Aggregate Uncertainty, Individual Uncertainty, and the Housing Market

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Abstract

In the post World War II period for the United States, housing investment has lead output by one to two quarters. At the same time, housing prices are procyclical. These two observations imply that a demand shock for housing leads the business cycle. This paper tests one possible mechanism that can generate such shifts in the demand for housing. The particular mechanism in question is composed of three parts: (1) a transaction cost in the housing market, such as broker fees, closing costs, etc; (2) uninsurable shocks to individual earnings; and (3) the uncertainty of shocks to individual earnings is countercyclical. These three components make a potential homebuyer reluctant to buy a home at the start of a recession due to the greater likelihood of a bad earnings shock causing him or her to have to re-sell a home just purchased at a substantial loss due to the transaction cost. On the other hand, a potential homebuyer would be quite willing to buy at the start of an expansion. The results of a model calibrated to the post World War II United States show that at constant interest rates, the median homebuyer buys a home with a down payment of 12.9% in expansions, and 17.8% in recessions. These results generate large increases (decreases) in housing demand at the start of an expansion (recession) that help explain the leading behavior of housing investment. Furthermore, the results suggest that if there are imperfections in asset markets then the presence of uninsurable individual earnings can have a significant impact on the business cycle.

Keywords: Housing, Business Cycle, Liquidity.

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1. Introduction

In the post-World War II United States economy, investment exhibits no leading or lagging behavior relative to GDP. However, when investment is broken up into its components of residential and non-residential investment a pattern appears. Namely, residential investment leads output by one to two quarters, while non-residential investment lags by a quarter. In addition, housing prices are procyclical. These observations suggest that there is a housing demand shock at the start of a business cycle.

Housing is different from many other assets that the average household in the United States possesses. Namely, as most homeowners will attest to, there is a sizeable transaction cost associated with the buying and selling of a house from broker fees, closing costs, moving, etc. Furthermore, recessions are often thought of as a time of great uncertainty for individuals. Particularly, individuals may face uncertainty in their future labor earnings that they cannot insure against that is higher during recession compared to expansions. The combination of high earnings uncertainty that cannot be insured against and a transaction cost in the housing market, imply that a potential homebuyer would be reluctant to purchase a home during a recession relative to an expansion. Therefore, there can be large increases (decreases) in housing demand at the start of expansions (recessions), that are consistent with housing investment leading the business cycle.

Fully explaining the leading behavior of housing investment is a great task. The test of this paper is simply to take an exogenous process for productivity, and explore if frictions in the housing market along with the interplay between aggregate uncertainty and individual uncertainty can generate large swings in housing demand that can contribute to residential investment leading output.

This paper adapts the model from Díaz-Giménez et al (1992) and calibrates it to the post-World War II US economy. This model economy is composed of many agents who are heterogeneous in asset holdings and uninsurable labor earnings. An aggregate shock determines interest rates and the process for individual earnings, with the uncertainty to individual earnings being higher during negative aggregate shocks. Agents have access to two types of assets: bank deposits, and a large asset that yields them direct utility, *i.e.* a house. It is costly to buy and sell the large asset, but an agent must posses the large asset in order to go into debt.

Results show that at constant interest rates, the median homebuyer buys a home with a down payment of 12.9% in expansions, and 17.8% in recessions. These results generate large increases (decreases) in housing demand at the start of an expansion (recession) that help explain the leading behavior of housing investment. Furthermore, the results suggest that if there are imperfections in asset markets then the presence of uninsurable individual earnings can have a significant impact on the business cycle.

There has been some recent literature emphasizing the effects of housing on the business cycle. The classics are Benhabib, Rogerson,and Wright (1991) and Greenwood and Hercowitz (1991) and more recently Davis and Heathcoate (2000). Papers primarily focusing on the lead/lag behavior of residential and non-residential investment are Gomme, Kydland, and Rupert (2000), Edge (2000) and Fisher (2001). Both Gomme, Kydland, and Rupert (2000), and Edge (2000) use a representative agent environment with a difference in time-to-build between residential and commercial structures. Edge (2000) can generate residential leading non-residential investment while Gomme, Kydland, and Rupert (2000) improves on the standard results in Greenwood and Hercowitz (1991) and Benhabib, Rogerson,and Wright (1991), but does not get residential leading non-residential investment. Fisher (2001) gets residential leading non-residential investment by assuming that residential capital is used in the production of market goods while market capital is not used in the production of residential services. Thus, agents have a desire to first adjust residential capital in response to a shock that raises productivity in both sectors. None of these papers generates residential investment leading output. Lastly, the paper by Carroll and Dunn (1997) is the closest in spirit to this paper. They examine how costs to purchase consumer durables and changes to individual uncertainty over the business cycle can effect the depth of a recession and the size of a recovery, with an emphasis on the recovery following the 1991 recession.

