{qy,c}$ - the elasticity of price with respect to income in the constrained economy

$\epsilon_{qy,uc}$ - the elasticity of price with respect to income in the unconstrained economy

$\epsilon_{qi,c}$ - the elasticity of price with respect to interest rate in the constrained economy

$\epsilon_{qi,uc}$ - the elasticity of price with respect to interest rate in the unconstrained economy

J_c - number of credit-constrained households

J_{uc} - number of unconstrained households

ω - exponent on housing in the Cobb-Douglas utility function

Parametrization 1: $J_c = 44784339$; $J_c = 62888650$; $\omega = 0.56$
Parametrization 2: $J_c = 44784339$; $J_c = 62888650$; $\omega = 0.64$
Parametrization 3: $J_c = 21737795$; $J_c = 85935104$; $\omega = 0.56$
Parametrization 4: $J_c = 21737795$; $J_c = 85935104$; $\omega = 0.64$

Table 4: Welfare adjustments with respect to each of the shocks

Adjustment	c (constrained)	uc (unconstrained)
Δy_s	4650	3780
Δy_y	-9950	-10770
Δy_i	-20360	-5830

2 Chapter 2

Housing price changes, general equilibrium and welfare

(with Martin Janíčko)

Abstract

This paper explores the aggregate welfare effects of housing price changes in the heterogeneous agent general equilibrium model with multi-sector production side. The model includes two types of households:credit-constrained households and unconstrained households. These types differ not only because of the presence or absence of credit constraints but also from the point of view of their time preference rates and factors of production which they own. The modelling of the production side of the economy is based on Davis and Heathcote (2005) and includes a composite good production sector housing production sector and intermediate goods production sector. Besides welfare comparisons between steady states, the welfare changes during transition between steady states are also calculated.

KEY WORDS: general equilibrium, housing price changes, aggregate welfare, binding credit constraints, multi-sector production side, construction regulations
JEL CLASSIFICATION: C68, R20, R31, R28, G15

2.1 Introduction

Over the last 14 years, the US housing market has been characterized by drastic changes in housing prices. In particular in the period from 1995 to 2006, according to National Association of Realtors the median house price increased by 190%, i.e, almost doubling. However, starting from 2007, because of the financial crisis and bust in the housing market, the trend has reversed and the median house price has decreased by around 80%.

Such considerable housing price shocks have had substantial implications for household consumption and welfare, which were explored in the previous literature both for individual groups of households as well as on the aggregate level. For exploring the effects of housing price changes on consumption and welfare of separate groups of households, mainly life-cycle models of housing choice have been used. For instance, Campbel and Cocco (2005), based on the life-cycle model and UK micro-level data on real non-durable consumption growth and real housing price growth, demonstrate positive correlation between an increase in the growth rate of housing prices and growth rate of non-durable consumption. Li and Yao (2004) also employ a life-cycle model of housing tenure choice and find that for homeowners less than 40 years old, an increase in housing prices leads to welfare losses, while in case of older homeowners it leads to an increase in both their welfare as well as consumption. Kiyotaki and Michaelides (2007) develop an open-economy life-cycle model of a production economy where residential and commercial structures are build by using land and capital. They use the model to investigate how housing prices, aggregate production and wealth distribution react to changes in technology and financial conditions and which groups of households gain and which lose from changes in fundamentals. They find that a permanent increase in the growth rate of labor productivity and a decrease in the world real interest rates substantially redistribute wealth from net buyers of houses to net sellers with a housing price hike.

Bajari et al.(2005) explore the aggregate welfare effects of housing price appreciation. In this paper the authors consider only exogenous changes in housing prices and assume that households are not credit-constrained. The authors develop a new approach to measuring the changes in consumer welfare due to changes in the prices of owner-occupied housing, which defines welfare adjustment as the transfer in the form of income required to keep expected discounted utility constant, given the change in housing prices. Using their measure of welfare adjustment, the authors show that there is no change in aggregate welfare due to an increase in the price of the existing stock of housing. Tsharakyan and Janíčko (2010) also analyze the effects of housing price appreciation on aggregate welfare but generalize the previously available results by incorporating credit constraints and endogenous housing price into welfare effects calculation. At first the credit constraint is incorporated into the model with endogenous housing price, and it is shown that in this model housing price appreciation leads to an improvement in aggregate welfare due to the effect of credit constraint relaxation resulting from housing price appreciation. Then the housing price is endogenized by modelling the supply side of the housing market. Finally the demand and supply shocks causing housing price appreciation are calibrated according to US housing market data from years 1995-2006, and it is demonstrated that housing price appreciation driven by the given combination of demand and supply shocks still leads to improvement in aggregate welfare.

While Tsharakyan and Janíčko (2010) keep the income formation exogenous, do not model the composite good production sector and use Bajari's definition of welfare adjustment, the present paper analyzes the aggregate welfare effects of housing price changes in a full general equilibrium environment. It contributes to the previous literature by building a heterogeneous agent general equilibrium model in which the aggregate welfare effects of housing price changes can be studied in a more comprehensive way. The model includes two types of households: credit-constrained households and unconstrained households. These types differ not only because of the presence or absence of credit constraints, but also from the point of view of their time preference rates and factors of production which they own. Incorporation of differential time preference rates (and consequently discount factors) is based on Kiyotaki and Moore (1997) and insures that in equilibrium more patient unconstrained households will lend their extra funds to credit-constrained households and the credit market will clear, providing the economy with a unique equilibrium. All the factors of production, namely capital, land and labor are owned by households and are supplied to the firms for production. There are two goods in this economy: a housing and a composite consumption good. The modelling of the production side of the economy is based on Davis and Heathcote (2005) and includes the composite good production sector, the housing production sector, and the intermediate good production sector.

A more explicitly modelled framework allows new important insights into the question of interest to be gained. First, in this model households' income and factor prices are determined endogenously, so any shock causing housing price changes affects also the household's income and returns on alternative investment assets such as bonds and housing. Moreover, if in the previous model the effect of housing price changes on consumption comes only through the borrowing channel, in a general equilibrium setting, in addition, the consumption allocation is explicitly dependent on housing price, reflecting the direct wealth effect of housing price changes. Finally, since the model includes several production sectors, it is possible to see how any shock causing a change in housing prices leads to redistribution of factors of production between those sectors.

After the model is defined, the steady state is calculated. Then it is explored what happens with aggregate welfare when different demand and supply-side shocks cause changes in housing price and economy transfers to a new steady state. Sources of housing price shocks include changes in productivity of different production sectors and changes in maximum loan-to-value ratios. Both the change of aggregate welfare in transition as well as change of aggregate welfare in the new steady state compared with the old steady state are calculated. Finally both the effects of housing price appreciation as well as the effects of housing price decline, which is currently characteristic for the US housing market, are considered.

Section 2.2 describes the model. Section 2.3 contains the derivation of the steady state. Section 2.4 contains log-linearization of the model, Section 2.5 contains the calibration.

Section 2.5 presents numerical results.

2.2 The Model

2.2.1 Production Sector: Housing Construction and Composite Good Production

Modelling of the production of housing and composite good is based on Davies and Heathcote (2005), but is simplified for the purposes of the present paper. Perfectly competitive intermediate goods producing firms use capital rented from the household and labor supplied by the households to produce an intermediate good. The intermediate good is produced using standard Cobb-Douglas technology where K stands for capital and N stands for labor. The intermediate good production sector is subject to a productivity shock denoted by z_t. The productivity shock follows standard AR(1) process, which is calibrated later. The production function is given by $Y_t = z_t K_t^{\alpha} N_t^{1-\alpha}$ The maximization problem for the intermediate goods producer is then given by

$$\max_{\{K_t, N_t\}} [p_t z_t K_t^{\alpha} N_t^{1-\alpha} - w_t N_t - r_t K_t], \tag{62}$$

s.t.

$$K_t, N_t \geq 0 \tag{63}$$

$$z_t = a\overline{z} + dz_{t-1} + \xi_t, \tag{64}$$

where p_t is the price of the intermediate good.The profit maximizing conditions for intermediate good producing firms are given by

$$p_t \alpha z_t K_t^{\alpha-1} N_t^{1-\alpha} = r_t, \tag{65}$$

$$p_t(1-\alpha) z_t K_t^{\alpha} N_t^{-\alpha} = w_t. \tag{66}$$

The good produced by intermediate good producers is used as input by final good producers to produce a composite consumption good and housing. Let us denote by subscript co the consumption good and by subscript h the housing good. The production function for the composite consumption good is given by $Y_{co,t} = X_{co,t}^{\alpha_{co}}$, where $X_{co,t}$ denotes quantity of intermediate good used in the production of the composite consumption good. The consumption good producer's problem is given by

$$\max_{\{X_{co,t}\}} [X_{co,t}^{\alpha_{co}} - p_t X_{co,t}], \tag{67}$$

s.t.

$$X_{co,t} \geq 0. \tag{68}$$

F.O.C. for this problem is given by

$$\alpha_{co} X_{co,t}^{\alpha_{co}-1} = p_t. \tag{69}$$

The housing construction sector combines intermediate good with land to produce housing units. It is subject to sector-specific productivity shock. The introduction of a specific productivity shock is intended for generating negative supply shock in the housing production, which according to Glaeser and Guyourko(2005) was characteristic for the 1990s and played an important role in the observed housing price dynamics. Glaeser and Guyourko(2005) argue that in 1990s new housing construction in the US was considerably limited by increasing difficulty of obtaining regulatory approval for building houses due to changing judicial tastes (that is willingness of judicial authorities to reject building permit approvals), increasing political pressures of existing homeowners, decreasing ability to bribe regulators, and rising environmental concerns. Such changes made the process of getting building permit for developers more costly both in monetary terms as well as in terms of time, or in other words, increased implicit costs of housing construction. Thus in my paper the increase in the strictness of building permit regulation works through decreasing productivity in housing production sector. Moreover, based on Saiz(2007), the level of strictness of regulatory restrictions is determined endogenously depending on the housing price level and the net change in housing demand, that is investment of households into new housing. Such determination of the degree of regulation tightness is quite logical since in case of higher demand pressure or lower price of the housing the political pressure of existing homeowners against new construction as well as environmental concerns and other factors should be stronger. Denoting regulation variable by rg , I assume that regulation strictness level is determined according to $rg_t = \psi q_{t-1} + \chi x_{t-1}$, where $x_{t-1} = x_{c,t-1} + g x_{u,t-1}$ and ψ and χ are constants calibrated later. When determining the process for productivity per se, it is assumed that it could change not only because of regulation but also because of production specific factors. Thus in my model productivity in housing sector in period t denoted by η_t is dependent both on regulation strictness rg as well as on its previous period value. That is, equation for productivity in housing sector is given by $\eta_t = \sigma + \rho\eta_{t-1} + \phi rg_t + \varsigma_t$. The housing production function is given by $Y_{h,t} = \eta_t (X_{h,t})^{\epsilon} (La_t)^{1-\epsilon}$, where $X_{h,t}$ stands for the amount of intermediate good used as input in production of housing units and La_t stands for the amount of land used. The profit maximization of construction firm is thus given by

$$\max_{\{X_{h,t}, La_t\}} [q_t \eta_t (X_{h,t})^{\varepsilon} (La_t)^{1-\varepsilon} - p_t X_{h,t} - p_{l,t} La_t], \tag{70}$$

s.t.

$$X_{h,t}, La_t \geq 0, \tag{71}$$

$$rg_t = \psi \log q_t + \chi \log x_t, \tag{72}$$

$$\eta_t = \sigma + \rho\eta_{t-1} + \phi rg_t + \varsigma_t, \tag{73}$$

where q_t stands for the price of a housing unit and $p_{l,t}$ stands for the price of land. The profit maximizing conditions for housing construction firms are given by:

$$q_t \eta_t \varepsilon X_{h,t}^{\varepsilon-1} {La_t}^{1-\varepsilon} = p_t; \tag{74}$$

$$q_t \eta_t (1-\varepsilon) X_{h,t}^{\varepsilon} {La_t}^{-\varepsilon} = p_{l,t}. \tag{75}$$

2.2.2 Households

There are two types of households in the model, namely credit constrained households with a population of size 1 and unconstrained households with a population of size g. The most important difference between these types is, correspondingly, the presence and absence of credit constraints in their optimization problems. In addition to ensure that in equilibrium unconstrained households will lend funds to constrained ones, a different structure of owned factors of production and different rates of time preference for each of the types are assumed. Both credit constrained and unconstrained households own land and the total amount of land in the economy , $\overline{L}$, is evenly distributed between and among households. Constrained households supply labor to the intermediate good producing firms. Here, the inelastic labor supply case is considered and labor supply is normalized to 1. Constrained households derive utility from consumption of housing and the composite consumption good and their preferences are denoted by $u(c_{c,t}, h_{c,t})$. The composite consumption good is considered numeraire and its price is normalized to 1. Constrained households can invest into risk-free bonds and if the bond holdings chosen by them are negative, it means that households are borrowers. The discount factor of credit constrained households is denoted by β^c.

Constrained households are subject to credit constraint of the form $b_{c,t+1} \geq -mq_t h_{c,t+1}$, implying that in each period households can borrow only a certain fraction m of the current value of their housing. When solving the model and simulating transitional dynamics, the credit constraint is used with strict equality. This means that in this paper, credit constrained households are those who have to borrow up to the maximum limit when financing a housing purchase. On one hand it can be interpreted as the upper limit of the degree of being credit constrained, but on the other hand it rules out the households who have enough cash to buy house without a mortgage but find it more profitable in terms of net present value to finance their housing purchase with a mortgage. Such households would typically not borrow the maximum possible amount since this implies a higher interest rate. Thus, only the households that have enough savings for a low down payment and have to borrow the rest are considered credit-constrained.

Housing depreciates at a constant rate δ_h. In what follows the allocations chosen by credit-constrained households are distinguished by subscript c. Households choose how many bonds to carry into the next period, $b_{c,t+1}$, how much housing to carry into next period $h_{c,t+1}$, and how much to consume in current period, $c_{c,t}$. Based on the assumptions above the constrained household problem can be formulated as follows:

$$\begin{aligned} V_c(h_{c,t}, b_{c,t}, \eta_t, z_t) \quad &= \max_{\{c_{c,t}, h_{c,t+1}, b_{c,t+1}\}} \{u(c_{c,t}, h_{c,t}) + \\ &+\beta^c E_t V_c(h_{c,t+1}, b_{c,t+1}, \eta_{t+1}, z_{t+1})\}, \end{aligned} \tag{76}$$

s.t.

$$c_{c,t} + q_t x_{c,t} + s_{c,t} = w_t + p_{l,t}(\overline{L}/(1+g)) + i_t b_{c,t}, \tag{77}$$

$$b_{c,t+1} - b_{c,t} = s_{c,t}, \tag{78}$$

$$h_{c,t+1} - h_{c,t} = x_{c,t} - \delta_h h_{c,t}, \tag{79}$$

$$b_{c,t+1} \geq -m q_t h_{c,t+1}. \tag{80}$$

Taking FOCs, rearranging, and using utility function of the form $u(c,h) = \frac{c^{1-\gamma}}{1-\gamma} + \theta\frac{h^{1-\gamma}}{1-\gamma}$, based on Campbell and Cocco (2004)yields the following Euler equations for credit-constrained households:

$$\upsilon_t = c_{c,t}^{-\gamma} - \beta^c E_t c_{c,t+1}^{-\gamma}(1 + i_{t+1}), \tag{81}$$

$$\begin{aligned} q_t c_{c,t}^{-\gamma} \quad &= \quad \beta^c \theta h_{c,t+1}^{-\gamma} + \beta^c E_t c_{c,t+1}^{-\gamma} q_{t+1}(1-\delta_h) + \\ &+m q_t \upsilon_t, \end{aligned} \tag{82}$$

where υ_t is the multiplier of credit constraint.

Each of unconstrained households possesses the same quantity of land as a constrained one. Each of them supplies one unit of labor to the intermediate good producers. In addition, unconstrained households own capital which they supply to the intermediate good producers. Assuming an additional source of income for the unconstrained households is on one hand justified from the modeling perspective, ensuring that they have additional wealth to lend in the equilibrium, and on the other hand by the fact that in real life, unconstrained households usually have higher net worth than constrained households. Capital depreciates at rate δ_k. Investment of unconstrained households into capital is denoted by I_t.The allocations made by unconstrained households are denoted by subscript u. To ensure that unconstrained households have incentives to lend, it is assumed that unconstrained households have low impatience so their discount factor is higher than that of the constrained households. The discount factor of unconstrained households is denoted by β^u. Unconstrained households choose how many bonds to carry into the next period, $b_{u,t+1}$, how much housing to carry into next period, $h_{u,t+1}$,how much to consume in current period, $c_{u,t}$, and how much capital to carry into the next period, $h_{u,t+1}$. The optimization problem of unconstrained households is given by:

$$\begin{aligned} V_u(h_{u,t}, b_{u,t}, k_t, \eta_t, z_t) \quad &= \max_{\{c_{u,t}, h_{u,t+1}, b_{u,t+1}, k_{t+1}\}} \{u(c_{u,t}, h_{u,t}) + \\ &+\beta^u E_t V_u(h_{u,t+1}, b_{u,t+1}, k_{t+1}, \eta_{t+1}, z_{t+1})\}, \end{aligned} \tag{83}$$

s.t.

$$c_{u,t} + q_t x_{u,t} + s_{u,t} + I_t = w_t + p_{l,t}(\overline{L}/(1+g)) + i_t b_{u,t} + r_t k_t, \tag{84}$$

$$b_{u,t+1} - b_{u,t} = s_{u,t}, \tag{85}$$

$$h_{u,t+1} - h_{u,t} = x_{u,t} - \delta_h h_{u,t}, \tag{86}$$

$$k_{t+1} - k_t = I_t - \delta_k k_t. \tag{87}$$

Taking FOCs, rearranging, and using the utility function above yields the following Euler equations for unconstrained households:

$$c_{u,t}^{-\gamma} = \beta^{uc} E_t c_{u,t+1}^{-\gamma}(1 + i_{t+1}), \tag{88}$$

$$q_t c_{u,t}^{-\gamma} = \beta^u \theta E_t h_{u,t+1}^{-\gamma} + \beta^u E_t c_{u,t+1}^{-\gamma} q_{t+1}(1 - \delta_h), \tag{89}$$

$$c_{u,t}^{-\gamma} = \beta^u E_t c_{u,t+1}^{-\gamma}(1 + r_{t+1} - \delta_k). \tag{90}$$

2.2.3 Definition of equilibrium

The equilibrium consists of prices $\{q_t, r_t, w_t, p_t, p_{l,t}\}_{t=0}^{\infty}$, , shadow price of credit constraint $\{\upsilon_t\}_{t=0}^{\infty}$ interest rate $\{i_t\}_{t=0}^{\infty}$, allocations $\{c_{c,t}, h_{c,t+1}, b_{c,t+1}, c_{u,t}, h_{u,t+1}, b_{u,t+1}, k_{t+1}\}_{t=0}^{\infty}$ by households and the profit maximizing input demands of firms $\{K_t, N_t, La_t, X_{co,t}, X_{h,t}\}_{t=o}^{\infty}$ and level of regulation $\{rg_t\}_{t=0}^{\infty}$ such that

1) given prices, households solve their optimization problem (conditions(81)-(83) and (88) -(90)) and firms maximize their profits (conditions (65)-(75));

2) Markets clear,

i)

$$x_{c,t} + g x_{u,t} = Y_{h,t} \tag{91}$$

(housing market),

ii)

$$c_{c,t} + g c_{u,t} + g I_t = Y_{co,t} \tag{92}$$

(composite good market),

iii)

$$K_t = g k_t \tag{93}$$

(capital market),

iv)

$$b_{c,t+1} = -g b_{u,t+1} \tag{94}$$

(credit market),

v)

$$N_t = g + 1 \tag{95}$$

(labor market),

vi)

$$X_{co,t} + X_{h,t} = Y_t \tag{96}$$

(intermediate good market),

vii)

$$La_t = \overline{L} \tag{97}$$

(land market).

2.3 Derivation of Steady State

In what follows we consider the situation in which credit constraints are binding for constrained households bind. In terms of the model this assumption implies that following should hold: $\frac{1}{(i_{t+1}+1)} < \frac{c_{c,t}^{-\gamma}}{\beta^c c_{c,t+1}^{-\gamma}}$.

In other words intertemporal MRS of credit constrained households should be higher than the real rate of return on bonds.

Given the assumption of s binding credit constraint, the steady state satisfies the following conditions:

$h_{c,t+1} = h_{c,t} = h_c^{ss}$

$h_{u,t+1} = h_{u,t} = h_u^{ss}$

$c_{c,t+1} = c_{c,t} = c_c^{ss}$

$c_{u,t+1} = c_{u,t} = c_u^{ss}$

$b_{c,t+1} = b_{c,t} = b_c^{ss}$

$b_{u,t+1} = b_{u,t} = b_u^{ss}$

$k_{t+1} = k_t = k^{ss}$

$s_c^{ss} = b_c^{ss} - b_c^{ss} = 0$

$s_u^{ss} = b_u^{ss} - b_u^{ss} = 0$

$x_c^{ss} = h_c^{ss} - (1-\delta_h)h_c^{ss} = \delta_h h_c^{ss}$

$x_u^{ss} = h_u^{ss} - (1-\delta_h)h_u^{ss} = \delta_h h_u^{ss}$

$I_{ss} = k^{ss} - (1-\delta_k)k^{ss} = \delta_k k^{ss}$

Using the above conditions, budgets constraints (77)and (84) for the constrained and unconstrained households in the steady state can be rewritten as:

$$c_c^{ss} = w^{ss} + p_l^{ss}(\overline{L}/(1+g)) + i^{ss}b_c^{ss} - \delta_h q^{ss}h_c^{ss} \tag{98}$$

$$c_u^{ss} = w^{ss} + p_l^{ss}(\overline{L}/(1+g)) + (r^{ss}-\delta_k)k^{ss} + i^{ss}b_u^{ss} - \delta_h q^{ss}h_u^{ss} \tag{99}$$

Rewriting binding credit constraint(80) and credit market equilibrium condition(94) in steady state yields the following expressions for b_c^{ss} and b_u^{ss}:

$$b_c^{ss} = -m^{ss}q^{ss}h_c^{ss} \tag{100}$$

$$b_u^{ss} = -\frac{b_c^{ss}}{g} \tag{101}$$

(81)-(83) in the steady state can be rewritten as

$$v^{ss} = (c_c^{ss})^{-\gamma} - \beta^c(c_c^{ss})^{-\gamma}(i^{ss}+1); \tag{102}$$

$$q^{ss} = \beta^c\frac{\theta(h_c^{ss})^{-\gamma}}{(c_c^{ss})^{-\gamma}} + \beta^c q^{ss}(1-\delta_h) + m^{ss}q^{ss}(1-\beta^c(i^{ss}+1)). \tag{103}$$

(88)-(90) in the steady state are given by the following:

$$1 = \beta^u(i^{ss}+1); \tag{104}$$

$$q^{ss} = \beta^u\frac{\theta(h_u^{ss})^{-\gamma}}{(c_u^{ss})^{-\gamma}} + \beta^u q^{ss}(1-\delta_h); \tag{105}$$

$$1 = \beta^u(1 + r^{ss} - \delta_k). \tag{106}$$

Rearranging (103) yields

$$c_c^{ss} = \left(\frac{1-\beta^c(1-\delta_h) - m(1-\beta^c(1+i^{ss}))}{\beta^c\theta}q^{ss}\right)^{1/\gamma} h_c^{ss}. \tag{107}$$

Rearranging (104)yields

$$\frac{1-\beta^u}{\beta^u} = i^{ss}. \tag{108}$$

Rearranging (105)yields

$$c_{uc}^{ss} = \left(\frac{1-\beta^u(1-\delta_h)}{\beta^u\theta} q^{ss}\right)^{1/\gamma} h_u^{ss}. \tag{109}$$

Rearranging (106)yields

$$r^{ss} = \frac{1}{\beta^u} - 1 + \delta_k. \tag{110}$$

The steady state level of capital and the rest of the prices can be determined by solving the supply side of the model and using market clearing conditions. Rewriting the conditions (65)-(66) in the steady state yields

$$p^{ss} z^{ss} (K^{ss})^{\alpha-1} (N^{ss})^{1-\alpha} = r^{ss}; \tag{111}$$

$$p^{ss} z^{ss} (1-\alpha)(K^{ss})^{\alpha} (N^{ss})^{-\alpha} = w^{ss}. \tag{112}$$

Using labor market clearing condition we can $N^{ss} = 1+g$. Substituting this into (111) and rearranging yields:

$$K^{ss} = \left(\frac{p^{ss} z^{ss} \alpha}{r^{ss}}\right)^{1/(1-\alpha)} (1+g). \tag{113}$$

Substituting the (113) into and expression for N^{ss} into (112) and rearranging yields

$$w^{ss} = \left(\frac{\alpha}{r^{ss}}\right)^{\alpha/(1-\alpha)} (p^{ss} z^{ss})^{1/(1-\alpha)} (1-\alpha). \tag{114}$$

The production volume of the intermediate good in the steady state is given by

$$Y^{ss} = (z^{ss})^{1/(1-\alpha)} \left(\frac{p^{ss}\alpha}{r^{ss}}\right)^{\alpha/(1-\alpha)} (1+g). \tag{115}$$

Now let's use the profit maximization conditions of final good producers. Rewriting the condition (69)in the steady state yields

$$X_{co}^{ss} = \left(\frac{\alpha_{co}}{p^{ss}}\right)^{\frac{1}{1-\alpha_{co}}}. \tag{116}$$

The quantity of composite good produced in the steady state is given by

$$Y_{co}^{ss} = \left(\frac{\alpha_{co}}{p^{ss}}\right)^{\frac{\alpha_{co}}{1-\alpha_{co}}}. \tag{117}$$

Rewriting the conditions (74)-(75) in the steady state yields

$$q^{ss}\varepsilon(X_h^{ss})^{\varepsilon-1}(La^{ss})^{1-\varepsilon} = p_{res}^{ss}; \tag{118}$$

$$q^{ss}(1-\varepsilon)(X_h^{ss})^{\varepsilon}(La^{ss})^{-\varepsilon} = p_l^{ss}. \tag{119}$$

Using land market clearing condition and solving (118) for X_h^{ss} yields:

$$X_h^{ss} = \left(\frac{\varepsilon q^{ss}}{p^{ss}}\right)^{\frac{1}{1-\varepsilon}} \overline{L} \tag{120}$$

This implies that quantity of new housing units produced in steady state is given by

$$Y_h^{ss} = \left(\frac{\varepsilon q^{ss}}{p^{ss}}\right)^{\frac{\varepsilon}{1-\varepsilon}} \overline{L}. \tag{121}$$

Finally housing market clearing condition (91) and composite good market clearing condition (92) in the steady state can be written as:

$$\delta_h h_c^{ss} + \delta_h g h_{uc}^{ss} = \left(\frac{\varepsilon q^{ss}}{p^{ss}}\right)^{\frac{\varepsilon}{1-\varepsilon}} \overline{L}; \tag{122}$$

$$c_c^{ss} + g c_{uc}^{ss} + g\delta_k k^{ss} = \left(\frac{\alpha_{co}}{p^{ss}}\right)^{\frac{\alpha_{co}}{1-\alpha_{co}}}. \tag{123}$$

Finally the level of regulation in the steady state and aggregate investment into housing in steady state are given by

$$rg^{ss} = \psi \log q^{ss} + \chi \log x^{ss}, \tag{124}$$

$$x^{ss} = x_c^{ss} + g x_u^{ss}. \tag{125}$$

Equations (98)-(102), (107)-(110), (113)- (114), (116),(120),(122)-(125), together with capital market clearing condition (93) represent system of 18 equations with 18 unknowns, which fully determines the steady state. The steady state values of the variables are given in Table 6.

2.4 Log-linearization

Log linearizing around steady state budget constraints (77)and (84), credit constraint (80, the optimality conditions for households ((81)-(83) and (88)-(90))and firms ((65)-(75, market clearing conditions (i-vii), equation for regulation level rg and laws of motion of stochastic exogenous variables η and z yields the following equations:

$$\widetilde{c_{c,t}} = \frac{w^{ss}}{c_c^{ss}}\widetilde{w_t}+\frac{\overline{L_c}p_l^{ss}}{c_c^{ss}}\widetilde{p_{l,t}}+\frac{i^{ss}b_c^{ss}}{c_c^{ss}}\widetilde{i_t}+\frac{i^{ss}b_c^{ss}}{c_c^{ss}}\widetilde{b_{c,t}}-\frac{b_c^{ss}}{c_c^{ss}}\widetilde{b_{c,t+1}}-\frac{q^{ss}h_c^{ss}}{c_c^{ss}}\widetilde{h_{c,t+1}}+\frac{q^{ss}h_c^{ss}(1-\delta_h)}{c_c^{ss}}\widetilde{h_{c,t}}--\frac{q^{ss}h_c^{ss}\delta_h}{c_c^{ss}}\widetilde{q_t}$$

$$\widetilde{c_{uc,t}} = \frac{w^{ss}}{c_{uc}^{ss}}\widetilde{w_t} + \frac{\overline{L_c}p_l^{ss}}{c_{uc}^{ss}}\widetilde{p_{l,t}} + \frac{i^{ss}b_{uc}^{ss}}{c_{uc}^{ss}}\widetilde{i_t} + \frac{i^{ss}b_{uc}^{ss}}{c_{uc}^{ss}}\widetilde{b_{uc,t}} - \frac{b_{uc}^{ss}}{c_{uc}^{ss}}\widetilde{b_{uc,t+1}} - \frac{q^{ss}h_{uc}^{ss}}{c_{uc}^{ss}}\widetilde{h_{uc,t+1}} + \frac{q^{ss}h_{uc}^{ss}(1-\delta_h)}{c_{uc}^{ss}}\widetilde{h_{uc,t}} -$$

$$-\frac{q^{ss}h_{uc}^{ss}\delta_h}{c_{uc}^{ss}}\widetilde{q_t} - \frac{k^{ss}}{c_{uc}^{ss}}\widetilde{k_{t+1}} + \frac{(1-\delta_k+r^{ss})k^{ss}}{c_{uc}^{ss}}\widetilde{k_t} + r^{ss}k^{ss}\widetilde{r_t}$$

$$\widetilde{b_{c,t+1}} = \widetilde{q_t} + \widetilde{h_{c,t+1}}$$

$$\widetilde{\upsilon_t} = \left(\frac{\beta^c\gamma}{\upsilon^{ss}(c_c^{ss})^\gamma} + \frac{\beta^c i^{ss}\gamma}{\upsilon^{ss}(c_c^{ss})^\gamma} + \gamma\right)\widetilde{c_{c,t}}\text{-}E_t\left(\frac{\beta^c i^{ss}}{\upsilon^{ss}(c_c^{ss})^\gamma}\widetilde{i_{t+1}} \quad - \left(\frac{\gamma}{\upsilon^{ss}(c_c^{ss})^\gamma} - \gamma\right)\widetilde{c_{c,t+1}}\right)$$

$$\widetilde{h_{c,t+1}} = -E_t(\widetilde{c_{c,t+1}} + \frac{\beta^c(1-\delta_h)}{\gamma h_c^{ss}}\widetilde{q_{t+1}}) + \left(\frac{\beta^c\theta}{q^{ss}h_c^{ss}} + \frac{\beta^c(1-\delta_h)}{h_c^{ss}} + \frac{mv^{ss}}{h_c^{ss}}\right)\widetilde{c_{c,t}} + \left(\frac{mv^{ss}}{\gamma h_c^{ss}} - \frac{1}{\gamma}\right)\widetilde{q_t} + \frac{mv^{ss}}{\gamma h_c^{ss}}\widetilde{\upsilon_t}$$

$$\widetilde{h_{uc,t+1}} = -E_t(\widetilde{c_{uc,t+1}} + \frac{\beta^c(1-\delta_h)}{\gamma h_c^{ss}}\widetilde{q_{t+1}}) + \left(\frac{\beta^c\theta}{q^{ss}h_{uc}^{ss}} + \frac{\beta^c(1-\delta_h)}{h_c^{ss}}\right)\widetilde{c_{uc,t}}$$

$$0 = \gamma\widetilde{c_{uc,t}} - E_t(\gamma\widetilde{c_{uc,t+1}} + \beta^{uc}r^{ss}\widetilde{r_{t+1}})$$

$$\widetilde{p_t} + \widetilde{z_t} + (\alpha-1)\widetilde{K_t} + (1-\alpha)\widetilde{N_t} = \widetilde{r_t}$$

$$\widetilde{p_t} + \widetilde{z_t} + \alpha\widetilde{K_t} - \alpha\widetilde{N_t} = \widetilde{w_t}$$

$$(\alpha_{co}-1)\widetilde{X_{co,t}} = \widetilde{p_t}$$

$$p^{ss}\widetilde{p_t} = q^{ss}\eta^{ss}\varepsilon(X_h^{ss})^{\varepsilon-1}(La^{ss})^{1-\varepsilon}\widetilde{q_t}+q^{ss}\eta^{ss}\varepsilon(X_h^{ss})^{\varepsilon-1}(La^{ss})^{1-\varepsilon}(\varepsilon-1)\widetilde{X_{h,t}}+q^{ss}\eta^{ss}\varepsilon(X_h^{ss})^{\varepsilon-1}(La^{ss})^{1-\varepsilon}\widetilde{\eta_t}-$$

$$-q^{ss}\eta^{ss}\varepsilon(X_h^{ss})^{\varepsilon-1}(La^{ss})^{1-\varepsilon}\ (1-\varepsilon)\widetilde{La_t}$$

$$p_l^{ss}\widetilde{p_{l,t}} = q^{ss}\eta^{ss}(1-\varepsilon)(X_h^{ss})^{\varepsilon}(La^{ss})^{-\varepsilon}\widetilde{q_t}+q^{ss}\eta^{ss}(1-\varepsilon)(X_h^{ss})^{\varepsilon}(La^{ss})^{-\varepsilon}\widetilde{\eta_t}+q^{ss}\eta^{ss}(1-\varepsilon)(X_h^{ss})^{\varepsilon}(La^{ss})^{-\varepsilon}\varepsilon\widetilde{X_{h,t}}-$$

$$-q^{ss}(1-\varepsilon)(X_h^{ss})^{\varepsilon}(La^{ss})^{-\varepsilon}\varepsilon\widetilde{La_t}$$

$$h_c^{ss}(\widetilde{h_{c,t+1}}-(1-\delta)\widetilde{h_{c,t}})+gh_{uc}^{ss}(\widetilde{h_{uc,t+1}}-(1-\delta)\widetilde{h_{uc,t}}) = (X_{res}^{ss})^{\varepsilon}(La^{ss})^{1-\varepsilon}(\varepsilon\widetilde{X_{res,t}}+(1-\varepsilon)\widetilde{La_t})$$

$$c_c^{ss}\widetilde{c_{c,t}} + gc_{uc}^{ss}\widetilde{cu_{c,t}} = (X_{co}^{ss})^{\alpha_c}\alpha_c\widetilde{X_{co,t}}$$

$$\widetilde{K_t} = \widetilde{k_{t+1}}$$

$$\widetilde{b_{c,t+1}} = \widetilde{b_{uc,t+1}}$$

$$\widetilde{N_t} = 0$$

$$\widetilde{La_t} = 0$$

$$X_{co}^{ss}\widetilde{X_{co,t}} + X_{res}^{ss}\widetilde{X_{res,t}} = (K^{ss})^{\alpha}(N^{ss})^{1-\alpha}(\alpha\widetilde{K_t} + (1-\alpha)\widetilde{N_t})$$

$$\widetilde{z_t} = d\widetilde{z_{t-1}} + \widetilde{\xi_t}$$

$$\widetilde{rg_t} = \psi\widetilde{q_{t-1}} + \chi\widetilde{x_{t-1}}$$

$$\widetilde{x_t} = \widetilde{x_{c,t}} + g\widetilde{x_{u,t}}$$

$$\widetilde{\eta_t} = \rho\widetilde{\eta_{t-1}} + \phi\widetilde{rg_t} + \widetilde{\varsigma_t}$$

2.5 Calibration

Based on Kiyotaki and Moore (1997)discount factor for unconstrained households β^u is set equal to conventional 0.99 while the discount factor for credit constrained households β^c is set equal to 0.97. Following Campbell and Cocco (2005) I set $\theta = 1.2$ and $\gamma = 2$. The value of m in the baseline case is set equal to 0.85 which is the average loan-to-value ratio for conventional mortgages in US for years 1990-2000 according to Monthly Interest Rate Survey of Federal housing Finance agency. The second considered value of m is set to 0.95 reflecting the rapid liberalization of mortgage conditions which happened from 2000 to 2006. The third value is set to 0.88, reflecting the post crisis tightening of the mortgage conditions (value again obtained from Monthly Interest Rate Survey as average for years 2007-2010). Depreciation rate for physical capital is set to 6.8 % which is the average annual depreciation rate for appropriately measured capital between 1995 and 2009. The share of raw land in the housing production $1-\varepsilon$, is set to 0.106 following an estimate from the Census Bureau. This implies that $\varepsilon = 0.894$. The depreciation rate for housing is set to 2.5 % based on

Tsharakyan (2007). The remaining parameters are estimated using GMM estimation and the following model variables which are observed for the period 1987-2009: a)real wage w which is represented by real wage from Bureau of Labor Statistics divided by the NIPA price index for Personal Consumption Expenditure ; b)interest rate i which represented by effective interest rate on mortgages from Monthly Interest Rate Survey of Federal Housing Finance Agency; c) relative price of housing q, which is represented by Freddie Mac Conventional Mortgage Home Price Index divided by NIPA price index for Personal Consumption Expenditure; d)physical capital k which is represented by the stock of private fixed capital (excluding the stocks of residential capital and consumer durables) plus the stock of government non-defense capital; e) relative price of land p_l which is represented by price index for land from Lincoln Institute of Land Policy divided by NIPA price index for Personal Consumption Expenditure; f) regulation level rg which is represented by Wharton Regulation Index from Saiz(2010); g)productivity in housing construction η, which is represented by multi-factor productivity in construction sector from EU-KLEMS database h)investment into physical capital in which is represented by gross capital formation from Bureau of Economic Analysis; i) quantity of housing units constructed which represented by new housing units completed from US Census Bureau. Values of all the parameters are summarized in Table 5.

2.6 Results: Changes in transition and steady state comparisons

2.6.1 Positive productivity shock in intermediate good production

For simulating the model the log-linearized equations from Section 2.4 and Dynare toolbox are used. The welfare change in this model is expressed in terms of percentage of average consumption in the initial steady state defined as $\frac{c_c+gc_{uc}}{1+g}$, necessary to make household indifferent between current situation and initial steady state.