The rest of the paper is organized as follows: the next section shows some empirical facts regarding housing and the business cycle. The subsequent sections lay down the environment of the model, calibration, the effects of uncertainty on the home purchase decision, and the aggregate results of the fully calibrated model. The last section concludes.

2. Some Facts

2.1. Housing and the Business Cycle

Table 1 presents Hodrick-Prescott filtered data on the relationship between housing and output for the post World War II United States economy. A variable x leads variable y if $|corr(x_{t-1}, y_t)| > |corr(x_t, y_t)|$. On the other hand if $|corr(x_{t+1}, y_t)| > |corr(x_t, y_t)|$ then variable x lags y. Inspection of table 1 shows that fixed investment peaks at the same time as output. However, non-residential investment lags, with its highest correlation with output coming a quarter after output (0.77 versus 0.72). On the other hand, residential fixed investment leads, with the highest correlations coming one to two quarters before output. The correlation of residential investment at time $t-1$ with output t is 0.69 versus a contemporaneous correlation of 0.59. Moreover, the leading behavior of housing is also evident in other series of housing activity, such as single family residential investment and starts. For single unit starts the lead is by three quarters.

In addition, table 1 also shows the relationship of real housing prices with output. The first housing price series is the price index for residential fixed investment from NIPA deflated by the GDP deflator. The second housing price series is the median value of a new home taken from the Census Department's construction survey and also deflated by the GDP deflator. Both series show that real housing prices are procyclical, and exhibit some lagging behavior. The observations on investment and prices imply that there is a positive demand shock in the housing market at the start of a business cycle.

2.2. Cyclicality of variance of earnings shocks

One of the primary features of the mechanism being tested in this paper is the difference in individual earnings uncertainty over the business cycle. In order for possible negative income shocks to have a large effect on agents' decisions they need to be persistent. In addition, the threat has to be of a large shock, so that the variance difference between recessions and expansions also needs to be large. Using data from the Panel Study on Income Dynamics, Storesletten et al (1999) have estimated an earnings process that follows

$$\begin{aligned} \log(e_t) &= z_t \\ z_t &= \rho z_{t-1} + \eta_t \end{aligned}$$

where e_t is total earnings and η_t is an iid shock that is distributed with mean zero and variance σ^2. They do two estimations. In the first σ^2 is constant and in the second σ^2 is allowed to depend upon whether the aggregate economy is in a recession or an expansion. Their results are presented in table 2, a subscript G refers to expansions B refers to contractions. They get a ratio of the variance to earnings shocks of recessions to expansions of 4.89, an increase of 126% for the standard deviations.

Table 2a Earnings Shocks, constant variance

ρ	σ^2
0.935	0.061

Table 2b Earnings Shocks, conditional variance

ρ	σ_G^2	σ_B^2
0.916	0.037	0.181

3. Model Economy

The model economy is a version of the one used by Díaz-Giménez et al (1992). The main features of this model are (i) households are heterogenous in earnings, facing an uninsurable labor earnings shock, (ii) households are heterogenous across portfolios of bank assets and liabilities and a large asset denoted as housing, (iii) households die stochastically replaced with new households without assets, (iv) it is costly to buy and sell housing, (v) a banking sector intermediates between borrowers and lenders, and (vi) an aggregate shock determines interest rates and the process for individual earnings.

3.1. Environment

3.1.1. Households

There is a measure of households equal to one. At the end of each period a measure δ of households die and an equal measure of new households are born. When households die their assets (described below) are possessed by the government via a death tax. Newborn households posses no assets. Households' preferences are defined over two goods: consumption goods, c, and a house of size $\tilde{h}$. Per period utility is given by

$$u(c, \tilde{h}).$$

Households discount the future with a discount factor β.