Lets suppose that economy is in the steady state when the productivity in intermediate good sector shifts up by 1 percent and stays at higher level. The positive productivity shock of 1% within present model results in increase in equilibrium wage by 0.21% during the first period. This increases the disposable income of households and generates increase in composite good consumption by 0.09% for credit constrained households and 0.12% for unconstrained households, thus resulting into increase in aggregate consumption by 0.113% over the first period. Housing consumption increases by 0.14% percent for credit constrained households and by 0,17% for unconstrained households, thus resulting into 0.158% of aggregate increase in housing consumption. Increase in housing consumption leads to an increase in equilibrium housing price by 0.135% and increase in housing construction at the end of period 1 by 0.13%. Since there is high demand pressure and an increase in housing price, regulation tightness increases resulting into decrease in productivity in housing production sector by 0.1% and decrease in the construction of new housing units by 0.07% over pushing up housing price by another 0.155% over the next 3 periods. From period 2 until converging to new steady state composite good consumption on aggregate continues to increase. Though there considerable additional income, the increase in aggregate housing consumption over the next periods is limited by the supply-side. The economy reaches the new steady state during 20 periods . In the new steady state the composite good consumption is higher by 0.35% and housing consumption is higher 0.24% .In the new steady state the lifetime expected utility of credit constrained households in terms of average consumption is higher by 0.295% and utility of unconstrained households is higher by 0.315 % . During the transition, due to positive dynamics of housing consumption and composite good consumption lifetime utility also rises by 0.22% for credit constrained households and 0.238 % for unconstrained households in terms of average consumption in the initial steady state.

2.6.2 Increase in loan-to-value ratio

Now let us consider the implications of shift in the loan-to-value ratio from 0.85 to 0.95, which reflects the rapid liberalization of mortgage market in the beginning of 2000s. The increase in the loan-to-value ratio leads to an increase in housing price over first period by 10.5% which increases the value of outstanding housing equity and allows households to increase both housing consumption and composite good consumption. During the first period composite good consumption rises by 7.85% (correspondingly by 6.8% and 8.45% for credit constrained and unconstrained households) and housing consumption rises by 9.35% (8.4% and 10.1% correspondingly). Housing construction at the end of period 1 increases by 8.9%. In period 2 again regulation becomes stricter which shifts down the productivity in housing construction sector by 6.5% and decreases the production of new housing units by 7.2%. The transitions to new steady state continues for 15 periods over which both composite good consumption and housing consumption increase. In the new steady state the composite good consumption is higher by 14.5% and housing consumption is higher by 12% . The lifetime utility in the new steady state in terms of average consumption is higher by 18,5 % (21% for constrained households and 17.7 for unconstrained).

2.6.3 Negative productivity shock in intermediate good production

The situations analyzed above were characteristic for housing boom years which continued up to 2006 where majority of shocks for the housing market were positive. Now we can analyze what happened when suddenly the negative income shock and tightening of the mortgage markets affected the housing market. Suppose that we start in a steady with 1% higher productivity than the initial one and model economy experiences negative productivity shock which leads to negative income shock. However even if we consider again the negative productivity shock of 1% the situation is not the same as going back to initial steady state. In the new steady state with higher productivity shock the constraints are again binding but the credit constrained households have borrowed more and with lower income it is harder for them to repay the debt. Also, for the after crisis situation the regulatory restrictions on new housing construction are not so characteristic anymore.1% negative income shock leads to decrease in housing consumption by 0.257% (0.36% decrease for constrained households and 0.205% for unconstrained households) and decrease in composite good production by 0.22 % (correspondingly 0.29% for constrained and 0,21% for unconstrained) during the first 3 periods of transition and this decrease continues further for the composite good consumption good since lower housing demand leads to lower housing price and consumption is positively related to housing price. In the new steady state both housing consumption and composite good consumption are lower by respectively 0.41% and 0.335 % and lifetime utility in terms of average consumption is lower by 0.38 % (correspondingly 0,42% and 0.368 for credit constrained and unconstrained households). There is also decrease in utility by 0.34 % for constrained households and 27,5 % for unconstrained during the transition process.

2.6.4 Decrease in loan-to-value ratio

The situation is similar when economy shifts from state with loan-to-value ratio of 95 % to state with LTV ratio of 87%. Tightening of the mortgage conditions decreases demand for housing and decreases housing price. The value of outstanding housing equity decreases which makes it more difficult for credit constrained households to return debt and forces them to significantly cut consumption . After the first five periods composite good consumption decreases by 25% for credit constrained households and then continues to slightly decrease reaching the new steady state. Housing consumption decreases by 28.5 % during the first 3 periods due to tightening of credit market and after third period starts to increase slightly due to lower housing price. Transition lasts 18 periods. In the new steady state the composite good consumption is lower by 30.2% and housing consumption is lower by 27.5% . The lifetime utility in the new steady state is lower by 33.6 % .

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2.7 Tables

Table 5: Parameter values

Name	Value
β^c	0.97
β^{uc}	0.99
m	0.8
α	0.31
α_{co}	0.27
a	0.7
σ	1.85
ρ	0.62
ε	0.894
ϕ	-0.57
g	2
θ	1.2
γ	2
δ_h	0.025
δ_k	0.068
$\overline{z}$	2
χ	0.322
ψ	0.481

Table 6: Steady state values

Variable	Value
cu	0.752
cc	0.832
hu	0.719
hc	0.751
k	8.093
bu	11.265
bc	-22.531
q	37.485
w	1.1588
r	0.065
ir	0.01
v	0.0291
Kp	16.186
X_{co}	5.686
X_h	1.213
pl	0.217
p	0.443
η	0.085
in	0.452
xu	0.117
xc	0.125
rg	1.714
z	2

3 Chapter 3

The effect of mortgage origination fees on housing price dynamics

Abstract

This paper explores the link between mortgage origination fees and housing prices. It is argued that a sharp decline in mortgage origination fees in the US since the late 1980s was caused by mortgage market deregulation and mortgage innovation. Based on this reasoning the sources of exogenous variation in mortgage fees are identified, and the effect of mortgage fees on housing prices is quantified. The results indicate that a decline in mortgage fees had a robust statistically significant positive effect on housing prices. The lagged effect of mortgage fees on housing prices is also present.

KEY WORDS: Mortgage origination fees, housing price, branching restrictions, mortgage market deregulation
JEL CLASSIFICATION: R21, R31,C33

3.1 Introduction

The mortgage market is naturally connected with the housing market through a housing demand channel. Among others, one of the important reasons for the increased housing price appreciation in the US in the last two decades was the significantly increased availability of mortgages, which made it easier to finance housing purchases and pushed up the demand for housing. Mortgage market deregulation, mortgage innovation, and the extensive involvement of commercial banks in mortgage lending have increased the competition in the mortgage markets and made mortgage lending less risky. This led to a decrease in both mortgage interest rates as well as mortgage origination fees.

Much of the previous research explored the link between mortgage interest rates and housing prices. Abraham and Hendershott (1996) identify the significant negative effect of mortgage interest rates on housing prices using an equilibrium correction model of housing prices. Baffoe-Bonnie (1998) analyzes the dynamic effects of employment, mortgage interest rates and other key macroeconomic variables on the housing prices and the stock of houses sold on the national and regional levels. Using a vector-autoregressive approach and impulse response functions, the author shows that both the housing price as well as the stock of houses sold are very sensitive to the changes in mortgage interest rates and employment both on the national as well as the regional level. McGibany and Nourzad (2004) analyze short-run and long-run relationships between mortgage interest rates and housing prices using advanced non-structural methods. As in previous literature, the authors .nd a long-run negative relationship between mortgage interest rates and housing prices. However, contrary to previous literature, Granger non-causality tests, impulse response functions, and variance decompositions indicate a small short-run influence from mortgage rates to housing prices. It is worth mentioning that in this paper, which concentrates on the short-run dynamics of housing prices, a mortgage interest rate is included into the housing price regression, and the effect of the mortgage interest rate on the housing price is found to be not very large in magnitude and closer to that found in McGibany and Nourzad (2004).

The effect of mortgage origination fees on housing price dynamics, on the other hand, has not been considered in the previous literature. A change in mortgage origination fees can be another channel through which changes in the mortgage market have affected the US housing market. Mortgage origination fees have to be paid up-front at the time of entering into a mortgage contract and should enter into the total cost of the mortgage for the household. When mortgage origination fees decrease, the total cost of the mortgage also decreases. Observing the availability of cheaper mortgages, households increase demand for housing. Mortgage origination fees in the US have significantly fallen since the mid-1980s (described in Section 3.2), which implies that the effect of the decline in mortgage origination fees on housing price dynamics is worth exploring. Consequently, this paper explores the effect of mortgage origination fees on housing prices, controlling for the other fundamentals previously used in the housing price determination literature.

Early studies on housing price appreciation, which are reviewed in Bartik (1991, Chapter 5), show that housing price appreciation is influenced by population and employment growth. The results of Poterba (1991) indicate that changes in income and construction costs are important in explaining housing prices, but do not provide much support for the role of demographic factors or after-tax user costs in explaining their movements. He also finds that house price movements are predictable on the basis of lagged housing price appreciation and lagged changes in real per capita income. Abraham and Hendershott (1996) study the existence of a bubble in the US housing market using an equilibrium error correction model while allowing for a lagged adjustment of housing prices. They show that the real housing price appreciation is positively correlated with the increases in real construction costs, employment, and real income and is negatively correlated with rises in real interest rates.

Jud and Winkler (2002) analyze the determinants of a real housing price change using a sample encompassing 130 metropolitan areas from 1984 through 1998. The model introduces a wealth effect on housing prices, and an MSA fixed-effects model is employed to account for changes in metropolitan-speci.c construction cost factors. The variables used to explain housing prices include real after-tax mortgage rates, income, population, real wealth, national construction costs, and MSA-specific cost factors. The authors find a significant positive effect of stock market wealth accumulation on the housing price changes. They also find a considerable positive effect of construction costs, income and population, and a negative effect of real mortgage rates on housing prices. Finally, lagged changes in real wealth and real construction costs also have a substantial positive effect on housing prices.

Galin (2006) explores the long-run relationship between income and housing prices in a demand/supply framework, and Mikhed and Zemcik (2009) use a structural demand/supply model of the housing market to study the effect of house rents, CPI, and several other already mentioned fundamentals on housing prices.

This paper analyzes the effect of mortgage origination fees on housing prices, estimating the housing price regression derived from the demand /supply model analogous to Jud and Wrinkler (2002). Besides mortgage origination fees, which is the key variable of interest, this paper also includes the unemployment rate and user cost into housing price regressions. The analysis is performed using several econometric speci.cations, including speci.cation with time fixed effects. Also, the endogeneity tests of the explanatory variables are performed and instrumental variable (IV) estimations are employed. Prior to estimating housing price models, the reasons for the decline in mortgage fees are explored. This helps to identify the sources of their supply-side variation exogenous to the housing market.

My results indicate that changes in the mortgage origination fees have had a statistically significant negative effect on housing prices and, along with the other variables, have contributed to a substantial housing price appreciation in the US. Also, a lagged effect of mortgage fees on housing price is found.

The rest of the paper is organized as follows. Section 3.2 discusses the factors behind the substantial decrease of mortgage origination fees. Section 3.3 contains the econometric model and description of different specifications. Section 3.4 contains the data description.

Section 3.5 reports the empirical results. Section 3.6 contains the endogeneity tests and results of IV estimations. Section 3.7 concludes the paper.

3.2 Mortgage Fees

Mortgage market deregulation, an increased involvement of commercial banks in mortgage lending, the removal of branching restrictions, and mortgage innovation appear to be very important reasons explaining the observed dynamics of mortgage origination fees in the US since the 1980s. Due to these developments, the US mortgage market changed from a locally segmented, heavily regulated market with limited competition to a more competitive, nationally integrated and less risky market. This reasoning allows to argue that those events increased the flow of funds to the mortgage lending activities, which shifted the mortgage market supply curve to the right and together with increased competition led to a signi.cant decrease in mortgage origination fees. This stimulated demand for mortgages and as a result pushed up the demand for housing. At the same time, this reasoning allows the identification of a substantial variation in mortgage fees caused by reasons exogenous to the housing market. In this section, the dynamics of mortgage origination fees since the 1980s is described, and the sources of exogenous variation in fees are discussed in detail.

The dynamics of US average initial fees and charges for conventional mortgages from 1980 to 2003 is reported in Figure 5. Figure 6-Figure 8 present the variation in initial fees and charges in the Metropolitan Statistical Areas (MSAs), where the decline of fees was the strongest. Data for initial fees and charges are taken from the Monthly Interest Rate Survey of the Federal Housing Finance Board. The survey reports terms and conditions on all conventional single-family, fully amortized, first-time, purchase-money loans closed by major lenders during the last five working days of the month. Reporting institutions include all major types of private mortgage lenders such as savings and loan associations, mortgage companies, commercial banks, and mutual savings banks. The survey excludes FHA-insured and VA-guaranteed loans, multifamily loans, mobile home loans, and refinancing loans. The survey is held monthly and the aggregated yearly data are available from the Federal Housing Finance Board. Initial fees and charges are measured in this survey as a percentage of the mortgage balance.

From Figure 5 it can be seen that from 1980 to 2003, the average initial fees and charges for mortgages in the US decreased from 1.97 % of the mortgage balance to only 0.37 % of the mortgage balance, which reflects the decrease in relative terms. At the same time, the average mortgage amount in the US according to the Monthly Interest Rate Survey increased only 3 times, which implies that mortgage origination fees declined in absolute terms as well. The same can be said about the dynamics of fees in major MSAs, which is plotted in Figure 6 - Figure 8. For instance, in Atlanta from 1980 to 2003, initial fees and charges decreased from 2.58% of the mortgage balance to 0.31% of the mortgage balance. At the same time the average mortgage amount increased only 2.4 times. In Boston during 60 the same period, fees decreased from 2.12 to 0.23% of the mortgage balance, while the mortgage amount increased only 4 times. In Chicago fees decreased from 2.5 to 0.16% of the mortgage balance, while the mortgage amount increased only 3 times. For reference Figure 9 - Figure 10 display the evolution of mortgage amounts over this period in those MSAs for which mortgage fees data are provided in Figure 6 - Figure 8 .

From an econometric perspective it is important to analyze the reasons behind the substantial decline of mortgage origination fees. One possibility could be the change over time in the pricing strategy of mortgage lenders towards charging lower fees but compensating them by higher interest rates. This would imply that mortgage origination fees and interest rates should be negatively correlated in the data. To check this possibility, the fixed effects regression of first-differenced initial fees and charges for conventional mortgages on first-differenced mortgage interest rates from the Monthly Interest Rate of Federal Housing Finance Board is performed. The t-statistics of the interest rate coefficient in this regression is -0.80, which implies that the data do not provide evidence for such pricing policy.

Another possibility is the occurrence of major supply driven changes in the mortgage market, leading to an increase in competition and supply of funds. The inspection of mortgage market developments since the 1980s confirms that the supply side of the mortgage market has undergone major changes both in terms of its structure as well as in intensiveness of competition. Until the 1980s, specialized depository institutions, mainly savings and loan associations, had the primary role in mortgage lending. They were induced by regulations and tax incentives to invest the majority of their assets in mortgages and weren't allowed by law to perform commercial banking activities (business loans, consumer credit credit cards, etc.). Moreover, until 1966 they were excluded from deposit rate ceilings applied to commercial banks, and in 1966 the deposit rate ceilings were extended to saving and loan associations, but they were set higher for those institutions than for commercial banks. Commercial banks, on the other hand, had the major role in business and consumer credit but a limited one in mortgage lending. Deposit rate ceilings, applied to commercial banks by regulation Q since the 1930s, restricted the maximum interest rate which could be paid by commercial banks for time and saving deposits. Thus, saving and loan associations at first not subject to those restrictions and later subject to milder restrictions, were able to more efficiently raise funds for making mortgage loans than commercial banks were. In essence and mainly due to regulatory reasons, savings and loan associations and commercial banks were specialized in different segments of the lending market.

Another factor limiting competition in the mortgage markets was the existence of branching restrictions on both commercial banks as well as savings and loan associations. The National Banking Act of 1863 did not explicitly allow national banks to open new branches, which was interpreted by the Comptroller of the Currency's office as a prohibition. Moreover, laws in the majority of states prohibited any kind of branching whereas in the remaining ones only intracity branching was allowed. By 1924 only 12 states allowed statewide branch banking, but no state allowed the existence of any branches of banks based in the other states. This led to a formation of a national banking system consisting of unit banks with no nationwide branching. The national mortgage market became segmented by location, since the local saving and loan associations and commercial banks were isolated from the competition of their counterparts based in the other locations.

The subsequent two decades were described by major changes in the mortgage market. The sharp increase in market interest rates in the late 1970s made deposits subject to interest rate ceilings much less attractive relative to other financial instruments offering the market interest rate. This resulted in a substantial outflow of funds from commercial banks and savings and loan associations and questioned the viability of traditional deposit. In response in 1980 Congress passed a procedure of complete removal of deposit rate ceilings until 1986. Moreover, to make savings and loan associations more competitive and solvent, the Garn-St.Germain Depository Institutions Act was passed in 1982. Savings and loan associations were authorized to make commercial, corporate, business and agricultural loans, borrow money from the Federal Reserve, and to issue credit cards. In a deregulated environment with a range of new profit opportunities, a large number of new savings and loan associations appeared on the market and competition became more fierce. As it can be seen in Figure 1-Figure 5, increased competition led to a decrease in mortgage origination fees during 1982-1984. However, in an effort to take advantage of high interest rates and the increased range of activities, savings and loan associations made a lot of incompetent investments in risky and fraudulent ventures and lent much more money than they should have. As a result starting from 1985, the savings and loan industry found itself in a severe crisis and more than 1,000 savings and loan institutions failed and became insolvent.

Right after the crisis of the savings and loan industry, commercial banks started to increase their presence in the mortgage market at a very high rate. Between 1987 and 1997, the amount of outstanding mortgages by US commercial banks grew at an average annual rate of 10.6%, raising their share of the market from 13.4% to 19.8%. This happened due to several reasons. First, the increased popularity of commercial papers such as promissory notes, certificates of deposit, drafts, etc., in the 1980s and 1990s decreased the role of commercial banks in business and consumer credit. Due to the reduced cost of borrowing through the commercial papers, many firms and consumers were able to satisfy their borrowing needs without going to the bank. If in 1987 banks lent to non- financial firms \$7 for every \$1 these firms borrowed in the commercial paper market, by 1997 they lent only \$4 for every \$1. Apparently, commercial banks searched for a substitute for the lost business, and the crisis condition of the savings and loan industry made the mortgage market very attractive to them. Secondly, since the 1989, the Federal Home Loan Bank (FHLB) system became open to commercial banks. The FHLB system provides billions of dollars of primary liquidity to approximately 80% of the nation's financial institutions. Banks that join the FHLB receive access to a wide range of low-cost services, including various types of loans. The opportunity to join the FHLB and receive corresponding benefits has further boosted mortgage lending activities of commercial banks. Finally, in the late 1980s, many banking organizations acquired savings and loan associations with the purpose of expanding their retail activities. The rapidly increasing involvement of the large number of commercial banks increased the 62 competition and supply of funds in the mortgage market. This explains why mortgage origination fees did not rise very sharply in 1985-1987 and gradually decreased from the end of 1980s.