3.1.2. Household Portfolios

Each period a household chooses a portfolio of assets for the next period. The portfolio consists of a position with a bank, a, and housing assets, h. If a is negative, then a household has a loan out from a bank and has to pay an interest rate on the loan next period of r_l. If a is positive then a household has deposits at the bank and receives an interest rate on the deposits next period of r_d. A household's portfolio choice is limited by a borrowing constraint of

$$a \geq -\theta h \tag{3.1}$$

$\theta \in (0,1)$, so that households can only borrow against a house.

3.1.3. Housing Technology

The housing decision is restricted to the set $H = \{0, \bar{h}\}$, so that a household either possesses no house, being a renter (described below), or possesses a single large house, being a homeowner. Homeowners receive housing services $\tilde{h} = \bar{h}$. Houses are costly to maintain, with maintenance costing $\mu\bar{h}$ each period.

Renters can rent a house of size h^r at a price of κ units of consumption goods. The cost to rent a house is the interest costs, r_d and maintenance, μ_r, so that $\kappa = r_d + \mu_r$. If $\mu_r > \mu$, then renting will be inefficient.

Buying and selling a house is costly. A household must pay a transaction cost of $\phi\bar{h}$ whenever it buys or sells a house. This cost is meant to reflect closing costs, broker fees and the possible loss due to forced liquidation of a house.

3.1.4. Aggregate Uncertainty

Let $X \in \{X_g, X_b\}$ be an aggregate state distributed according to $\Pi_X(X'|X)$. The aggregate state determines the return to non-housing assets, $r(X)$, and the process for individual earnings as described below.

3.1.5. Earnings Process

Let labor earnings be given by $ew(X)$. The second term, $w(X)$ can be interpreted as the market wage that depends upon the aggregate state of the economy. The first term, e, can be interpreted as the level of an individual household's productivity. Let e_t evolve according to the following process

$$\log(e_t) = z_t$$
$$z_t = \rho z_{t-1} + \eta_t$$

where $\eta_t \backsim (0, \sigma^2(X))$. Note that the variance of shocks to individual household productivity can depend upon the aggregate state of the economy. Newborns earnings, z_0, are distributed according to $F_0(z)$.

3.1.6. Banks

There is an infinite set of banks. Banks compete for deposits from households and loan funds out either as a mortgage at an endogenous rate of r_l or as a loan to a non-housing sector at a rate of $r(X)$. Intermediation in this economy is costly, so that for every dollar that a bank intermediates between a borrower and a lender the bank has to pay a real cost of η. In equilibrium, this cost will create a spread between the lending rate and the borrowing rate.

3.1.7. Government

The government taxes the dead at the end of a period for 100% of their net assets. Households receive no utility from any government spending.

3.2. Equilibrium

3.2.1. Household Problem

A household's individual state variable is the vector (a, e, h), which includes the household's current position with a bank, a, its current productivity, e, and its current housing status, h. The only aggregate variable is X, which gives the household full information to make expectations over future prices. The exogenous process for prices allows for the distribution of households across individual state variables to be ignored by an individual household. This assumption is necessary to make this model economy computationally feasible. Households choose consumption, c, rental housing services (if any), h^r, next period's position with a bank, a', and next period's housing status, h'. The standard bellman equation for an individual household is given by

$$V(a,e,h,X) = \max_{c,h^r,h',a'} u(c,\tilde{h}) + \beta(1-\delta)\sum_{X'} \pi(X'|X) E_{e'|X'} V(a',e',h',X')$$

$$s.t. \quad a' + h' + c + (r_d(X) + \mu_r)h^r + \mu h + \tfrac{\phi}{h}(h-h')^2 \leq a(1+r) + h + ew(X)$$

$$r = \begin{cases} r_l(X) & \text{if } a \leq 0 \\ r_d(X) & \text{if } a \geq 0 \end{cases}$$

$$\tilde{h} = \begin{cases} \bar{h} & \text{if } h = \bar{h} \\ h^r & \text{if } h = 0 \end{cases}$$

$$a' \geq -\theta h'$$

$$h^r \geq 0$$

where V is the value function of a household. This yields a solution of $h(a,e,h,X)$, $a(a,e,h,X)$, $c(a,e,h,X)$ and $h^r(a,e,h,X)$.