Another important development which further reinforced the competition and the supply of funds in the mortgage market was the evolvement of interstate nationwide banking because of the gradual removal of state branching restrictions. Table 7 contains the year of the removal of branching restrictions for each state. According to the table, from 1960 to 1979, sixteen states removed the branching restrictions, and from 1980 to 1999 thirty five states did so. Thus, in the 1980s and 1990s, competition in the majority of state-level mortgage markets became more intense since the banks and savings and loan associations were allowed to open new branches in the other states. Furthermore, in the states where branching restrictions were removed prior to 1987, this effect should have been the strongest since by the time commercial banks got actively involved in mortgage lending, they were already well established in those locations. The increased competition and supply of funds in the local markets further contributed to the downward trend in mortgage origination fees, which is evident from Figure 5-Figure 8.

Finally, one of the most important causes of the decrease in mortgage fees in the 1990s was the large number of innovations in the mortgage industry that increased the liquidity and decreased the riskiness of mortgage loans. The development of credit-scoring models has enabled quicker and more accurate evaluation of prospective borrowers. Securitization programs, which make possible the packaging and selling of loans to the secondary market have greatly improved the liquidity of mortgages. They can now be quickly moved out of bankers' balance sheets and are thus much less risky. Developments in information technologies have greatly reduced the mortgage origination costs incurred by the lenders. Due to the use of E-mail and fax machines, the time of assembling the information needed for an underwriting decision and sharing it with credit bureaus, title companies, appraisers, insurers, etc. has significantly decreased. Furthermore, the appearance of a "paperless" mortgage dramatically reduced the amount of time between closing the loan and securitization. These developments have considerably decreased the transaction costs of mortgage origination. Since mortgage origination fees charged by the lender should be based both on transaction costs as well as the riskiness of the loan, it is natural to expect that a decrease in risk and transaction costs should lead to a decrease in fees.

3.3 Econometric Model

The model employed in this research is a demand/supply model of housing prices, analogous to Jud and Winkler (2002). The demand for housing in the Metropolitan Statistical Area (MSA) j at time t is given by the following equation:

$$Q^D_{j,t} = D(P_{j,t}, F_{j,t}, Ij, t, Yj, t, Popj, t, UR_{j,t}, UC_{j,t}, W_t, u_{j,t}), \tag{126}$$

where P is the real price of housing, F are the mortgage origination fees (as a percentage of mortgage balance), I is the real mortgage interest rate, Y is the real income, Pop is the population, UR is the unemployment rate, UC is the user cost of housing, W is the real wealth (stock market wealth), and u is the random error. Market supply is defined by the following equation:

$$Q^S_{j,t} = S(P_{j,t}, CC_{j,t}, \upsilon_{j,t}), \tag{127}$$

where P is the real price of housing, CC is the real construction cost, and υ is the random error. By equating the demand and supply equations , one can derive the equation for the housing price:

$$P_{j,t} = f(F_{j,t}, Ij,t, Yj,t, Popj,t, UR_{j,t}, UC_{j,t}, W_t, CC_{j,t}, \varepsilon_{j,t}). \tag{128}$$

To insure stationarity, the data is first-differenced and before differencing, logarithmic transformation is applied to all the variables except mortgage fees, the unemployment rate, and the user cost (which are defined in terms of percentages). The stationary of each variable after the performed transformations is confirmed by Im-Pesaran-Shin stationarity test results presented in Table 8. After the described transformations, the following regression equation is derived:

$$\begin{aligned}\Delta \log P_{j,t} \quad = \quad & cosnt_j + \alpha_1 \Delta F_{j,t} + \alpha_2 \Delta I_{j,t} + \alpha_3 \Delta \log Y_{j,t} + \alpha_4 \Delta \log Pop_{j,t} + \\ & + \alpha_5 \Delta UR_{j,t} + \alpha_6 \Delta UC_{j,t} + \alpha_7 \Delta \log CC_{j,t} + \alpha_8 \Delta \log W_t + a_j + \eta_{j,t}, \end{aligned} \tag{129}$$

where a_j stands for the MSA fixed effects. The demand/supply framework with first differences allows a focus on short-run effects of the explanatory variables. Equation (129) is estimated by means of the fixed-effects estimation procedure. The standard errors of the coefficients are corrected for possible autocorrelation and heteroskedasticity in the data by means of the heteroscedasticity robust estimation and clustering by MSA. Since real wealth is time series but not panel variable, its stationarity was tested by means of the Dickey-Fuller test, which confirmed stationarity in terms of first difference in logs. and clustering by MSA. In addition to (129), the same specification supplemented by year dummies is estimated. This takes out the national time variation and allows separation of the MSA specific time variation. In this specification, dummy variables capture the effects of nationwide, only time varying variables, which drop out.

The expected sign of population, income, wealth and construction cost in these regressions is positive. While the first three variables are positively correlated with housing demand and consequently housing price, the construction cost is negatively correlated with housing supply. Lower housing supply resulting from higher construction costs should lead to higher housing prices and vice versa. The expected sign of mortgage fees according to the hypothesis is negative. The expected signs of user cost, unemployment rate and mortgage interest rate is also negative. The user cost represents the opportunity cost of owning housing stock. When the user cost decreases, the housing demand should increase and the housing price should go up as well. A high unemployment rate, on the other hand, indicates a recession in the economy and causes housing demand and the housing price to fall. The next section reports the results of estimations.

3.4 Data Description

The data set used for estimation covers 30 MSAs in the period from 1982 to 2003. The real price of housing is represented by the Housing Price Index (HPI) from the Office of Federal Housing Enterprize Oversight (OFHEO) deflated by MSA- specific CPI. MSA level CPI is available from the Bureau of Labor Statistics for 23 MSAs of the sample, and for the remaining ones the corresponding regional CPI is used. Mortgage fees are initial fees and charges on conventional mortgages available from the Monthly Interest Rate Survey of the Federal Housing Finance Board and measured as the percentage of mortgage balance. The real interest rate on mortgages is represented by contract interest rates from the Monthly Interest Rate Survey of Federal Housing Finance Board, which are adjusted for inflation using the MSA level CPIs.

Real income is measured by per capita personal income from the Bureau of Economic Analysis, adjusted by the corresponding CPI. MSA-level population is also reported by the

Bureau of Economic Analysis. The unemployment rate is taken from the local area unemployment statistics of the Bureau of Labor Statistics (BLS). Construction cost is represented by state level structure costs published by Lincoln Institute of Land Policy. These costs represent the replacement cost, after accounting for depreciation, of a typical owner-occupied housing structure for each state. These costs are turned into real construction costs through dividing them by corresponding CPIs from Bureau of Economic Analysis. The real stock market wealth variable constitutes the S&P 500 deflated by CPI-U. Finally, direct user cost from Galin(2004) is used as a measure of the user cost of housing. The formula for direct user cost is given by $C = (i + \tau^p)(1 - \tau^y) + \delta$, where i is the real interest rate, τ^p is the property tax, τ_y is the income tax and δ is the depreciation rate.

The long-term (10 years) US government bond yield from the IMF International Financial Statistics deflated by the local CPI is employed as the real interest rate. State property taxes are taken from Emrath (2002). The 1990 Census property taxes are used for the period 1980-1989 and 2000 Census property taxes are used for the remaining years. Finally, income taxes from the TAXSIM model of the National Bureau of Economic Research and $\delta = 0.025$ (Harding, Rosenthal and Sirmans, 2004) are used to calculate the user cost.

3.5 Empirical Results

The results of the regressions using Specification(1)- Specification(2) are presented in Table 9. Furthermore,Table 10 reports the coefficients and standard errors of year dummies from regression in Specification (2). All the standard errors are corrected for autocorrelation and heteroscedasticity. As expected, in both specifications the coefficient of initial fees and charges is statistically significant at the 5% level and negative. All the other variables also have the expected signs, and coefficients are mostly significant. In the benchmark specification, the coefficient of fees is -0.021 and t-statistics is - 2.33. Since the dependent variable is determined in terms of difference in logs and fees are determined in terms of difference in levels, this is a log-level specification. Consequently, a decrease in mortgage origination by 1 percentage point leads to an increase in housing prices by 100*0.021 = 2.1 percent. In contrast to Poterba (1991), in my data set the user cost has a significant negative effect on housing prices. The unemployment rate has the expected sign and the statistical significance in specification with year dummies is included. Mortgage interest rates are significant in the regression without year dummies but lose their significance in specifications with year dummies, which is due to the fact that they do not vary much across MSAs. Moving towards a more general specification decreases the coefficient on fees to -0.014 in Specification(2), but still leaves it statistically significant at the 5% level, which demonstrates the robustness of the observed effect of fees on housing prices.

The observed results allow us to conclude that the negative change in mortgage origination fees has a positive effect on housing price changes. However, in the previous regressions the possibility of a lagged effect of fees is not explored. Another point is that other explanatory variables can also have a lagged effect on housing prices. Thus, in Table 11, the results of the regressions allowing lagged adjustments of explanatory variables, are displayed. The results indicate significant lagged effects of initial fees and charges in specification (1)-(2). It is possible to conclude from the observed results that a lagged effect of fees on housing prices is present in the data. The regression also indicate lagged effect of the user cost, the unemployment rate, the construction cost, and the S&P 500. The statistical significance of fees, however, remains robust to the inclusion of relevant lags of other explanatory variables.

Since both current as well as lagged fees have a statistically significant effect on the housing price, the same specifications but with two year-moving averages are also estimated. In specification (1) the coefficient on the moving average of fees is given by -0.038, and in specification (2) it is given by -0.029 . In both cases, the moving average of fees becomes significant even at the 1% level.

3.6 Endogeneity Issues and IV Estimations

In the previous sections, it was argued that changes in mortgage origination fees were mainly driven by the increase in the supply of mortgages due to reasons exogenous to the housing market, and the effects of exogenous variation in fees on the housing prices were quantified. Observing the dynamics of fees and housing prices, one can conclude that supply side factors were more significant since the supply story of the mortgage market is consistent with falling mortgage fees and rising housing prices.

However, an alternative story can also be considered. Suppose that due to some reasons (for instance growth of the population in a given location or income growth), demand for housing increases. On the one hand, this generates an increase in the housing price, but on the other hand, it increases the demand for mortgages and drives up the mortgage origination fees. This causes simultaneity in housing prices and mortgages fees and creates a bias in coefficient of fees. In this case, variation in fees is endogenous to the housing market.

To prove the validity of the previous arguments about the exogeneity of fees and reject the alternative story, the endogeneity of fees is tested for, using the endogeneity test equivalent to the Hausman specification test. The algorithm of the endogeneity test is the following: the suspected variable is regressed on all instrumental variables and exogenous variables; the residuals from this regression are obtained; the obtained residuals are added to the housing price equation, and the significance of residuals in the housing price regression is tested for by means of a t-test. If the residuals are statistically different from zero, the variable is endogenous. One of the instruments for mortgage fees is generated based on the change in branching restrictions. Intuitively, the removal of branching restrictions on commercial banks and savings and loan associations allows them to expand geographically, which increases the availability of mortgages and competition in each location and decreases the mortgage fees. Using Table 7, which reports the year when branching restrictions were removed in each state, the corresponding dummy variable is generated. This variable takes value 0 for each year when the state to which the given MSA belongs had branching restrictions and value

1 for the year when branching restrictions were and all the subsequent years. The results of instrumenting regressions in which lags of independent variables are included together with a branching dummy, are reported in Table 12. It demonstrates that mortgage fees are strongly correlated with the branching dummy, lag of fees, and lag of income. Consequently, these variables are used as instruments. The t-statistics of the residuals' coefficient in the housing price regression is 1.09 (Table 15), which implies that there is no evidence of endogenous variation in fees; thus previous arguments on exogeneity are confirmed.

The same procedure as described above is employed for testing the endogeneity of the remaining explanatory variables. The results of instrumenting regressions for mortgage interest rates and income (variables found endogenous) are reported in Table 13-Table 14. Based on these regressions, first lags of explanatory variables are used as instruments. The t-ratios for the corresponding residuals are reported in Table 15. The results indicate that interest rates and income are endogenous since the corresponding residuals are statistically significant. Thus, these variables need to be instrumented. The results of IV regressions in Specification(1)-Specification(2) are reported in Table 16. It can be seen from Table 16 that coefficients of mortgage fees are not changed much and are still negative and statistically significant.

3.7 Summary

This paper explores the effects of changes in mortgage origination fees on housing prices. It identifies the major supply side factors on the mortgage market, which have driven a sharp decline in mortgage fees during the last two decades. Using the reasoning that observed supply side changes in the mortgage market are exogenous to the housing market, the effect of mortgage origination fees on housing prices is quantified. The most general set of regressors employed in the previous housing price literature is used together with different econometric speci.cations, including ones allowing for lagged adjustment in independent variables. The results demonstrate that negative changes in mortgage origination fees have a statistically signi.cant positive effect on housing prices. The instrumental variable approach is also used to prove the robustness of the results to endogeneity issues. It is shown that in the case of accounting for possible endogenous variation in mortgage fees and other explanatory variables, the negative effect of fees on housing prices remains significant.

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3.8 Figures

Figure 5: Dynamics of initial fees and charges for conventional mortgages in the US