3.2.2. Banks' Problem

Banks take the process for the return to non-housing capital, $r(X)$ as given and choose $r_l(X)$ and $r_d\,(X)$to maximize total revenue equal to

$$Lr_l(X) - Dr_d(X) - \eta L$$

where L is loans and D is deposits. Loans are either mortgages to individuals or loans to businesses. Since all loans are repaid, then

$$r_l\,(X) = r(X). \tag{3.2}$$

A zero profit condition implies

$$r_l(X) = r_d(X) + \eta, \tag{3.3}$$

which is independent of L and D.

3.2.3. Equilibrium

Define the distribution of agents across (a,e,h) as $G(a,e,h)$. Furthermore, let $g(G,X)$ describe the evolution of $G(a,e,h)$. These functions are necessary to ensure that statements regarding the aggregate realization of this economy are clearly defined.

Definition 1: *An Equilibrium is a list of functions* $g(G,X)$, $r_l(X)$, $r_d\,(X)$, $h(a,e,h,X)$, $a(a,e,h,X)$, $c(a,e,h,X)$ *and* $h^r(a,e,h,X)$ *such that:*

(i) *Optimality of Households' decisions:* $h(a, e, h, X)$, $a(a, e, h, X)$, $c(a, e, h, X)$ *and* $h^r(a, e, h, X)$ *solve the consumer's Bellman equation,*

(ii) *Optimality of Banks:* $r_l(X)$, $r_d(X)$ *satisfy equations (3.2) and (3.3),*

(iii) *Consistency:* $g(G, X)$ *is generated by* $h(a, e, h, X)$, *and* $a(a, e, h, X)$, *and* $G' = g(G, X)$, *and*

(iv) *Feasibility:* $\int a dG(a, e, h) \geq 0$.

3.3. Calibration

The model is calibrated to be consistent with the post World War II United States economy.

3.3.1. Model Period

Since the interest of this paper is on business cycles and the greatest wealth of data is at the quarterly frequency, the length of a period is set at a quarter.

3.3.2. Preferences

Following Díaz-Giménez et al, the utility function is

$$u(c, \tilde{h}) = \frac{1}{1-\gamma}[(c^{1-\alpha}\tilde{h}^{\alpha})^{1-\gamma} - 1].$$

This gives two parameters, the coefficient of relative risk aversion, γ, and the share parameter of housing in utility, α. Risk aversion is set at 2, which is within the wide range of $(1.0, 4.0)$ used in calibrated business cycle models. For α, data from the Consumer Expenditure survey reports that consumption spent on housing has been around 21% for renters, see table 5. Thus $\alpha = 0.21$.

3.3.3. Discount Factor

The discount factor is chosen so that the level of aggregate wealth over quarterly GDP is 10.44. This number comes from the 1995 Survey of Consumer Finances when the top 5% of the wealth distribution is removed. The top 5% of the wealth distribution is removed because models with individual uncertainty have been unsuccessful in matching the large wealth concentration in the wealthiest 5% observed in the United States.

3.3.4. Aggregate Uncertainty

The process for aggregate uncertainty is contained in the 2×2 transition matrix Π_X. The two free parameters are chosen so that the expected duration of an expansion is 14.33 quarters and the expected duration of a contraction is 3.66 quarters. These numbers match the average length of expansions and contractions for the post-World War II US economy based upon the NBER's definitions of a contraction and an expansion. This results in

$$\Pi_X = \begin{bmatrix} 0.9302 & 0.273 \\ 0.0698 & 0.727 \end{bmatrix}$$

3.3.5. Labor Earnings Process

The labor earnings process is approximated by a three state Markov chain. Two calibrations are done. In the first one, the earnings process, $\Pi(e)$, is independent of the aggregate state. In the second calibration the earnings process depends upon the aggregate state $\Pi(e|X_b)$ and $\Pi(e|X_g)$. In all calibrations the possible earnings states, E, are constant and the distribution across earnings states is a constant. This ensures that the only difference between processes is on individual earnings uncertainty, not on aggregate earnings. The parameters are chosen to give permissible transition matrices and to come as close as possible to matching the results from Storesletten, Telmar, and Yaron (1999) (STY). Since the results from STY are annual, the target moments hit are the quarterly variance implied by the annual variance and persistence numbers, and the annual variance implied by the model quarterly process. This results in

$$E = \{0.670, 0.897, 1.120\}$$

$$\Pi(e) = \begin{bmatrix} 0.973 & 0.013 & 0.000 \\ 0.027 & 0.974 & 0.027 \\ 0.000 & 0.013 & 0.973 \end{bmatrix}$$

$$\Pi(e|Z_g) = \begin{bmatrix} 0.984 & 0.008 & 0.000 \\ 0.016 & 0.984 & 0.016 \\ 0.000 & 0.008 & 0.984 \end{bmatrix}$$

$$\Pi(e|Z_b) = \begin{bmatrix} 0.921 & 0.038 & 0.000 \\ 0.079 & 0.923 & 0.079 \\ 0.000 & 0.038 & 0.921 \end{bmatrix}.$$

3.3.6. Interest Rates and Banking Technology

Table 3 shows some average real interest rates over the span 1971 to 2001. The interest rates are set so that $r_l = 3.24\%$ and $\eta = 1.7\%$. in the steady-state. Results will be given for acylical, procylical, and countercyclical interest rates.

Table 3: Average Real Interest Rates

30 Year Mortgage	10 Year T-bond	1 Year T-bill
4.91	3.24	2.37

3.3.7. Death Rate

The rate of death, δ, is chosen so that the expected life span is fifty years.

3.3.8. Other Utility and Technology Parameters

The parameters left to calibrate are θ, $\bar{h}$, μ, μ_r and ϕ. The borrowing constraint is set at $\theta = 0.9$, so that the lowest down payment on a house is 10%. From the CEX, (see table 5) the size of a house is set so that a house is three times annual consumption of homeowners. Also from the CEX, the cost of housing maintenance, μ, is set at 2.3%.[1] The transaction cost, ϕ, is set at 5%.

The rental inefficiency is set at two levels. One, $\mu_r = 3.86\%$ sets the number of homeowners at 62%, consistent with the 1995 SCF and the 1995 CEX. This results in down payments on housing purchases of $30 - 50\%$, numbers that seem much too high. To get around this, results are also shown for $\mu_r = 4.86\%$, so that down payments for consumers with currently high productivity purchase a house with a 10% down payment.

The calibrated parameters are summarized in table 4.

Table 4 Calibrated Parameters

γ	β	$\bar{h}$	α	μ	μ_r	ϕ	η	δ
2.0	0.9959	13.0	0.21	0.023	0.0386; 0.00	0.05	0.017	0.005

4. Results

4.1. Constant Interest Rates

Table 6a shows the down payments to purchase a home for different parameter values. Note that when interest rates and earnings variance are constant, there is little, or no effect on down payments over the business cycle. However, when earnings variance is countercyclical *and* there is a transaction cost, then there is a considerable effect on down payments, with the middle earner raising his down payment from 12.9% to 17.8% when calibrating to the down payment and from 42.6% to 48.3% when calibrating to the percentage of homeowners. These results imply that the

[1] Percentages are all annual rates.

combination of countercyclical earnings variance and a transaction cost can lead to large swings in housing investment at the start of an expansion or the start of a contraction.

Table 7a shows the aggregate behavior for housing investment over the business cycle for different model calibrations. In a model with constant interest rates the combination of countercyclical earnings variance and a transaction cost can generate leading behavior of housing. In the model calibrated to the percentage of homeowners, the correlation of housing investment at $t-1$ with output at t is 0.40, while the correlation of housing investment at $t+1$ with output at t is -0.15. Note that both the transaction cost and the countercyclical earnings variance are necessary to generate any significant behavior. Results are similar in the model calibrated to the down payment. The correlation of housing investment at $t-1$ with output at t is 0.30, while the correlation of housing investment at $t+1$ with output at t is -0.14.

4.2. Countercyclical Interest Rates

The model is also simulated for countercyclical interest rates. In recessions the interest rate is set at $r = 3.80\%$, while in expansions it is set at $r = 3.08\%$. Table 6b shows down payments when interest rates are countercyclical. The effects are similar to the combination of countercyclical earnings variance and a transaction cost. The middle earner raises his down payment from 13.3% to 18.3% when calibrating to the down payment and from 43.0% to 47.3% when calibrating to the percentage of homeowners. Thus countercyclical interest rates can also generate large swings in housing investment at the start of an expansion or the start of a contraction.