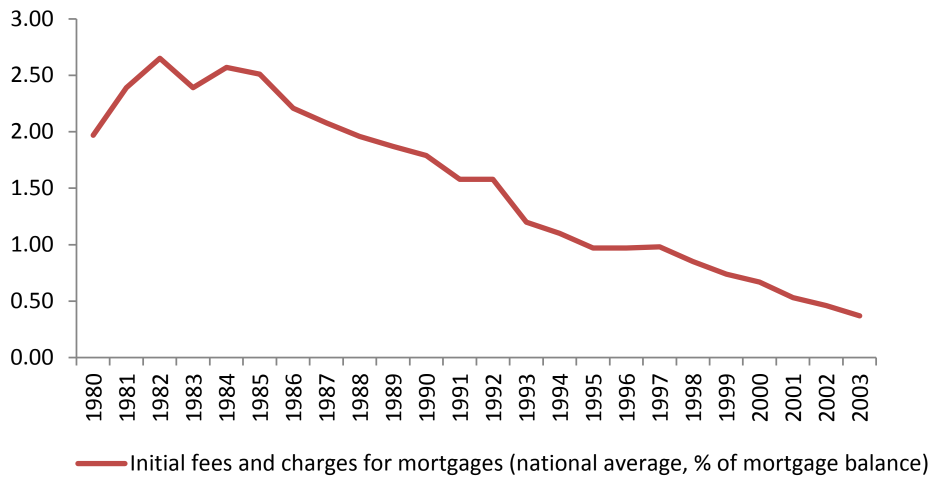


Figure 6: Dynamics of initial fees and charges in individual MSAs 1/3

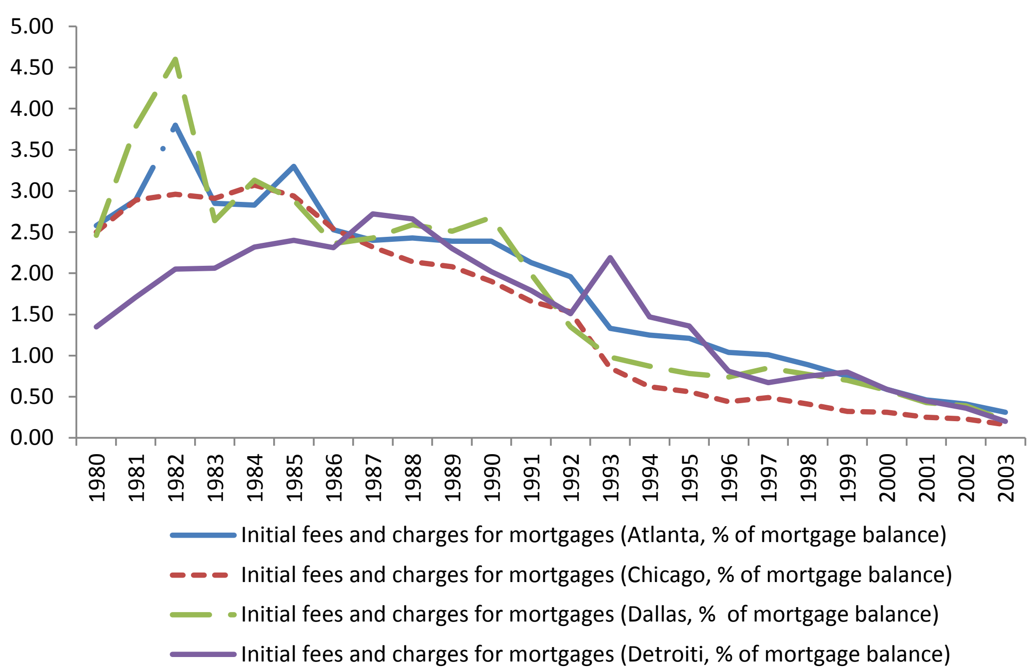


Figure 7: Dynamics of initial fees and charges in inidividual MSAs 2/3

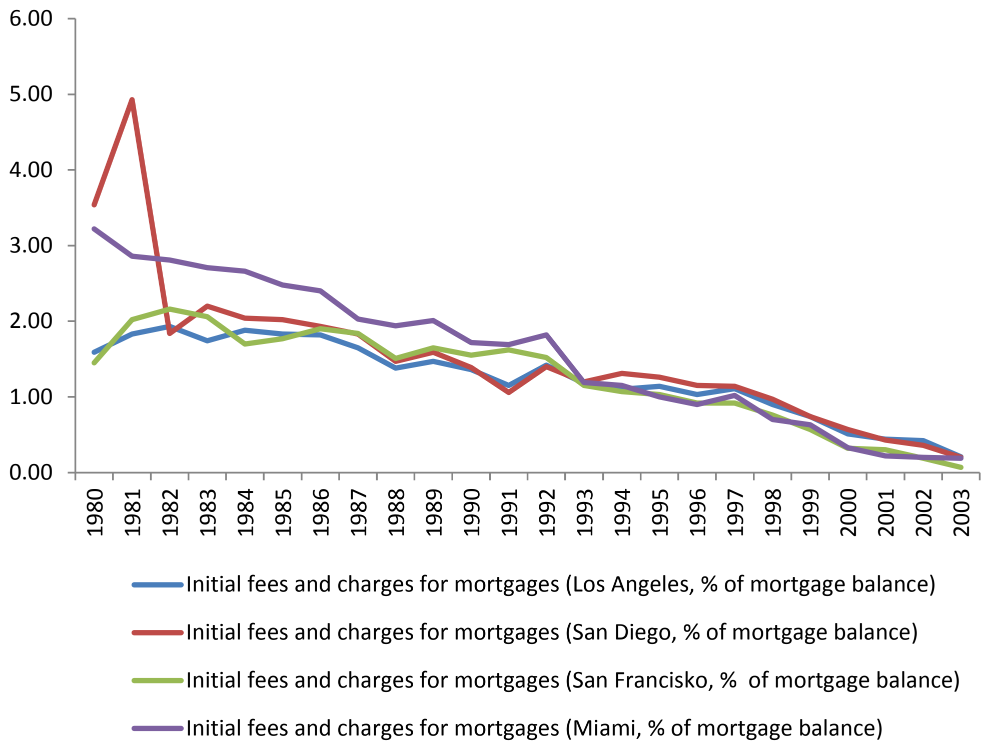


Figure 8: Dynamics of initial fees and charges in individual MSAs 3/3

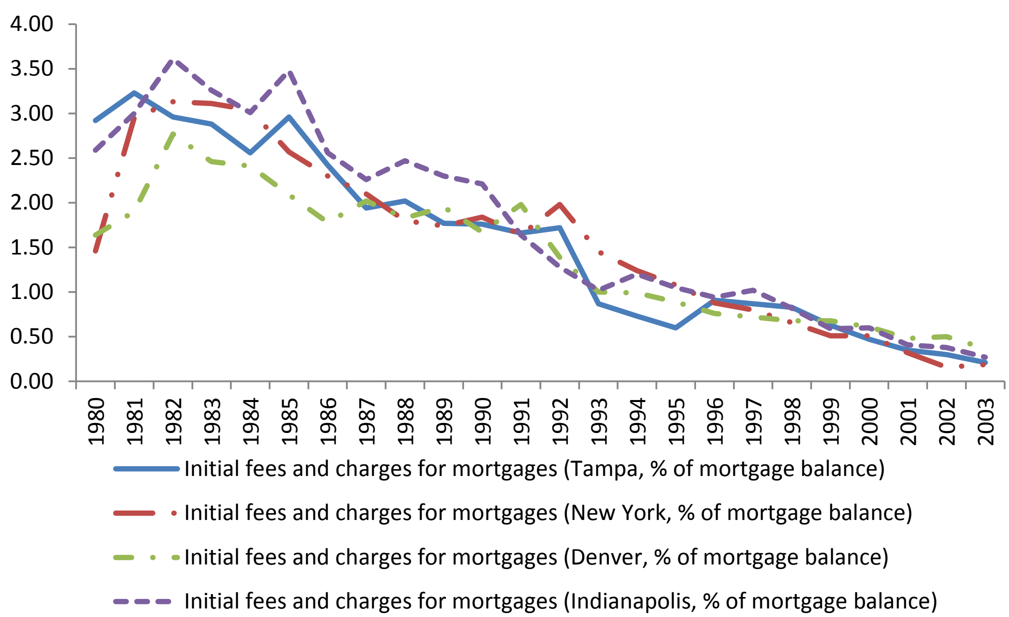


Figure 9: Dynamics of initial fees and charges in inidividual MSAs 2/3

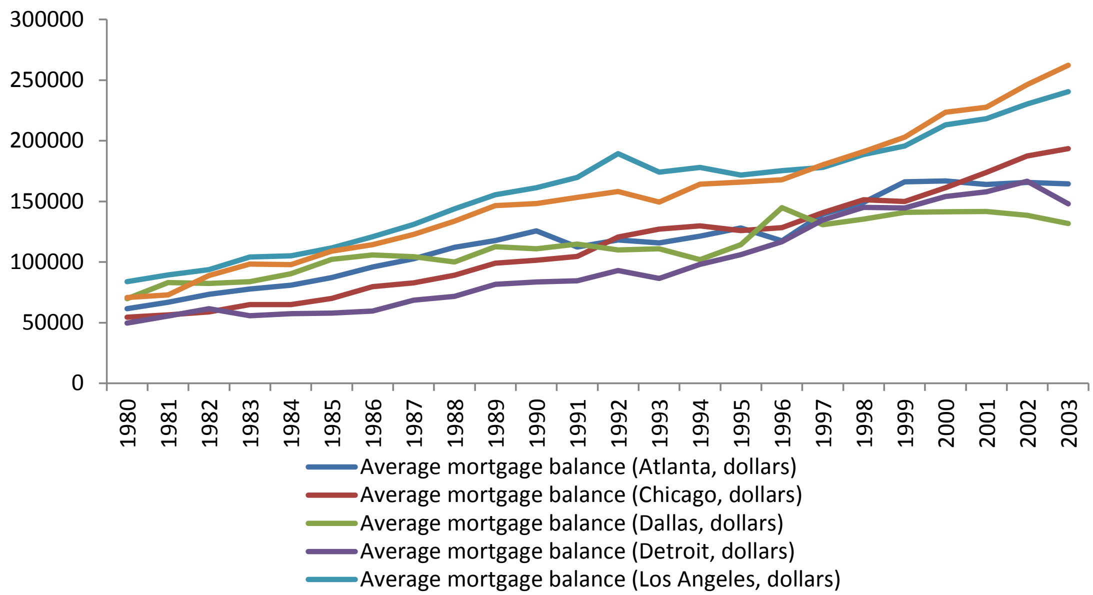
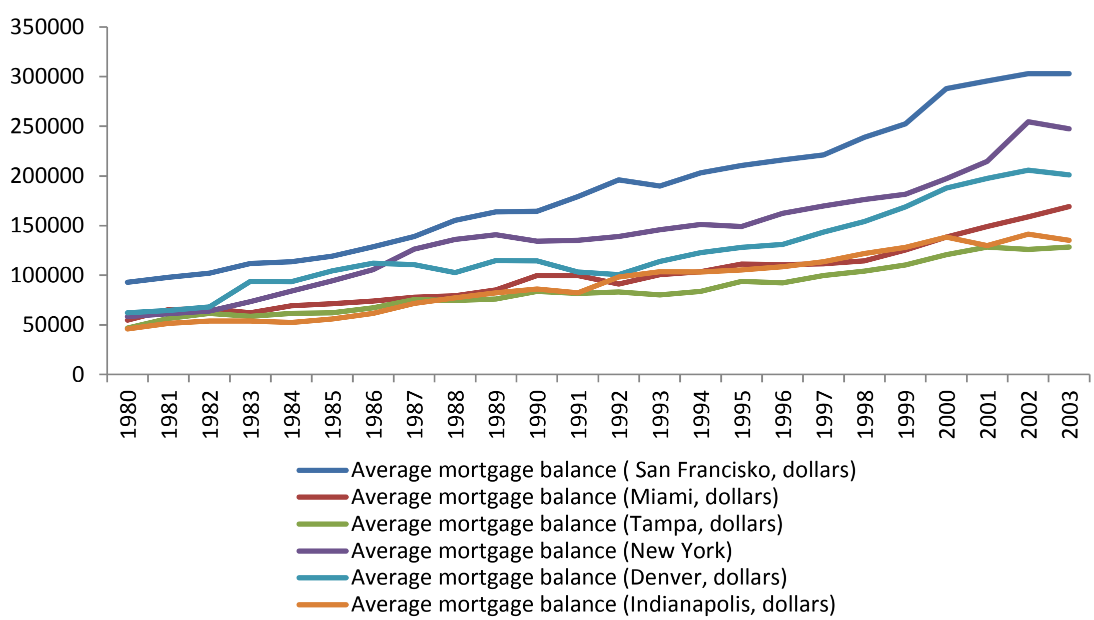


Figure 10: Dynamics of initial fees and charges in individual MSAs 3/3



3.9 Tables

Table 7: Year when branching restrictions were removed

State	Year of removal	State	Year of removal
Alabama	1981	Missouri	1990
Alaska	1960	Montana	1990
Arizona	1960	Nebraska	1985
Arkanzas	1994	Nevada	1960
California	1960	New Hampshire	1987
Colorado	1991	New Jersey	1977
Connecticut	1980	New Mexico	1991
District of Columbia	1960	New York	1976
Florida	1988	North Carolina	1960
Georgia	1983	North Dakota	1987
Hawaii	1986	Ohio	1979
Idaho	1960	Oklahoma	1988
Illinois	1988	Oregon	1985
Indiana	1989	Pennsylvania	1982
Iowa	1999	Rhode Island	1960
Kansas	1987	South Carolina	1960
Kentucky	1990	Tennessee	1985
Louisiana	1980	Texas	1988
Maine	1975	Utah	1981
Maryland	1960	Vermont	1970
Massachusetts	1987	Virginia	1978
Michigan	1984	Washington	1985
Minnesota	1993	West Virginia	1987
Mississippi	1986	Wisconsin	1990

Source: Beck, Levin, Levkov(2007)

Table 8: Stationarity test results (Im-Pesaran-Shin unit root test in the presence of cross-sectional dependence, version with constant and trend)

Variable	Transformation	t-statistics	Cv. 10%	Cv. 5%	Cv. 1%
Price Index	first difference in logs	-2.872	-2.580	-2.670	-2.830
Fees	first difference in levels	-3.775	-2.580	-2.670	-2.830
Income	first difference in logs	-2.792	-2.580	-2.670	-2.830
Population	first difference in logs	-2.859	-2.580	-2.670	-2.830
User cost	first difference in levels	-3.095	-2.580	-2.670	-2.830
Unempl. rate	first difference in levels	-2.751	-2.580	-2.670	-2.830
Mortgage rate	first difference in levels	- 3.898	-2.580	-2.670	-2.830
Construction cost	first difference in logs	-3.228	-2.580	-2.670	-2.830

Notes: Under null hypothesis, the series is non-stationary. Cv. stands for critical value. Real wealth variable is a time series variable, so its stationarity was tested by means of Dickey-Fuller test.

Table 9: Relationship between mortgage origination fees and housing prices: Fixed effects estimation

	I	F	Y	Pop	UC	UR	CC	W	const.	R squared
			Specification(1)							
Coef.	-0.039	-0.021	0.499	2.314	-0.451	-0.007	0.525	0.035	- 0.010	63
Standard error	0.017	0.009	0.127	0.485	0.133	0.003	0.149	0.015	0.009	
Significance	**	**	***	***	***	**	***	**	-	
		Specification(2)(with year dummies)								
Coef.	-0.028	-0.013	0.982	2.052	-0.312	- 0.005	0.414	-	- 0.097	69
Standard error	0.037	0.005	0.215	0.514	0.135	-0.002	0.178	-	0.025	
Significance	-	**	***	***	**	**	**	-	**	
Number of observations	630									

Note:In Specification(2), year dummies are included. Since there is a constant in the regression, year dummies start from the year 1984 (1 year of observations is lost before the estimation due to first differencing). Standard errors are displayed in parentheses. The dependent variable is the housing price index (first difference in logs), estimated using fixed effects estimation (dif-in-dif estimator). Clustering by MSA and heteroskedasticity robust estimation (White's standard errors) is used to account for potential heteroskedasticity and autocorrelation in the data.
*, ** and *** denote significance at correspondingly 10%, 5% and 1% level

Table 10: Year dummies coefficients from the regression in Specification (2)

Year dummy	Coefficient	Standard Error
1984	1.485	0.541
1985	1.515	1.112
1986	2.352	0.835
1987	2.115	0.744
1988	2.288	0.805
1989	2.175	0.882
1990	1.382	0.915
1991	1.412	0.720
1992	1.208	0.814
1993	1.617	0.671
1994	1.445	1.014
1995	1.263	0.919
1996	2.049	0.630
1997	2.112	0.831
1998	1.719	0.622
1999	1.380	0.519
2000	1.844	0.644
2001	- 1.808	0.652
2002	2.418	0.741
2003	2.127	0.816

Table 11: Relationship between mortgage origination fees and housing prices in the case of allowing for a lagged adjustment in the independent variables: Fixed effects estimation

	I	F	lag F	Y	Pop	UC	UR	CC	W	const.	R squared
	Specification(1)										
Coef.	-0.051	-0.018	-0.024	0.687	1.577	-0.650	-0.003	0.458	0.048	0.013	67
Standard error	0.022	0.007	0.010	0.118	0.418	0.170	0.002	0.183	0.012	0.011	
Significance	**	**	**	***	***	***	-	**	***	-	
	Specification(2)(with year dummies)										
Coef.	-0.043	-0.011	-0.017	0.757	1.396	-0.441	- 0.005	0.393	-	- 0.115	72
Standard error	0.039	0.005	0.007	0.185	0.507	0.199	0.003	0.124	-	0.020	
Significance	-	**	**	***	**	**	-	**	-	-	
Number of observations	600										

Note: *, ** and *** denote significance at correspondingly 10%, 5% and 1% level

Table 12: Instrumenting regression for fees

Variable	Coefficient	Standard Error
Branching dummy	-0.049	0.018
Lag of I	-0.037	0.106
Lag of F	- 0.177	0.54
Lag of Pop	-1.396	1.478
Lag of Y	0.812	0.475
Lag of UC	0.590	0.885
Lag of UR	-0.005	0.012
Lag of CC	1.453	0.788
Lag of S&P 500	0.058	0.083
Constant	-0.162	0.035
Number of observations	600	

Table 13: Instrumenting regression for mortgage interest rates

Variable	Coefficient	Standard Error
Branching dummy	-0.033	0.016
Lag of I	-0.195	0.028
Lag of F	-0.013	0.006
Lag of Pop	-0.838	0.315
Lag of Y	0.08	0.003
Lag of UC	0.035	0.148
Lag of UR	-0.028	0.007
Lag of CC	3.029	0.688
Lag of S&P 500	0.025	0.087
Constant	-0.255	0.092
Number of observations	600	

Table 14: Instrumenting regression for income

Variable	Coefficient	Standard Error
Branching dummy	-0.011	0.005
Lag of I	-0.016	0.008
Lag of F	- 0.542	0.387
Lag of Pop	- 0.838	0.309
Lag of Y	0.865	0.205
Lag of UC	-0.033	0.015
Lag of UR	-0.057	0.024
Lag of CC	1.245	0.730
Lag of S&P 500	0.182	0.083
Constant	-0.036	0.125
Number of observations	600	

Table 15: Results of endogeneity tests

Tested Variable	Coefficient of residuals	Standard error	t-statistics
Fees	0.029	0.027	1.09
Population	-1.106	0.723	-1.53
Income	0.636	0.236	2.69
Mortgage rate	0.130	0.059	2.20
User cost	-0.194	0.400	-0.49
Unemployment rate	-0.018	0.015	-1.17
Construction cost	0.816	0.552	1.47
S&P 500	0.357	0.256	1.34

Notes: This table reports the results of endogeneity tests. Each variable is regressed on the instruments and exogenous variables. The residuals from these regressions are obtained and incorporated into the housing price regression in the most general speci.cation. The coefficients and standard errors of the residuals in the housing price regression are reported in the table. The lags of all explanatory variables as well as the branching dummy are used as instruments for endogeneity tests. For each variable, the relevant lags which are strongly correlated with the tested variable, are used. The correlation was checked by means of corresponding regressions. Instrumenting regressions for mortgage fees, which is the key variable of interest as well as for income and mortgage interest rates, which are found to be endogenous, are presented above in Table 12 - Table 14.

Table 16: Relationship between mortgage origination fees and housing prices: Fixed effects estimation

	I	F	Y	Pop	UC	UR	CC	W	const.	R squared
			Specification(1)							
Coef.	-0.049	-0.019	0.904	1.875	-0.182	-0.003	0.348	0.042	- 0.017	66
Standard error	0.022	0.007	0.292	0.519	0.096	0.0012	0.131	0.019	0.011	
Significance	**	**	***	***	*	**	**	**	-	
			Specification(2)(with year dummies)							
Coef.	-0.043	-0.025	0.357	2.285	-0.325	- 0.007	0.481	-	- 0.023	70
Standard error	0.028	0.011	0.123	0.745	0.114	0.003	0.125	-	0.015	
Significance	-	**	***	***	**	**	***	-	-	
Number of observations	630									

Note: Fixed effects 2 SLS regression, interest rate and income are the instrumented variables; lags of explanatory variables and branchuing dummy are used as instruments.
*, ** and *** denote significance at correspondingly 10%, 5% and 1% level

4 Chapter 4

Rent deregulation, tenure choice, and real estate price expectations

(joint with Petr Zemcik)

Abstract

We study a natural experiment in the Czech Republic where the maximum regulated rent appreciation has depended explicitly on the price of real estate since 2007. We track the tenure choice of households from consumption surveys for subsequent years. Rent deregulation makes households in regulated apartments more likely to own real estate while the opposite is true for other renters and owners. The net present value of buying property vs. renting is an increasing function of the real estate price appreciation for renters in regulated apartments. We use their tenure choice to generate the distribution of property price expectations.

KEY WORDS: Czech Republic, expectations, rent regulation and deregulation; real estate prices, tenure choice
JEL CLASSIFICATION: C25, R21, R3

4.1 Introduction

A large number of rental markets are characterized by a certain degree of rent regulation. A simple non-targeted rent regulation consists of setting upward ceilings on the rent level. This type of rent regulation was common prior to the year 2000 in many countries of Central and Eastern Europe. After 2000, some countries such as Bulgaria and Estonia abandoned the practice and others, such as Poland, significantly reformed this policy. The Czech Republic was slow to follow this trend and introduced its plan for rent deregulation only in 2006, two years after it joined the European Union (EU). The plan aimed to reach a target rent given by 5% of the market real estate price by 2010; after 2010, rents would be completely deregulated. Prior to 2010, a law set the maximum annual appreciation for regulated rents, which explicitly depended on the market property price. This feature makes it very convenient to investigate the impact of the deregulation process on the tenure choice of households and enables us to deduce real estate price expectations of households living in rent-regulated apartments based on their choice between renting and owning.

Using mainly theoretical arguments and data on housing units, rent regulation has been shown to have both adverse and positive effects.[6] Under pressure from the European Union, Czech executive and legislative powers started the process of deregulation. This implied a tacit acceptance that the negative effects of rent regulation in the Czech Republic were greater than the positive effects. While the impact of various types of deregulation has been

[6]Rent regulation affects real estate vacancies, household welfare, mobility and housing affordability. Moon and Rapoport (1997) use longitudinal Housing and Survey data from New York and find that a rent-controlled apartment is less likely to be vacant. Annas (1997) shows that rent regulation welfare improvements over laissez-faire only occur if gains from centralized matching can offset the decrease in housing quality, the possible increase in waiting times, and the risks of rationing induced by rent controls. Raess and Von Ungern-Sternberg (2002) study the impact of tenancy rent control for short-term contracts, which limits the owners' possibilities to increase rents for a certain number of years. This type of rent control leads to lower equilibrium rents and higher social welfare. Munch and Svarer (2001) find that the presence of rent regulation on the private Danish housing market negatively affects a household's mobility. Simmons-Mosley and Malpezzi (2006) use panel data from the New York City Housing and Vacancy Survey and find a significant impact of benefits of lowered rent and costs of distortions in housing consumption on mobility. The costs are larger than the benefits. Lux (2001) compares the development of the social housing sector in the Czech Republic, Poland and Slovakia during the 1990s and concludes that maintenance of non-targeted rent regulation in the Czech Republic and Slovakia worsened the affordability of housing for low-income households.

studied,[7] the Czech process is distinctive because of its simple design, explicit consideration of the market real estate price, and nationwide coverage. Moreover, the impact of sequential rent deregulation can be analyzed ex-post thanks to the availability of household level data.

Our primary focus is on how rent deregulation affects the tenure choice of households, i.e., the decision to own vs. to rent. This aspect of deregulation has been neglected in the literature. We quantify the degree of deregulation in two ways, depending on the current status of a household. If the household rents a regulated apartment, the maximum annual rent appreciation serves as a measure of deregulation. An increase in rental costs implies either the necessity to pay higher rent closer to free market rent or to switch to owning instead of renting. If the household currently pays market rent or owns its dwelling, our measure of deregulation is the ratio of the number of regulated apartments to the number of all rented apartments. This measure reflects the anticipation that previously regulated housing units would soon increase the supply of unrestricted rental housing. Lux and Sunega (2003) show that this would lead to a decrease of free market rents in the Czech Republic. Lower market rents should translate into a lower likelihood of being an owner in the next period.

We further control for standard household characteristics such as income, age, education, and size, and also consider two additional variables of interest. The first is the interest rate calculated by approximating output from a mortgage calculator. The second is the real estate price prevailing in the household's location. Li and Yao (2005) build a life-cycle model to show that higher property prices reduce the welfare of renters and increase the welfare of older owners. We concentrate on changes in the probability of owning due to changes in

[7] Roistacher (1992) analyzes three possible forms of partial rent deregulation on the New York City rental market: income-targeted decontrol, high-rent decontrol and vacancy decontrol. She finds that a combination of income-targeted decontrol and vacancy decontrol seems the best option for reforming New York City's rent regulation system and would generate substantial new taxable rental income. Van der Klaauw and Kock (1999) develop a static partial equilibrium model to investigate deregulation of the Dutch housing market on private market prices and allocations of houses among households. They focus on three regulation measures: individual rent, supporting social housing projects, and social rules for owner-occupied houses. They conclude that there are potential welfare gains as a result of simultaneous deregulation of the owner occupied and the rental segments of the Dutch housing market.

property prices.

We employ a unique dataset for Czech households. It is based on a series of budgetary surveys in a rotating sample where only some 25% of households are replaced each year. By using this feature of the data, we can follow a particular household for two years in a row and see if its status remained the same or changed during this period: renters living in regulated apartments can become owners or renters for market rent; renters paying market rent can become owners; and owners can become renters on the free rental market. We record the tenure choice between years t and $t+1$ and construct datasets for periods 2005-6, 2006-7, and 2007-8, respectively. This approach differs from the prevailing cross-sectional analysis. For example, Beck, Kibuuka, and Tiongson (2010) employ data from the European Union Statistics on Income and Living Conditions (SILC). This is a series of cross-sections between 2005-2007 from old and new member countries of the EU.[8] This study finds it difficult to explain households' tenure choice, which may be due to the inability to follow households over time. In contrast, our data enables us to see actual choices made by households. The effect of rent deregulation on tenure choice is analyzed using standard models of limited dependent variables. Our results demonstrate that appreciating regulated rents make households living in regulated apartments seek other alternatives more frequently. As expected, increasing regulated rents decrease the probability of owning for renters on the unregulated market. Rent deregulation makes current owners more likely to sell their apartment and to rent since the market rent is expected to decrease.

In the next step, we exploit the specific nature of the Czech deregulation law to characterize real estate price expectations for households living in apartments with regulated rents. For these households, the present value of renting depends on the growth rate of regulated rents, which in turn depends explicitly on property prices. The only source of uncertainty is the price process. A similar scenario holds for the present value of property purchase, which takes into account the fact that property can be sold in the future. Households in

[8]Note that the SILC data are collected in the Czech Republic as well, in parallel with the sample used in this paper.

regulated apartments compare the present value of owning with the present value of renting a regulated apartment. Using the fact that regulated rents explicitly take into account real estate prices, and assuming that these follow an AR(1) process, we solve for the real estate price appreciation, which makes households indifferent between an apartment purchase and renting. This appreciation is the upper bound for expectations of the households which remained renters and the lower bound for households which did not. The distributional characteristics of the price appreciation are more realistic when we assume that households mainly consider holding their potentially acquired property until a mortgage is paid off. The implied upper bound for expected real estate price growth was on average 1.8% in 2006-7 and 2.3% in 2007-8. The implied lower bound was on average 2.2% in the same two sub-periods. This indicates that household expectations were fairly realistic at the time, showing no signs of irrationality.

Research papers which explicitly deduce or survey expectations regarding real estate prices are scarce. Two exceptions close to our study are Case and Shiller (2004) and Clayton (1997). The former paper includes a survey of real estate price expectations of recent home buyers in four US counties and finds unrealistically high expected annual rates of growth for real estate prices.

The selection in Case and Shiller (2004) consists of households which recently purchased real estate property. In our case, we focus on renters living in apartments with regulated rents and distinguish between those who opted for owning and those who did not. Clayton (1997) focuses on the implications of the present value model, which resembles our approach. He shows that there is a negative correlation between an ex-post house price appreciation and the forecast of risk-neutral agents, which rejects the null hypothesis of rational expectations. Unlike us, Clayton (1997) uses data on condominiums in the Vancouver metropolitan area rather than on households.

The rest of the paper is organized as follows. Section 4.2 describes the evolution of rent regulation in the Czech Republic, section 4.3 describes the data used, and section 4.4

formulates an econometric model for tenure choice and discusses empirical results. Section 4.5 deduces real estate price expectations and section 4.6 concludes.

4.2 Regulation of Rents in the Czech Republic

In the Czech Republic, the permanent right to live in an apartment with low regulated rents was established in the 1980s. This right cannot be rescinded and can be passed only to a family member. It applies to a particular apartment, which makes it very hard to evict current tenants. Such a regulation has made part of the housing stock inaccessible for new tenants and has created a shortage of rental housing, since regulated apartments constitute around 80% of the housing stock on the rental market. As a result, free market rents have rapidly appreciated and a substantial gap has appeared between them and the regulated rents. The presence of two distinct segments of rental housing with considerably differing rents appears unjust from the social perspective and has generated public concern. Moreover, since regulated rents explicitly depend only on location and size of the dwelling, and the right to live in a regulated rent apartment was assigned 20 years ago, in many cases regulated rents do not reflect the social status and income of the tenants (see Lux, Sunega, Kostelecký, and Čermák 2003).

Many municipal regulated apartments were either returned to their original owners in the restitution process during the 1990s or were sold to private owners in the early 2000s. The low level of regulated rents, however, did not allow the owners to cover maintenance costs. In the early 2000s, the Czech Constitutional Court ruled in favor of owners on a number of occasions. In its decisions, the Court approved that an owner was allowed to find a compensatory rental apartment for the tenant, with a rent corresponding to the free rental market level. The main justification for these decisions was the outdated nature of a regulation based on the Ministry of Finance Bill 176 from 1993. The Czech government repeatedly attempted to legally reinstate this old regulation via formally new legislation, trying to sidestep the rulings of the Czech Constitutional Court. The Ministry of Finance for example, tried to freeze rent levels via a Bill 567 in 2002, which was also struck down by the Constitutional Court. The position of the Czech government was later affected by the international case Hutten-Czapska vs Poland, which was heard at the European Court of Human Rights in Strasbourg. The plaintiff claimed the right to collect a rent sufficient to at least cover the costs related to real estate. This case ended in 2008 with a friendly settlement. In light of this court case and due to rising public concern about the consequences of rent regulation, the Act 107 of Unilateral Rent Increase was proposed and approved in 2006. The Act specified a gradual increase of in regulated rent from 2007 to 2010.

One of the most important features of Act 107 was that the regulated rent level and rent appreciation rates became explicitly dependent on actual apartment prices. These prices reflected apartment price indices calculated by the Czech Statistical Office (CSO) based on transaction real estate prices, which were available from the Ministry of Finance.[9] This played a crucial role in the subsequent evolution of regulated rents since starting from 2006, the housing price appreciation rate in the Czech Republic increased considerably (see Figure 11). This led to an increase in regulated rents and a reduction in the gap between free market rents and regulated rents. This is likely to have had an immediate effect on the tenure choice of households living in regulated apartments since the cost of staying in those apartments was now greater. Indirectly, there should be an impact on other types of households as well.

The Act specifies the target rent and the maximum annual percentage increase for the years 2007-2010. Specifically, the target regulated rent is given by

$$T_t = \frac{1}{12}\, c\, P_t, \tag{130}$$

, where T_t is the regulated monthly rent in Czech koruna per 1 m.^{2}; c is the coefficient reflecting the ratio of the annual rent to the price for a given apartment ($c = 0.05$ for apartments of higher quality, previously referred to in the Czech Republic as apartments of the 1st and 2nd categories. $c = 0.045$ for apartments with lower quality, i.e. apartments

[9] The Ministry of Finance collects this information because there is a 3% sales tax on real estate.

of the 3rd and 4th categories in the previous classification). P_t is the price per 1 m^2, which is published by the Czech Ministry for Regional Development. The maximum annual percentage increase is calculated as

$$M_{t+w} = 100\,((T_{t+w-1}/R_{t+w-1})^{\frac{1}{4-w+1}} - 1), \tag{131}$$

where $w = 1$ for 2007, 2 for 2008, 3 for 2009, and 4 for 2010, respectively. R_{t+w-1} is the regulated rent at time $(t + w - 1)$. The formula is constructed to make the regulated rent equal to the target rent in 2011, assuming that the real estate price does not change.

4.3 Data

The data used in this paper are extracted from Family Accounts of the Czech Household Budget Survey for the years 2005-2008. This survey includes 3200+ households each year; 71-78% of the sample remains the same - see Table 17 for details. This feature makes it different from the EU-Statistics on Income and Living Conditions, which is a series of cross-sections with a random sample drawn each year. The fact that only up to 1/4 of the sample of households are replaced enables us to record households' tenure choice between years t and t+1. The consumption survey data is complemented by real estate prices from the Czech Statistical Office, which is also published by the Czech Ministry of Regional Development.

Information about the type of rental apartment has been available only since 2006. In 2005, we had to separate households living in apartments with regulated vs. unregulated rents based on a comparison of reported rents with market rents from the Institute of Regional Information in Brno. Actual rents, significantly lower than market rents, corresponded to regulated apartments. However, in smaller cities the regulated rents were fairly close to market rents, and we could not decide to which group we should assign a given household. We therefore excluded these households from our 2005-2006 sample. Table 17 characterizes the sub-samples by the ownership type of the households. Of the sample, 21-23% represent renters, and from this number on average about 81-84% are renters in apartments with regulated rent. The rest of the sample are owners. The number of households is somewhat reduced in the last sub-period due to a coding change in one of the regions, which made it harder for us to identify households remaining in the sample. Note that households in apartments with regulated rents can, in addition, switch to renting apartments for the market rent. This can occur if they cannot afford the regulated rent and do not have sufficient income and/or savings to purchase their own property. They are also not likely to qualify for a mortgage, especially if they are already retired. The ratio of households switching to owning among renters in regulated apartments increases from 5% for the period 2005-6 to 14% in 2006-7. This illustrates that Act 107 had an immediate impact on tenure choice. The ratio of households moving from regulated to unregulated apartments is very small:1-2 %. Only 2-3% of owners become renters again. Two-year panels are constructed for each group. For example, we use the data on households living in apartments with regulated rents in 2005, which also remained in the sample in 2006. A similar approach is used for the other groups and the remaining years.

We make use of a number of variables characterizing each household. The first group includes income per person, age and education of the household head, and the number of household members. The remaining variables are related to real estate: mortgage interest rate, regional real estate price, maximum regulated rent appreciation for households paying regulated rent, and the percentage of regulated apartments on the regional rental market for households paying the market rent. Table 18 provides summary statistics for renters and Table 19 for owners. The monthly income per household member in Czech crowns (Kč) is always higher for households in regulated rental apartments than for households in unregulated ones, which confirms that rent regulation does not help poorer households as initially intended. Households in regulated apartments are also somewhat older and slightly more educated as compared to the other renters. Owners have on average the highest income and age from all considered groups. The number of household members is a proxy for needed space and/or a measure of the need for stability attached to ownership.[10] The first five

[10]In addition, we have considered the so-called family structure, which is the number of children per number of employed adults. This can be viewed as endogenous and we therefore opted simply for the

variables measure the ability of a household to accumulate the necessary wealth to purchase real estate and/or to qualify for a mortgage. Similarly to other countries, banks in the Czech Republic provide mortgages in two steps. In the first step, the size of the maximum mortgage loan is determined. This depends on how much a household can afford to pay monthly, which is the amount that a household has left after income is spent on standard consumption. Each bank uses a slightly different definition of this standard consumption, but it is always above a legally given minimum.

The second step in the mortgage approval process is setting the interest rate. As a basis for interest rate determination, we consider the mortgage calculator of the bank CSOB at www.csob.cz. There are only two determinants of the interest rates implicitly embedded in this calculator: the loan-to-value ratio (LTVR) and the fixation period for the interest rate. The maturity of the loan only matters if it changes jointly with the fixation period. In October 2010, the interest rate was 4.49 for LTVR ≤ 0.85 and 5.69 for for LTVR > 0.85. We implement this rule in our sample as follows. We assume that a household would be interested in buying an apartment of the same size and in the same location as its current rented apartment. We calculate the value of this apartment simply by multiplying its footage by the price per m^2 from the Czech Statistical Office. We subtract available savings for each household from the apartment's value and compute LTVR. This LTVR translates into a mortgage interest rate for each household. If the household has sufficient savings to purchase real estate without a need for the loan, we set the corresponding mortgage rate to zero. The calculator gives us an interest rate only for the year 2010. For example, a data point for a household from 2006 is used to get the interest rate, which would be charged for a household with the same characteristics in 2010. Clearly, the macroeconomic conditions are different in 2010 as compared to other years. To account for this change, we compute the difference of the mean mortgage interest rate for 1-5 year mortgage rates from the Czech National Bank between a given year and 2010. The rates in percentages are 4, 4.58, 4.92, 5.69, and 4.99 for

number of persons living in a household. However, the results of our regressions do not change if the family structure replaces the number of household members.

the years 2005-8 and 2010, respectively. We add the difference to the rates of all households with a positive LTVR in the given year. For instance, we add 4.00-4.99=-0.99 to mortgage rates in 2005. We employ the thus acquired interest rates in our tenure-choice regressions where they represent the cost of borrowing, which is part of the opportunity cost of staying as a renter of a regulated apartment. For owners, the interest rates reflect savings decreasing below a threshold given by 15% of the value of the dwelling where they live.

The next explanatory variable is the price of real estate in Kč per m^2. The source of the data is the CSO. For the surveys before 2006, the coding of regions in the consumer survey corresponds exactly to real estate indices published by the CSO. Only a less detailed coding is available since then. For households which remained in the sample since 2005, this is not a problem. For some households in smaller regions, we can use available information on the size of the population in sub-regions to identify a finer location corresponding to the data from the CSO. In addition, we can calculate the price from the maximum rent appreciation (131) for households which stayed in regulated apartments and the actual rent appreciation equals the legal maximum. There is a handful of observations left in bigger cities, and for these we use a price average for the bigger region. The apartment price is likely to be a stationary variable, as indicated by the panel data unit root tests for Czech apartment prices in Zemčík (2011). However, we can see that the price has increased. Figure 11 depicts the Apartment Price Index from the CSO (it equals 100 in 2003). The regulated rent appreciation is calculated using equation (131) for households living in apartments with regulated rent. Prior to 2006, we use the actual regulated rent appreciation since the deregulation act was not yet passed. After Act 107 took effect, regulated rents appreciated much faster than market rents and the two were converging, as intended by regulation. Table 20 reports average rents in regulated and unregulated apartments. The regulated rents increased by 14% from 2005 to 2006 since some renters may have agreed on greater rents before Act 107 became effective to avoid potentially greater increases in the future (the Act was approved in March 31, 2006 and became effective on January 1, 2007). Nevertheless, the next increase was even greater in the following year, 18%. The market rents' mean is somewhat misleading for the first year. The mean is likely to be biased upward since we eliminated renters when we were not sure if their rent was regulated or not (recall that an indicator for regulated vs. unregulated rent was only introduced in the following year). This left us with renters paying higher rent. We can conclude though that market rents were stagnating or growing at a slower rate than regulated rents.

The next variable of interest is the supply shock in the free rental market measured by the ratio of regulated vs. non-regulated apartments in the household's geographical location. The expected result of rent deregulation is a larger number of apartments on the free rental market (i.e., a shift of the supply curve to the right) in the near future and hence lowered market rents.

4.4 Tenure Choice

In this section, we concentrate on the probability of changing status. For renters, this means the actual purchase of property and for owners the sale of property and switching to renting. This is in contrast to the standard analysis of cross-sectional data where the objective is to predict the current tenure status of households. Let us define a binary response variable $y_{i,t+1}$, which equals one if a household switches its status between years t and $t+1$, and zero otherwise. The response probability is given by

$$Prob(y_{i,t+1} = 1|x) = G(x'_{i,t}\beta). \tag{132}$$

In the case of the probit model, G is the standard normal cumulative distribution function. We also consider the logit model where G is the logistic function and the linear probability model, where $G = x'_{i,t}\beta$. The vector of explanatory variables is given by

$$x_{i,t} = (const., Y_{it}, age_{it}, age^2_{it}, educ_{it}, members_{it}, i_{it}, P_{it}, RRA_{it} \text{ or } SS_{it})'. \tag{133}$$

Estimates of β coefficients are calculated by the method of maximum likelihood. The first explanatory variable is the household income Y_{it}, which is a measure of the expected income.

Characteristics of the household head such as age and education can themselves affect the tenure decision or they can proxy for income; age^2 accounts for life-cycle related effects. For example, income can start declining after reaching a peak at about age 50. Also, households can consider staying in a small rented apartment when they are getting closer to retirement. The variable *members* reflects a greater need for perceived stability often associated with property ownership, especially for families with children. A higher mortgage interest rate i_{it} should reduce the probability of a switch to owning. The price of a current household dwelling P_{it} is a measure of the market price of the household's potential future apartment. For renters of regulated apartments, the legally given regulated rent appreciation RRA should increase the probability of owning property. The supply shock SS_{it} is relevant for renters of apartments on the free rental market and for owners. The greater the ratio of regulated vs. non-regulated apartments, the more likely it is that market rents will decline in the near future. In this case, renters are less likely to purchase their own apartment and owners are more likely to become renters.

The results of the estimation for the parameters of the probit model for renters paying regulated rent are reported in Table 21. We estimate β also for the years 2005-2006 for the sake of comparing the effects of the considered variables before and after adoption of the deregulation act. Income is mostly significant with an always positive coefficient estimate, as expected. Coefficients of age and age^2 are positive and negative. Interestingly, the age effects became more pronounced after the change in the law. The opposite is true for education, whose coefficient has a varying sign; age, age^2, and $educ$ can serve as a proxy for income and the age-related variables have an explanatory power in addition to income. The estimated coefficient for the number of household members is mostly positive and occasionally significant. The mortgage interest rate coefficient is negative and with one exception significant, in line with our intuition. Our main variables of interest are the real estate price and the regulated rent appreciation. The results provide strong evidence of the impact of rent deregulation on tenure choice. Prior to 2006, higher apartment prices do reduce the probability of a switch to owning but the estimates are insignificant. This is because the benefits of living in an apartment with regulated rents outweigh any effect of the price. The RRA coefficient is insignificant since there is only a small change in the regulated rents and the new law has not yet been adopted. The situation changes dramatically when the deregulation starts. The effects of the real estate price and the regulated rent appreciation are both significant and in accordance with our prior. Higher prices lower the probability of owning and higher regulated rents increase it.

The probit estimates for renters paying market rent are given in Table 22. The estimated income coefficient is always positive and significant. The age-related variables are not significant and with varying signs, which is in contrast with our previous results. The likely reason is that heads of households in unregulated apartments are about 10 years younger and the variation in their age is smaller than the age of the heads of households in regulated apartments (see Table 18). We therefore exclude them from our remaining regressions as well as education, whose impact does not follow a regular pattern either. The coefficient for $members$ is always significantly positive, which may be due to the stability of owning real estate as compared to renting at the market rent. The coefficient of the interest rate is negative and significant. Our primary focus is again on real estate prices and a measure of the market rent appreciation, represented here by the supply shock. First, there does not seem to be any change after deregulation starts. The price is clearly more important to renters on the free market in 2005-2006 as ownership is a closer substitute for them than it is for renters in regulated apartments. The supply shock already matters in this sub-period as well. This is due to implicitly anticipated deregulation, even without an explicit form. As long as the rental market is deregulated some time in the future, the supply shock will play a role in household decisions. Second, both variables negatively affect the probability of switching to owning. The significance of estimates varies. This can be explained by the nature of the relationship between P and SS. The real estate price should be related to the market rent (represented by the supply shock). Ceteris paribus, if the market rents increase, households will demand more apartments to own, pushing up their price. Therefore unless there is a strong segmentation of these two markets, there may be collinearity between P and SS. We examine this hypothesis by including only one of these variables in our probit model at a time. In such cases, an estimate of at least one of the variables is always significant. The insignificant price in 2007-2008 is likely to be due to a somewhat less precise matching between household region and the corresponding real estate price (see our discussion of this issue in Section 4.3).

We perform a number of checks to evaluate the robustness of our results. First, we examine the sensitivity to the employed estimation method. Estimating the parameters using logit and linear probability models yields estimation results that are quantitatively and qualitatively similar to the ones reported in Tables 21 and 22. Second, we experiment with alternates to some of the used key variables. We replace the mortgage interest rate by the total mortgage interest payment for a 25-year loan. We use the net present value of renting a regulated apartment vs. owning one (discussed in detail in the next section) to proxy for the regulated rent appreciation. We also use the price of an apartment as opposed to the unit price. None of these alterations affects our results in any significant manner. In addition to studying renters, we estimate the same regression for owners to investigate what affects their decision to switch to renting. The percentage of owners who actually switch to renting is very small (see Table 17). Table 23 reports regression results. Greater income translates into a lower probability of a switch, as intuitively expected. The coefficient estimate is significantly positive in six out of nine cases. Age, age squared and education do not seem to matter for any sub-period. The sign of the coefficient estimate for the number of household members switches after the new act is introduced but the estimate is only once significantly positive. The impact of the mortgage interest rate is interesting. Here it serves as a way to assess households' savings rather than an opportunity cost related to borrowing. Greater rates are associated with lower savings since the mortgage rates are greater for loan-to-value ratios over 85%. Savings actually do not imply significant coefficients if they replace the mortgage rates. We assume this is because the amount of savings matters only below a certain threshold. Therefore greater rates imply a greater probability of selling an apartment and starting to rent but only after the change in the law is introduced. Again, the main variables of interest are the real estate price and the supply shock. Here the timing of deregulation matters less since both variables affect owners only indirectly. The effect of the price is positive and statistically significant since higher prices tempt households to realize capital gains. Greater supply shock implies lower expected rents in the future and increases the probability of a switch to renting. The impact of the two variables tends to be stronger if only one of them is included in the regression due to previously discussed collinearity. Employing logit and linear probability models does not alter the results. Finally, to account for the possibility that households living in regulated apartments can switch to renting a smaller apartment at the market rent, we use a multinomial probit/logit model where the renters living in regulated apartments can also switch to apartments with market rent in addition to becoming an owner. No clear pattern is identified here, most likely due to the very small number of households which swapped paying regulated rent for market rent (see Table 17). This is not a surprising outcome because such a decision is irrational in the context of our econometric model. Regulated rent is typically much lower than market rent for an apartment of the same size, and the moving household would have to have a good reason to abandon the regulated apartment - perhaps to get closer to a hospital or because of conflicts with the current landlord. We do not have information at our disposal to be able to address this particular issue.

The fact that 84% of renters still paid regulated rent in 2005 even though the communist system had already collapsed in 1989 and that only 5% switched to owning in 2005-2006 supports our conclusion that with rare exceptions, households living in regulated apartments prior to 2006 remained in their regulated apartments. In other words, there are no systemic unobserved characteristics of households which remained renters since the early 1990s. A final issue that may affect our results is privatization. Especially in the 1990s, municipalities tried to off-load the burden of apartments with regulated rents by selling them to tenants for a fraction of the market price. This would reduce the effect of deregulation in our regressions. However, the privatization process was nearly complete by the end of the 1990s. Also, while only 5% of renters in regulated apartments purchased real estate prior to the deregulation, this percentage increased to 14 and 18%, respectively, in the two subsequent periods. This increase is likely due to the deregulation. Moreover, some of the switchers prior to 2006 may have switched to owning because they already anticipated the forthcoming deregulation.

4.5 Property Price Expectations

In this section, we try to characterize the households' expectations for market real estate prices. We focus exclusively on households initially living in apartments with regulated rents since in this case we can express the expected rent appreciation explicitly in terms of real estate price appreciation. In each period, these households can choose to stay in the apartment with regulated rent (*no switch*) or to purchase an apartment of their own (*switch*). A present value model is used to define rationality. The household choices impose bounds on the real estate price expectations. This approach is new and differs from simply asking households what are their expectations for property prices. It is also a non-standard use of the present value model, which can be employed to see if the household choices are rational, given their price expectations. Here we assume the households behave rationally and we do not attempt to make their tenure choice conditional on price expectations.

The present value model is in general characterized by the first-order condition from an optimization problem of a risk neutral consumer:

$$P_t = E_t\left[(P_{t+1} + D_{t+1})\right], \tag{134}$$

where P_t is the price of the household's dwelling and D_t is the cash-flow associated with it. If a household decides to purchase real estate (a house or an apartment), the present value of owning is given by:

$$PV(own) = E_t\left[\beta D_{t+1} + ... + \beta^k D_{t+k} - \beta^k((1-\tau_{property})\ P_{t+k} - LB_{t+k})\right], \tag{135}$$

where $D_{t+1}, ...$ are cash outflows of the household, which take into account tax exemption of mortgage interest rates. We abstract from the possibility that the legal system can change.[11] D_{t+1} also includes the down payment on the real estate. $\tau_{property}$ are transaction costs as a portion of the sales price. They consist of the 3% sales tax and the common 2% fee for a real estate agent. Real estate agent fees are lower in the Czech Republic, where their services are used less frequently than in the United States and therefore this is probably an upper limit. $\tau_{property}$ is then 5% in total. We first set the time for selling property to $k = 4$ years, which corresponds to the time when the annual regulated rent reaches 5% of the apartment price. In addition, we consider $k = 25$ to account for the possibility that the household resides in the acquired dwelling until it pays off the mortgage. Here we only consider households in which the age of the head is less than or equal to 50, to abstract from the possibility that a mortgage loan is denied due to the potential death of the creditor. $\beta = 0.99$. We assume that $\beta = \frac{1}{1+i_{free}}$ where i_{free} is a risk-free rate. We further assume for the sake of simplicity that β and hence i_{free} are constant. LB_{t+k} is the mortgage balance at time $t+k$. The cash outflow consists of a time-varying part d_t and a constant part $\bar{d}$, i.e. $D_t = \bar{d} + d_t$. $\bar{d}$ is an annual debt service for the mortgage with monthly compounding. i_t is the mortgage rate. Let us define the monthly interest rate $i^* = i_t/12$, the number of periods in months n, and the present value factor

$$PVF(i_t^*, n) = 1/(1+i_t^*)^n. \tag{136}$$

The annual mortgage payment is calculated as

$$\bar{d} = 12\ L\ \frac{i_t^*}{1 - PVF(i_t^*, T)}, \tag{137}$$

[11]The system actually did change after the end of our sample period in 2009 when the Czech government introduced the notion of a "super-wage" flat tax. This reduced the tax exemption on mortgage interest payment for households in higher income categories, with the marginal tax rate reduced from 32% to 15%.

where the loan size L is computed as P_t minus the household's current savings. We set $T = 25 * 12 = 300$ months i.e. 25 years. Now we can write

$$PV(own) = E_t \left[d_t + \beta d_{t+1} + ... + \beta^k d_{t+k} + \bar{d}\frac{1-\beta^{k+1}}{1-\beta} - \beta^k((1-\tau_{property})\ P_{t+k} - LB_{t+k}) \right]. \tag{138}$$

Let us further define the number of periods in months $n = 12t$, the loan balance at time t as LB_t, the principal at time t as $PRINCIPAL_t$, and the annual interest payment during the year t as $INTEREST_t$. Note that $LB_t = L$. Then

$$\begin{array}{lcl} LB_{t+j} & = & \frac{\bar{d}/12[1-PVF(i^*,T-12j)]}{i^*}, \\ PRINCIPAL_{t+j} & = & LB_{t+j-1} - LB_{t+j},\ j = 1, 2, ..., k, \\ INTEREST_{t+j} & = & \bar{d} - PRINCIPAL_{t+j}. \end{array} \tag{139}$$

The time-varying savings from interest payments in the year t are given by

$$\tau_{income}\ INTEREST_t, \tag{140}$$

where τ_{income} is the income tax, which we set equal to the highest marginal tax rate of 32%.

Real estate prices are assumed to follow an AR(1) process

$$P_{t+k} = a\ P_{t+k-1} + \epsilon_{t+k} = ... = a^k\ P_t + \sum_{i=0}^{k-1} a^{k-1-i}\epsilon_{t+i+1}, \tag{141}$$

and $E_t P_{t+k} = a^k\ P_t$. This assumption reflects autocorrelation present in first-differenced property prices in OECD countries demonstrated, for example, by Englund and Ioannides (1997). This result implies that the current price level depends on the price level in the previous period. Also, this specification corresponds directly to testing for unit roots in levels (see for instance Mikhed and Zemčík (2009) for the US data and Zemčík (2011) for the Czech data) . Real estate researchers are interested in knowing whether $a \geq 1$, in which case there is a unit root, the real estate price process is non-stationary, and there is a rational bubble. The bubble is rational since this price process does not violate equation (134), which represents first-order conditions of the household optimization problem. Equation (138) simplifies somewhat to

$$PV(own) = d_t + \beta d_{t+1} + ... + \beta^k d_{t+k} + \bar{d}\frac{1-\beta^{k+1}}{1-\beta} - \beta^k((1-\tau)\ a^k P_t - LB_{t+k}). \tag{142}$$

The expectation is removed from this equation since the only uncertainty stems from the future price in our set-up. The time varying cash-flows are predictable because they are determined at time t assuming the legal framework for real estate does not change. We do not take into account the possibility of a default on mortgage payments by the household. We plan to draw information about a from the household decisions to rent vs. to own. To filter out price expectations, we make use of the official formulae used to calculate the target rent and the maximum rent appreciation; see equations (130) and (131), respectively. We set $t = 2006$. Noting that we need the annual rent, we can write

$$E_t[R_{t+1}] = \left(\frac{c\,P_t}{R_t}\right)^{1/4} R_t = (cP_t)^{1/4} R_t^{3/4}. \tag{143}$$

Using the process for the real estate price (141), we can also see that

$$E_t[R_{t+2}] = \left(\frac{c\,P_{t+1}}{R_{t+1}}\right)^{1/3} R_{t+1} = (c\;a\;P_t)^{1/3} R_{t+1}^{2/3} = c^{1/2} a^{1/3} P_t^{1/2} R_t^{1/2} \tag{144}$$

and

$$E_t R_{t+3} = c^{3/4} a^{7/6} P_t^{3/4} R_t^{1/4}. \tag{145}$$

From this point on, the rent should be equal to the target rent, i.e.,

$$E_t R_{t+3+i} = ca^{3+i} P_t, \quad i = 1, 2, ... \tag{146}$$

Now we can determine the present value of living in an apartment with regulated rent

$$\begin{aligned} PV(reg) \;\; = \;\; & E_t[R_t + \beta\,(cP_t)^{1/4} R_t^{3/4} + \beta^2\, c^{1/2} a^{1/3} P_t^{1/2} R_t^{1/2} + \beta^3\, c^{3/4} a^{7/6} P_t^{3/4} R_t^{1/4} \\ & + \beta^4\; ca^4 P_t + ... + \beta^m\; c\; a^m P_t], \end{aligned} \tag{147}$$

where m is the life-expectancy of the household head in the Czech Republic. According to the data from the Czech Statistical Office in 2004, the life expectancy was 73.1 years for 15-year old males and 79.6 for 15-year old females, respectively. We set m to be 75 minus the current age of the household head. This in part reflects more households with male heads who are older than 15 years (the available data then lists this information for 45-year olds). The present value of interest on the savings not used to pay a down payment is zero since we set the discount factor β using the risk-free interest rate. Expression (147) can be further simplified to

$$\begin{aligned} PV(reg) \;=\; & R_t + \beta\ (cP_t)^{1/4} R_t^{3/4} + \beta^2\ c^{1/2} a^{1/3} P_t^{1/2} R_t^{1/2} + \beta^3\ c^{3/4} a^{7/6} P_t^{3/4} R_t^{1/4} \\ & + \beta^4\ c a^4 P_t\ \tfrac{1-(\beta\ a)^{m-3}}{1-\beta\ a}. \end{aligned} \tag{148}$$

The final step of comparison between owning vs. renting an apartment is calculation of the Net Present Value (NPV);

$$NPV = PV(reg) - PV(own), \tag{149}$$

which is a function of a, the autoregressive parameter of the real estate price process. This parameter characterizes expectations of the household. Renters living in an apartment with regulated rent should have NPV greater than zero if they purchased an apartment and lower than zero otherwise. We solve numerically for a, which sets NPV to 0 for all renters in regulated apartments, i.e., we find a^* such that $NPV(a^*) = 0$. If households decide to purchase real estate, a^* is a lower bound on their price expectation, and if they stay in the rental apartment, then a^* is an upper bound on their price expectation.

Our results are summarized in Table 24. We calculate the distribution of a^* for households which shifted from renting to owning and for those which did not. We do this for all three sub-periods, i.e., 2005-2006, 2006-2007, and 2007-2008, respectively. The first sub-period serves as a control group since the rent regulation law was effective only since 2006, though there may have been some anticipation of the law passing through the Czech parliament. The present value model fits the data worse in the first sub-period because in some cases there was no interest rate, which would make NPV positive for non-shifters. These households by definition cannot be rational according to the present value model, and we eliminated them from our further calculations. No such case has been found for the other two sub-periods. We have also tested for equality of means using a standard t-test and a Welch F-test, which accounts for potentially differing variances. There are no meaningful patterns emerging either from a comparison between shifters and non-shifters within a sample period nor from a comparison of the same groups across time.

The appreciation means are fairly reasonable as compared with the actual price growth though non-shifters seem to be more conservative with their upper bound on growth lower than the realized growth. This may reflect an element of surprise in increasing real estate prices after 2006, probably due to changing fundamentals.[12] Figure 11 indicates a period of decline in apartment prices from 2003 to 2005. This in part occurred due to a public expectation of rapid increases in 2004, which was the year the Czech Republic joined the European Union. The prices increased prior to 2004 due to this expectation and then stagnated; the accelerated growth starting in 2006 therefore could have come as a surprise. The household expectations in any case do not appear to be irrationally high as often occurs when surveys are used. To gain additional insights, we tabulate the empirical distribution of the expected growth of apartment prices for k=25 in Figure 12. We choose k=25 since the present value model implies values of growth closer to their ex post realizations, and it is more likely that households do not buy apartments for purely speculative reasons but instead intend to keep them for an extended period. The most frequent values for non-shifters tend to be the higher ones at the right-hand side of the histogram. The lowest reported values for shifters are greater than the ones for non-shifters since 2006, suggesting again a somewhat greater optimism among the shifters.

4.6 Summary

Rent deregulation in the Czech Republic is a natural experiment where regulated rents explicitly reflect real estate prices. This dependence induces predictability of regulated rent appreciation, which can be usefully exploited. The impact of deregulation is studied using unique household consumption survey data. The advantage of this dataset is the possibility of recording actual households' tenure choices due to the fact that only 25% of the sample is changed every year.

[12]For example, according to the Czech National Bank, the volume of mortgages for apartment purchases grew by 37.9% between 2006 and 2007 and by 17.5% between 2007 and 2008. Also, the real GDP increased by 6.1% and 2.5% in our two sub-samples.

Our first objective is the analysis of the impact of rent deregulation in the Czech Republic on the tenure choice of households. We control for household characteristics such as income, age, education, and the number of household members. The real estate price and expected mortgage interest rates predictably lower the probability of owning for all renters. Regulated rent appreciation does in fact increase the probability of a real estate purchase for households currently living in rent-controlled apartments. The households in unregulated apartments, meanwhile, anticipate lower market rents. This is because the supply on the free rental market is going to increase due to regulated apartments becoming unregulated in the near future. This effect implies a lower probability of owning for free market renters. For owners, lower savings, greater prices, and greater supply shock increase the frequency of renting. Deregulation makes it more likely for mostly middle-aged households in regulated apartments to seek their own property. Owners who are older more frequently switch to renting due to expected lower rents. The deregulation process therefore makes the tenure choices related to the life cycle of households smoother.

The second objective of the paper is the deduction of real estate price expectations using present value analysis for households in regulated apartments. We assume that the price process is AR(1). The ex-post appreciation was 9.6% from 2006 and 2007 and 12.9% from 2007 to 2008, respectively. We can solve for the real estate price appreciation, which makes the net present value (NPV) of renting vs owning zero. The net present value increases if the price appreciation increases. Therefore, the appreciation making NPV equal to zero imposes an upper limit on households opting to remain in regulated apartments to keep their choice rational. This upper limit is closer to the actual appreciation when we assume that households only sell their property after paying off their mortgages with a maturity of 25 years. It is 1.8% for the sub-period 2006-2007 and 2.3% for the sub-period 2007-2008, respectively. Similarly, the appreciation forms a lower bound for households that have become owners. This lower bound is 2.2% for both sub-periods after 2006.

These results suggest that household expectations were fairly conservative. This may be either because the expectations derived from actual choices are more realistic than those based on surveys or because of the specificity of the Czech real estate market. In either case, the rising prices were more likely to be due to underlying fundamentals, i.e., demand and supply factors other than expectations.

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4.7 Figures

Figure 11: Apartment Price Index from the Czech Statistical Office (equals 100 in 2003)

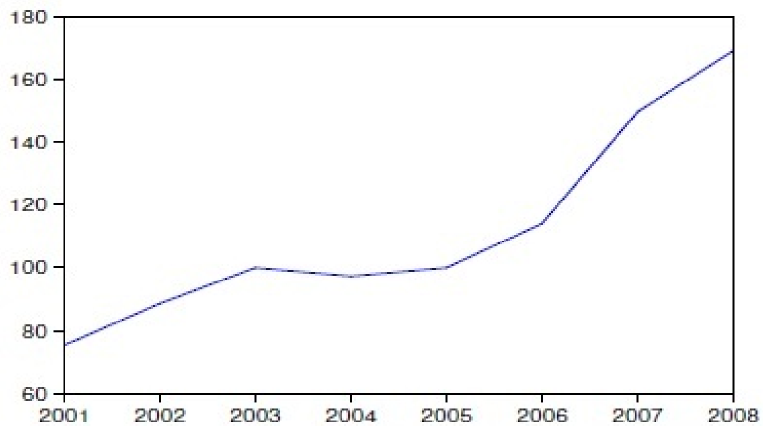
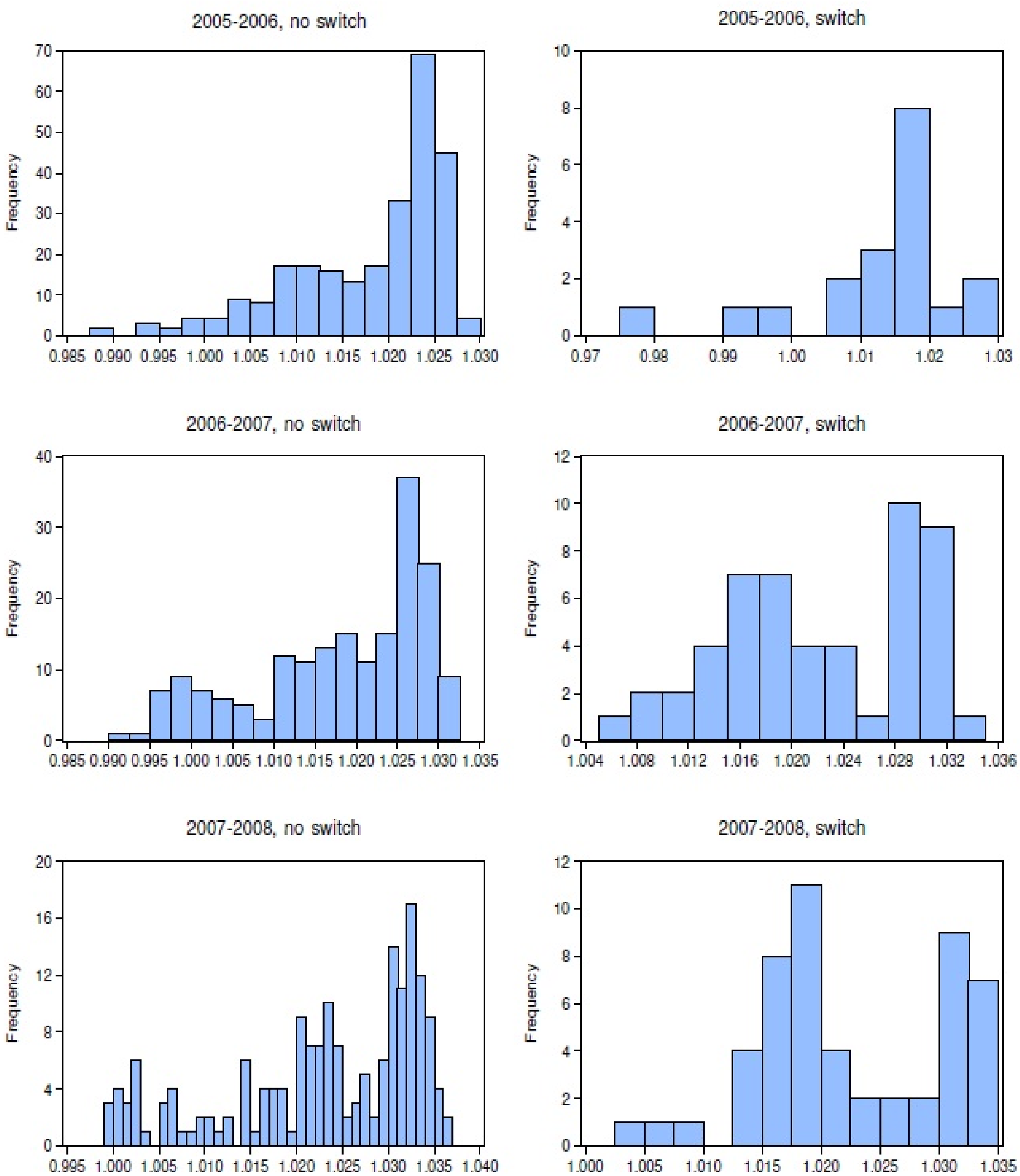


Figure 12: Expectations of Real Estate Price Appreciation for k=25

Notes
1) *switch* refers to those households that purchased property. *no switch* denotes households that stayed in regulated apartments.
2) $k = 25$ are number of years of holding property before it is sold.



4.8 Tables

Table 17: Household Status and Sample Size

	Sample			Status in the following year					
	Initial	Remaining		Regulated rent		Owners		Mkt. rent	
	count	count	%	count	%	count	%	count	%
				2005-2006					
all groups	3223	2529	78	459	18	1943	77	127	5
renters, reg. rent	720	487	68	459	94	25	5	3	1
renters, mkt. rent	123	91	74	0	0	15	16	76	84
owners	2380	1951	82	0	0	1903	98	48	2
				2006-2007					
all groups	3242	2448	76	359	15	1940	79	149	6
renters, reg. rent	625	427	68	359	84	61	14	7	2
renters, mkt. rent	154	100	65	0	0	19	19	81	81
owners	2463	1920	78	0	0	1859	97	61	3
				2007-2008					
all groups	3221	2291	71	345	15	1804	79	142	6
renters, reg. rent	600	425	71	345	81	74	17	6	1
renters, mkt. rent	172	99	58	0	0	13	13	86	87
owners	2449	1767	72	0	0	1717	97	50	3

Notes: There are three types of a status: renters living in apartments with regulated rents, renters living in apartments with market rents, and owners living in their own apartments. Renters paying regulated rents can become owners or rent for the market rent. Renters paying market rents can become owners. Owners can switch to renting for the market rent.

Table 18: Summary Statistics for Renters

	Y	age	$educ$	$members$	i	P	RRA	SS
				2005-2006, regulated rents, 484 obs.				
mean	19,304	46.07	12.01	2.44	4.14	11,887	2.37	
min	4,786	18.00	9.00	1.00	0.00	3,729	0.00	
max	68,550	87.00	20.00	6.00	4.70	4,1026	5.33	
st. dev.	11,047	14.79	2.72	1.19	0.90	7,260	0.99	
				2005-2006, mkt. rents, 91 obs.				
mean	18,385	35.56	11.91	2.45	3.95	11,725		21.12
min	6,963	21.00	9.00	1.00	0.00	3,729		9.50
max	55,748	77.00	20.00	6.00	4.70	41,076		36.50
st. dev.	8,261	11.53	2.43	1.14	0.94	6,798		10.00
				2006-2007, regulated rents, 420 obs.				
mean	20,937	47.84	12.10	2.38	4.41	12,255	19.80	
min	4,620	21.00	9.00	1.00	0.00	3,520	0.00	
max	78,852	84.00	20.00	6.00	5.28	44,275	91.69	
st. dev.	11,497	14.15	2.85	1.18	1.37	7,857	17.06	
				2006-2007, mkt. rents, 100 obs.				
mean	19,208	35.62	12.05	2.22	3.87	13,091		21.38
min	4,783	21.00	9.00	1.00	0.00	4,014		6.50
max	60,690	81.00	20.00	5.00	5.28	44,725		36.00
st. dev.	10,813	10.88	2.82	1.09	1.84	10,521		10.69
				2007-2008, regulated rents, 419 obs.				
mean	22,636	48.86	12.23	2.35	4.81	13,427	24.19	
min	4,215	23.00	9.00	1.00	0.00	3,824	0.00	
max	139,027	90.00	20.00	6.00	5.62	45,537	96.00	
st. dev.	13668	14.05	2.98	1.21	1.39	8,518	20.77	
				2007-2008, mkt. rents, 100 obs.				
mean	19,849	38.54	11.84	2.16	4.43	14,314		22.98
min	4,005	24.00	9.00	1.00	0.00	3,824		6.00
max	51,790	82.00	20.00	5.00	5.62	45,337		36.00
st. dev.	9,696	13.03	2.85	1.10	1.60	11,394		10.33

Notes: Y is the monthly household income per person; age is the age of the household head in years; $educ$ is the education of the household head in years; $members$ is the number of household members; i is the mortgage interest rate to be paid for a loan covering up to LTVR % of the value for a household apartment; P is the regional real estate price in Kč per m^2; RRA is the regulated rent appreciation given per m^2 in % - it is the actual appreciation for the period 2005-2006 and the legally given maximum for the subsequent periods; and SS is the supply shock, i.e. the ratio in % of regulated to non-regulated apartments in the households' location.

Table 19: Summary Statistics for Owners

	Y	age	$educ$	$members$	i	P	SS
			2005-2006, 1951 obs.				
mean	21,633	49.57	12.15	2.58	4.02	9,999	16.49
min	4,591	22.00	9.00	1.00	0.00	3,729	7.00
max	125,425	90.00	20.00	11.00	4.70	41,076	36.50
st.dev	10,891	13.72	2.97	1.21	0.78	5,039	8.06
			2006-2007, 1920 obs.				
mean	23,571	50.03	12.14	2.54	4.32	9,249	15.02
min	3,776	20.00	9.00	1.00	0.00	3,520	6.50
max	145,401	88.00	20.00	9.00	5.28	44,275	36.00
st.dev	12,355	13.98	2.99	1.15	1.18	6,441	9.66
			2007-2008, 1767 obs.				
mean	25,996	50.68	12.18	2.51	4.58	10,241	14.02
min	4,159	20.00	9.00	1.00	0.00	3,824	5.50
max	208,187	89.00	20.00	8.00	5.62	45,537	35.00
st.dev	14,235	13.77	3.04	1.15	1.25	7,120	9.38

Notes: See Table 18 for definitions of variables.

Table 20: Rents

Period	Regulated rents	Mkt. rents
2005-6	21.65	76.85
2006-7	24.72	58.78
2007-8	29.17	62.84

Notes: Reported monthly rents in Kč per m^2 are from the first year of each period.

Table 21: Probit Model Estimation: Renters, Regulated Rents

	Int.	Y	age	age^2	$educ.$	$members$	i	P	RRA	Pseudo R^2	Obs.
						2005-2006					
coef.	-2.53E+00	5.13E-05	2.22E-02	-4.53E-04	-4.53E-04	2.09E-01	-3.44E-01	-4.28E-05	-1.09E-01	0.43	484
(z-stat)	(-1.11)	(3.13***)	(0.21)	(-0.36)	(2.14**)	(1.70*)	(-2.97***)	(-1.21)	(-0.82)		
coef.	-1.95E+00	5.48E-05	-	-	-	2.39E-01	-3.10E-01	-4.37E-05	-9.42E-02	0.41	484
(z-stat)	(-3.32***)	(3.53***)				(2.22**)	(-2.59***)	(-1.22)	(-0.68)		
coef.	-2.43E+00	-	4.24E-02	-5.85E-04	1.12E-01	3.41E-01	-5.26E-01	-9.69E-06	-1.00E-01	0.34	484
(z-stat)	(-1.27)		(0.53)	(-0.66)	(3.37***)	(3.61***)	(-5.43***)	(-0.39)	(-0.77)		
						2006-2007					
coef.	-7.06E+00	1.79E-05	2.21E-01	-3.02E-03	4.92E-02	-1.56E-03	-1.12E-01	-8.79E-05	1.14E-01	0.62	420
(z-stat)	(-3.20***)	(1.40)	(2.05**)	(-2.36**)	(1.11)	(-0.01)	(-1.42)	(-4.27***)	(7.90***)		
coef.	-2.95E+00	2.00E-05	-	-	-	1.95E-01	-1.22E-01	-6.93E-05	8.73E-02		
(z-stat)	(-6.64***)	(2.12**)				(2.08**)	(-1.90*)	(-3.47***)	(7.28***)		
coef.	-7.15E+00	-	2.30E-01	-3.10E-03	6.56E-02	8.32E-02	-1.68E-01	-7.62E-05	1.13E-01	0.61	420
(z-stat)	(-3.28***)		(2.17**)	(-2.48**)	(1.66*)	(0.80)	(-2.53**)	(-3.83***)	(7.89***)		
						2007-2008					
coef.	-6.38E+00	2.30E-05	2.36E-01	-2.75E-03	-3.07E-02	2.42E-02	-1.77E-01	-2.45E-05	5.40E-02	0.48	419
(z-stat)	(-3.32***)	(2.45**)	(2.76***)	(-2.89***)	(-0.88)	(0.23)	(-2.64***)	(-2.03**)	(7.88***)		
coef.	-2.35E+00	1.91E-05	-	-	-	1.77E-01	-1.38E-01	-3.04E-05	4.98E-02	0.42	419
(z-stat)	(-5.09***)	(2.39**)				(2.15**)	(-2.14**)	(-2.41**)	(8.43***)		
coef.	-6.37E+00	-	2.47E-01	-2.82E-03	-1.17E-02	1.19E-01	-2.49E-01	-1.79E-05	5.46E-02	0.46	419
(z-stat)	(-3.41***)		(3.00***)	(-3.17***)	(-0.38)	(1.43)	(-4.32***)	(-1.52)	(7.85***)		

Notes: Variables are defined in Notes to Table 18 ; *, **, and *** are significance levels at 10%, 5%, and 1%, respectively.

Table 22: Probit Model Estimation: Renters, Market Rents

	Int.	Y	age	age^2	$educ.$	$members$	i	P	SS	Pseudo R^2	Obs.
						2005-2006					
coef.	-2.40E-01	7.50E-05	-5.04E-02	8.66E-04	8.64E-04	4.63E-01	-5.14E-01	-8.98E-05	-7.07E-03	0.39	91
(z-stat)	(-0.10)	(3.16***)	(0.50)	(0.80)	(0.01)	(2.28**)	(-2.53**)	(-1.66*)	(-0.20)		
coef.	-9.58E-01	6.75E-05	-	-	-	4.66E-01	-4.36E-01	-	-5.28E-02	0.34	91
(z-stat)	(-1.11)	(3.08***)				(2.78***)	(-2.25**)		(-1.92) *		
coef.	-8.70E-01	6.72E-05	-	-	-	4.14E-01	-4.48E-01	-9.06E-05	-	0.36	91
(z-stat)	(-0.99)	(3.16***)				(2.32**)	(-2.45**)	(-2.07**)			
						2006-2007					
coef.	-5.99E+00	5.09E-05	1.43E-01	-1.67E-03	1.29E-01	5.10E-01	-1.88E-01	-4.24E-05	-3.07E-02	0.42	100
(z-stat)	(-2.00**)	(2.78***)	(1.20)	(-1.26)	(1.69*)	(2.64***)	(-2.03**)	(-1.36)	(-1.36)		
coef.	-1.47E+00	4.35E-05	-	-	-	5.06E-01	-2.13E-01	-	-4.75E-02	0.38	100
(z-stat)	(-1.94) *	(2.67***)				(2.84***)	(-2.41**)		(-2.25**)		
coef.	-1.97E+00	4.80E-05	-	-	-	4.80E-01	-1.66E-01	-5.48E-05	-	0.35	100
(z-stat)	(-2.86***)	(2.49**)				(2.76***)	(-1.81*)	(-1.95) *			
						2007-2008					
coef.	2.55E+00	5.54E-05	-9.42E-02	8.97E-04	-1.33E-01	3.39E-01	-2.73E-01	-1.03E-05	-4.20E-02	0.38	99
(z-stat)	(1.21)	(2.72***)	(-1.04)	(1.07)	(-1.45)	(2.03**)	(-2.41**)	(-0.39)	(-2.08**)		
coef.	-8.78E-01	4.97E-05	-	-	-	3.50E-01	-3.06E-01	-	-4.69E-02	0.35	99
(z-stat)	(-1.27)	(2.56**)				(2.06**)	(-2.85***)		(-2.11**)		
coef.	-1.54E+00	4.34E-05	-	-	-	3.66E-01	-2.53E-01	-3.83E-05	-	0.30	99
(z-stat)	(-2.24**)	(2.22**)				(2.07**)	(-2.52**)	(-1.16)			

Notes: Variables are defined in Notes to Table 18 ; *, **, and *** are significance levels at 10%, 5%, and 1%, respectively.

Table 23: Probit Model Estimation: Owners

	Int.	Y	*age*	age^2	*educ.*	*members*	i	P	SS	Pseudo R^2	Obs.
						2005-2006					
coef.	-6.36E-01	-1.54E-04	-2.42E-02	2.74E-04	-5.40E-03	1.42E-01	-5.90E-02	-2.01E-05	7.62E-02	0.37	1951
(z-stat)	(-0.53)	(-6.30***)	(-0.76)	(-0.93)	(-0.15)	(-1.4)	(-0.37)	(-0.94)	(5.55***)		
coef.	-1.16E+00	-1.58E-04	-	-	-	1.19E-01	-3.49E-02	-	6.56E-02	0.37	1951
(z-stat)	(-1.62)	(-6.59***)				(1.28)	(-0.23)		(8.52***)		
coef.	-9.42E-01	-1.29E-04	-	-	-	4.85E-02	2.25E-02	5.51E-05	-	0.29	1951
(z-stat)	(-1.39)	(-6.02***)				(0.51)	(0.15)	(4.91***)			
						2006-2007					
coef.	-2.17E+00	-3.98E-05	-2.44E-02	2.50E-04	-7.52E-03	-1.02E-01	2.72E-01	2.92E-05	1.60E-02	0.23	1920
(z-stat)	(-2.49**)	(-1.42)	(-0.99)	(1.07)	(-0.35)	(-1.03)	(2.45**)	(2.79***)	(1.82**)		
coef.	-3.18E+00	-3.93E-05	-	-	-	-1.30E-01	3.77E-01	-	3.10E-02	0.22	1920
(z-stat)	(-5.18)	(-1.40)				(-1.28)	(3.48***)		(3.93***)		
coef.	-2.66E+00	-4.10E-05	-	-	-	-1.21E-01	2.81E-01	4.37E-05	-	0.22	1920
(z-stat)	(-3.78***)	(-1.48)				(-1.21)	(2.32**)	(4.55***)			
						2007-2008					
coef.	-1.79E+00	-1.20E-04	-1.88E-02	2.25E-04	-1.57E-02	-1.51E-01	3.14E-01	4.76E-05	1.39E-02	0.45	1767
(z-stat)	(-1.11)	(-3.39***)	(-0.47)	(0.64)	(-0.38)	(-0.96)	(1.61)	(4.16***)	(1.34)		
coef.	-3.13E+00	-1.12E-04	-	-	-	-2.64E-01	5.14E-01	-	4.45E-02	0.42	1767
(z-stat)	(-2.63***)	(-3.39***)				(-1.74*)	(2.72***)		(5.81***)		
coef.	-2.48E+00	-1.19E-04	-	-	-	-2.04E-01	3.91E-01	5.67E-05	-	0.45	1767
(z-stat)	(-2.06**)	(-3.54***)				(-1.34)	(2.06**)	(6.93***)			

Notes: Variables are defined in Notes to Table 18 ; *, **, and *** are significance levels at 10%, 5%, and 1%, respectively.

Table 24: Real Estate Price Expectations

	2005-2006		2006-2007		2007-2008	
Actual appreciation	1.0310		1.0956		1.1291	
	no switch	switch	no switch	switch	no switch	switch
			k=4			
Mean	0.9944	0.9884	0.9933	1.0099	1.0169	1.0083
Median	0.9993	0.9907	0.9998	1.0083	1.0197	1.0072
Maximum	1.0225	1.0150	1.0319	1.0354	1.0487	1.0379
Minimum	0.9002	0.9193	0.9225	0.9828	0.9855	0.9675
Std. Dev.	0.0198	0.0228	0.0220	0.0135	0.0156	0.0161
			k=25			
Mean	1.0180	1.0125	1.0180	1.0223	1.0230	1.0224
Median	1.0218	1.0159	1.0204	1.0209	1.0246	1.0201
Maximum	1.0284	1.0261	1.0322	1.0327	1.0360	1.0343
Minimum	0.9887	0.9776	0.9922	1.0073	0.9996	1.0031
Std. Dev.	0.0084	0.0119	0.0105	0.0073	0.0104	0.0079

Notes:
1) *Actual appreciation* is the actual gross price increase of prices of all apartments with a regulated rent based on regional market prices.
2) *switch* refers to those households that purchased property. *no switch* denotes households that stayed in the regulated apartments.
3) $k = 4, 25$ are number of years of holding property before it is sold.