Turning to the aggregate results (see table 7b), in the model calibrated to the percentage of homeowners, the correlation of housing investment at $t-1$ with output at t is 0.36, while the correlation of housing investment at $t+1$ with output at t is -0.28. Results are similar in the model calibrated to the down payment. The correlation of housing investment at $t-1$ with output at t is 0.32, while the correlation of housing investment at $t+1$ with output at t is -0.17.

4.3. Procyclical Interest Rates

Lastly, real business cycle models with housing do not do a good job of generating leading behavior of housing, since productivity shocks imply that interest rates are procyclical. I ran the model when interest rates are 0.5% higher in good times. The results are shown in tables 6c and 7c. When the earnings variance is constant, then housing investment is counter-cyclical, contradicting the data. However, when the earnings variance is countercyclical housing investment in pro-cyclical, even though interest rates are pro-cyclical. This result implies that the process for individual earnings can have implications for the aggregate behavior of the economy that are not captured by a representative agent economy.

5. Conclusion

This paper has quantified the effects of one possible mechanism that can contribute to residential investment leading the business cycle. The mechanism in question was frictions in the housing market along with the interplay between aggregate uncertainty and individual uncertainty causing agents to bunch housing purchases at the start of an expansion, and to put off purchases at the start of a recession. Results show that the combination of countercyclical earnings variance and a transaction cost can generate leading behavior of housing investment. Counter-cyclical interest rates can also generate similar leading behavior. The most striking result is that the combination of countercyclical earnings variance and a transaction cost can generate leading, procyclical behavior of housing investment even when interest rates are procyclical. Thus, the presence of uninsurable idiosyncratic earnings shocks can have significant implications for the aggregate behavior of the economy. In particular, the results of this paper imply that the demand for housing depends upon the cyclical behavior of the variance of uninsurable shocks to earnings.

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Table 1: Cross Correlation of Variable x at time (t+s) with GDP at time (t)

x\s	-4	-3	-2	-1	0	1	2	3	4
GDP	0.13	0.36	0.62	0.85	1.00	0.85	0.62	0.32	0.13
Res Investment	0.48	0.59	0.67	0.69	0.59	0.35	0.10	-0.11	-0.26
Non-Res Inv	-0.17	-0.04	0.19	0.45	0.72	0.77	0.69	0.57	0.37
Real Res Inv Prices	-0.01	0.10	0.18	0.34	0.43	0.48	0.51	0.53	0.46
Real Median New Home Price*	0.18	0.32	0.46	0.57	0.63	0.60	0.51	0.40	0.27
Single Family Res Inv	0.59	0.68	0.74	0.74	0.63	0.39	0.12	-0.13	-0.31
Multi Family Res Inv	0.20	0.33	0.44	0.53	0.54	0.47	0.35	0.22	0.08
Starts**	0.61	0.67	0.67	0.58	0.38	0.11	-0.12	-0.29	-0.40
1 Unit Starts**	0.66	0.70	0.67	0.55	0.31	0.02	-0.20	-0.37	-0.45
Multi Unit Starts**	0.45	0.54	0.57	0.55	0.42	0.22	0.04	-0.11	-0.23
New Home Sales*	0.69	0.71	0.68	0.51	0.28	0.01	-0.16	-0.31	-0.40

Quarterly Data: 1950:1 to 2002:1
*Quarterly Data: 1963:1 to 2002:1
*Quarterly Data: 1959:1 to 2002:1
Source: GDP, Investment, and Inv Prices: NIPA;
Starts and New Homes Prices: Census Construction Survey

Figure 5.1:

Table 5: CONSUMER EXPENDITURE SURVEY

	1984	1991	1994	1995	2000
All					
Consumption (c)	21,975	28,381	31,731	32,264	38,045
Housing-Owners					
Percent	62.5%	62.4%	63.0%	64.0%	66.0%
Consumption (ch)	25,675	33,272	36,976	37,598	43,603
Ch/C	1.168	1.172	1.165	1.165	1.146
Shelter	3,754	5,210	6,061	6,371	7,627
Interest	1,982	2,882	3,023	3,264	4,007
Property Taxes	672	956	1,453	1,443	1,723
Maintenance, repairs, insurance	622	862	1,027	1,113	1,245
Housing Cost/Ch (alpha)	0.146	0.157	0.164	0.169	0.175
House Size	75,182	105,249	108,331	111,279	140,444
Interest %	2.64%	2.74%	2.79%	2.93%	2.85%
Property Taxes %	0.89%	0.91%	1.34%	1.30%	1.23%
Mainetenance, repairs, insurance %	0.83%	0.82%	0.95%	1.00%	0.89%
House/Ch	2.93	3.16	2.93	2.96	3.22
Renters					
Consumption (chr)	15,802	20,166	22,728	22,730	27,406
Shelter	3,048	4,214	5,044	5,139	6,133
Rental Housing Cost/Chr (alpha)	0.193	0.209	0.222	0.226	0.224

Figure 5.2:

Table 6a: Home Buying Decisions at constant interest rates

Transaction Cost	High Earnings				Middle Earnings			
	Good State		Bad State		Good State		Bad State	
	amin	dp	amin	dp	amin	dp	amin	dp
Calibrated to % homeowners (high rental cost)								
Earnings Variance Constant								
0.00	1.74	15.8%	1.77	15.8%	2.98	23.7%	3.01	23.8%
0.05	4.23	29.9%	4.28	30.0%	6.17	43.3%	6.20	43.4%
Earnings Variance Countercyclical								
0.00	1.73	15.8%	1.86	16.5%	2.99	23.7%	2.99	23.7%
0.05	4.16	**29.4%**	4.81	**34.3%**	6.08	**42.6%**	6.85	**48.3%**
Calibrated to down payment (low rental cost)								
Earnings Variance Constant								
0.00	0.86	10.0%	0.89	10.0%	1.09	10.0%	1.12	10.0%
0.05	1.52	10.0%	1.55	10.0%	2.28	13.6%	2.32	13.7%
Earnings Variance Countercyclical								
0.00	0.86	10.0%	0.88	10.0%	1.09	10.0%	1.12	10.0%
0.05	1.52	**10.0%**	1.55	**10.0%**	2.19	**12.9%**	2.85	**17.8%**

dp=down payment

amin=Minimum assets to purchase a house

Figure 5.3:

Table 6b: Home Buying Decisions at countercyclical interest rates

Transaction Cost	High Earnings				Middle Earnings			
	Good State		Bad State		Good State		Bad State	
	amin	dp	amin	dp	amin	dp	amin	dp
Calibrated to % homeowners (high rental cost)								
Earnings Variance Constant								
0.00	1.63	15.0%	2.31	19.9%	2.79	22.2%	3.71	29.1%
0.05	4.18	29.6%	4.67	33.1%	6.14	43.0%	6.71	47.3%
Earnings Variance Countercyclical								
0.00	1.63	15.0%	2.43	20.9%	2.80	22.3%	3.67	28.8%
0.05	4.17	29.5%	5.20	37.2%	6.08	42.6%	7.22	51.2%
Calibrated to down payment (low rental cost)								
Earnings Variance Constant								
0.00	0.86	10.0%	0.91	10.0%	1.09	10.0%	1.14	10.0%
0.05	1.52	10.0%	1.57	10.0%	2.24	13.3%	2.91	18.3%
Earnings Variance Countercyclical								
0.00	0.86	10.0%	0.90	10.0%	1.09	10.0%	1.14	10.0%
0.05	1.52	10.0%	1.58	10.0%	2.19	12.9%	3.31	21.3%

dp=down payment

amin=Minimum assets to purchase a house

Figure 5.4:

Table 6c: Home Buying Decisions at procyclical interest rates								
Transaction Cost	**High Earnings**				**Middle Earnings**			
	Good State		**Bad State**		**Good State**		**Bad State**	
	amin	**dp**	**amin**	**dp**	**amin**	**dp**	**amin**	**dp**
Calibrated to % homeowners (high rental cost)								
Earnings Variance Constant								
0.05	4.29	30.4%	4.09	28.6%	6.25	44.0%	5.99	28.6%
Earnings Variance Countercyclical								
0.05	4.20	**29.7%**	4.63	**32.9%**	6.11	**42.9%**	6.64	**46.7%**
Calibrated to down payment (low rental cost)								
Earnings Variance Constant								
0.05	1.52	10.0%	1.54	10.0%	2.37	14.3%	2.04	11.6%
Earnings Variance Countercyclical								
0.05	1.52	**10.0%**	1.53	**10.0%**	2.22	**13.1%**	2.58	**15.7%**

dp=down payment

amin=Minimum assets to purchase a house

Figure 5.5:

Table 7a. Cross Correlation of Res. Inv. at time (t+s) with GDP at time (t)									
Constant Interest Rates									
Model \ s	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Data	0.48	0.59	0.67	0.69	0.59	0.35	0.10	-0.11	-0.26
Calibrated to % homeowners (high rental cost)									
Earnings Variance Constant									
$\phi=0.00$	-0.06	0.02	0.13	0.28	0.54	0.22	0.16	0.00	-0.14
$\phi=0.05$	-0.05	0.02	0.11	0.23	0.45	0.11	0.07	0.00	-0.04
Earnings Variance Countercyclical									
$\phi=0.00$	0.03	0.09	0.14	0.22	0.35	0.15	-0.13	-0.18	-0.30
$\phi=0.05$	0.06	0.17	0.26	0.40	0.65	-0.15	-0.22	-0.17	-0.11
Calibrated to downpayment (low rental cost)									
Earnings Variance Constant									
$\phi=0.00$	-0.05	-0.01	0.04	0.13	0.22	0.28	0.35	0.23	-0.06
$\phi=0.05$	-0.03	0.03	0.06	0.14	0.34	-0.02	-0.06	-0.01	-0.05
Earnings Variance Countercyclical									
$\phi=0.00$	0.05	0.07	0.10	0.14	0.16	0.25	0.23	0.03	-0.01
$\phi=0.05$	0.03	0.08	0.18	0.30	0.52	-0.14	-0.21	-0.22	-0.23

Figure 5.6:

Table 7b. Cross Correlation of Res. Inv. at time (t+s) with GDP at time (t)									
Countercyclical Interest Rates									
Model \ s	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Data	0.48	0.59	0.67	0.69	0.59	0.35	0.10	-0.11	-0.26
Calibrated to % homeowners (high rental cost)									
Earnings Variance Constant									
ϕ=0.00	0.08	0.13	0.18	0.28	0.45	-0.47	-0.27	-0.17	-0.13
ϕ=0.05	0.06	0.15	0.24	0.36	0.60	-0.28	-0.29	-0.22	-0.19
Earnings Variance Countercyclical									
ϕ=0.00	0.08	0.13	0.18	0.28	0.44	-0.46	-0.27	-0.18	-0.15
ϕ=0.05	0.06	0.16	0.26	0.39	0.62	-0.14	-0.18	-0.19	-0.21
Calibrated to downpayment (low rental cost)									
Earnings Variance Constant									
ϕ=0.00	0.07	0.15	0.20	0.31	0.46	-0.33	-0.31	-0.22	-0.17
ϕ=0.05	0.03	0.10	0.19	0.32	0.50	-0.17	-0.22	-0.22	-0.22
Earnings Variance Countercyclical									
ϕ=0.00	0.12	0.17	0.20	0.28	0.41	-0.24	-0.23	-0.15	-0.15
ϕ=0.05	0.04	0.10	0.17	0.27	0.45	-0.14	-0.19	-0.19	-0.23

Figure 5.7:

Table 7c. Cross Correlation of Res. Inv. at time (t+s) with GDP at time (t)									
Procyclical Interest Rates									
Model \ s	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**
Data	0.48	0.59	0.67	0.69	0.59	0.35	0.10	-0.11	-0.26
Calibrated to % homeowners (high rental cost)									
Earnings Variance Constant									
$\phi=0.05$	-0.10	-0.14	-0.19	-0.29	-0.47	0.47	0.34	0.26	0.18
Earnings Variance Countercyclical									
$\phi=0.05$	0.07	0.16	0.24	0.39	0.62	-0.25	-0.18	-0.11	-0.10
Calibrated to downpayment (low rental cost)									
Earnings Variance Constant									
$\phi=0.05$	-0.07	-0.15	-0.22	-0.35	-0.52	0.25	0.39	0.31	0.22
Earnings Variance Countercyclical									
$\phi=0.05$	0.03	0.09	0.18	0.27	0.47	-0.22	-0.26	-0.29	-0.21

Figure 5.8: