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Consumption commitments and precautionary savings

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CONSUMPTION COMMITMENTS AND PRECAUTIONARY SAVINGS

by

Haimanti Banerjee

<u>An Abstract</u>

Of a thesis submitted in partial fulfillment of the
requirements for the Doctor of Philosophy
degree in Economics in the
Graduate College of The
University of Iowa

July 2011

Thesis Supervisor: Associate Professor Gustavo J. Ventura

ABSTRACT

In incomplete market models, agents with homothetic preferences over one non-durable consumption good and exposed to idiosyncratic income shocks use precautionary savings as an instrument to smooth consumption across different contingencies. The magnitude and role of precautionary savings is therefore essential in the understanding of savings behavior of agents in such an economy. In this dissertation, I study the effects of consumption commitments on aggregate savings behavior within an otherwise standard incomplete market framework.

In the first chapter, I explore the impact of a consumption commitment good like housing in an incomplete market framework (Aiyagari(1994), Huggett(1997)). Conceptually, I concentrate on the argument whether consumption of housing is associated with changes in risk aversion and therefore reflected in precautionary savings behavior of agents. I study an analytical framework that captures key elements in the data like (i) heterogeneity in earnings through fixed effects and uninsurable idiosyncratic shocks, (ii) fraction of income spent on housing, (iii) magnitude of moving costs.

In the second chapter, I present a dynamic incomplete market model with a key feature: a commitment good (housing) with positive transaction (moving) costs. I focus on a stationary recursive equilibrium for agents in the benchmark economy. I calibrate the benchmark model to the US economy. I find that the benchmark economy replicates (i) the fraction of income spent on housing services, (ii) the fraction of people moving in each period.

In the third chapter, I quantitatively evaluate the magnitude of precautionary savings in the presence of housing consumption in the benchmark economy and compare it to the standard incomplete market model. Results indicate that the presence of housing leads to higher aggregate precautionary savings by nearly 13% when compared to the Aiyagari specification. I find transaction costs to have significant impact on aggregate savings behavior.

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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

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has been approved by the Examining Committee for the thesis requirement for the Doctor of Philosophy degree in Economics at the July 2011 graduation.

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To my mother, Mitra Banerjee

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In the first chapter, I explore the impact of a consumption commitment good like housing in an incomplete market framework (Aiyagari(1994), Huggett(1997)). Conceptually, I concentrate on the argument whether consumption of housing is associated with changes in risk aversion and therefore reflected in precautionary savings behavior of agents. I study an analytical framework that captures key elements in the data like (i) heterogeneity in earnings through fixed effects and uninsurable idiosyncratic shocks, (ii) fraction of income spent on housing, (iii) magnitude of moving costs.

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CHAPTER 1
CONSUMPTION COMMITMENTS: THEORY

1.1 Introduction

There is considerable literature that has emphasized the quantitative importance of the role of precautionary savings as an instrument in understanding savings behavior of agents who try to smooth consumption across different contingencies. This class of models generally has standard homothetic preferences over one non-durable consumption good that can be flexibly adjusted. In this paper, the magnitude of aggregate precautionary savings behavior of agents facing uninsurable idiosyncratic shocks is studied in the presence of *committed* consumption goods. Commitment goods, as studied here, require substantial expenditures and are *difficult* to adjust in the short run. For example, consumption goods like housing, land, cars, furniture require transaction costs and therefore are relatively inflexible to changes as compared to the class of cost-lessly adjustable non-durable consumption goods.

The paper addresses the question: quantitatively, how do commitment goods affect precautionary savings in an otherwise incomplete market framework? In this paper, housing can be considered as an appropriate representative for the class of consumption goods because of its easy amenability to the empirical evidence and its significant magnitude in aggregate data. Moving typically signifies transaction costs in form of brokerage fees or sales taxes leading to infrequent adjustments. Housing is also a major component of consumption expenditure. According to the 2006 National Income and Product Accounts data, housing services represent approximately 15% of aggregate consumption expenditure and is also the single largest asset for the majority of households.[1] As a result, housing services can be considered as focus of the current study, addressing the issue of quantitative analysis of precautionary savings.

Conceptually, the paper concentrates on two conflicting arguments pertaining to savings behavior of agents in presence of housing. Consumption of housing in models with pre-committed consumption and transaction costs are associated with implicit risk aversion changes in consumers depending on whether they have sufficient wealth to trigger an adjustment in housing.[2] The parameters characterizing the ratio of non-durable consumption to housing services, the magnitude of transaction costs and the discount factor create a *zone of inaction* for consumers affecting their constant relative risk aversion measures. The underlying homothetic preferences of the consumers show increased risk aversion in the presence of the unadjustable housing services. This makes a compelling case for increased precautionary savings. Conversely, in a dynamic economics environment, consumers can choose to adjust housing and behave differently from consumers who do not expect to move in the near future. The choice of adjusting inflexible consumption might effectively reduce risk aversion in consumers.[3]

1.2 The Problem

The paper specifically tries to quantify the pivotal forces associated with the aggregate savings pattern of agents, capital accumulation and interest rate in the

[1] 80% of these services are acquired through home ownership and the remainder in the rental market. Diaz and Luengo-Prado (2008).

[2] Stokey(2008) shows that housing consumption follow (S,s) type policy where ratio of non-durable consumption to housing services and ratio of expenditure to wealth determine the behavior within the band.

[3] Vereshchagina(2008) shows discrete inflexible adjustments make agents more tolerant to small risks relative to agents in model without discreteness.

presence of a committed consumption good. In this paper, I incorporate the features of a housing good described above into a standard incomplete market general equilibrium model. Specifically, I extend the Huggett(1997) and Aiyagari(1994) framework to allow for consumption with two components: (i) one that is non-durable and cost-lessly adjustable (ii) the other involving inflexible adjustment due to transaction costs and one period pre-commitment. Agents in this economy experience uninsurable idiosyncratic income shocks and can hold a single risk free asset that enables them to smooth consumption over time. Agents derive utility from housing and pre-commit to some form of mortgage or rental payments every period. Moreover, transaction costs are incurred while moving between housing choices.

Every period in the benchmark economy, the agents receive a stochastic labor endowment and simultaneously choose consumption, asset holdings for next period *and* pre commit to a housing decision. One must note that the agents decide on the choice of a new housing level prior to the realization of the shock next period and cannot insure against any unfavorable outcome except by accumulating precautionary savings. The magnitude of associated transaction costs magnifies agent's risk aversion. Alternatively, the underlying homothetic preference structure emphasizes the importance of the share of housing goods in the utility function. Agents can move away from asset accumulation and potentially exhibit transitory behavior leading to an increase in their lifetime utility. Thus, the magnitudes of transaction costs, the coefficient of relative risk aversion, the rate of time preference and the persistence of endowment shocks differentially affects the extent of precautionary savings and requires a quantitative analysis to explain the savings behavior of agents in incomplete market model with consumption commitment.

This paper presents a benchmark model calibrated to the US economy. The analytical framework captures key elements like the heterogeneity in earnings through fixed effects and uninsurable idiosyncratic shocks, the fraction of income spent on housing good and distributional characteristics like the fraction of agents moving each period in the data. Agents have a rate of time preference that match the capital-output ratio in the data, relative risk aversion estimated from microeconomic studies and technological parameters compatible with other macroeconomic studies of incomplete markets. The labor endowments of agents in the model are calculated based on data from the Earnings of the Civilian Population, US Census 2003 where the data is categorized into two permanent types of agents who face idiosyncratic endowment shocks. Housing choices are estimated from Consumer Expenditure Survey (CEX) such that the fraction of income spent on housing services for the lowest income level considered in the economic model is consistent with the data. The share of housing services in the utility function is evaluated from National Income and Product Accounts data to match the ratio of nondurable consumption to housing.

The paper analyzes the aggregate savings behavior and focuses on a stationary equilibrium. The benchmark model solves for stationary distribution of agents across the state space for assets and housing. A general equilibrium solution of the benchmark economy focuses on the effects of aggregate capital accumulation and market clearing interest rate. Results indicate that in the benchmark economy, the presence of housing in an incomplete market model increases the magnitude of precautionary savings by nearly 4% when compared to the standard incomplete model framework. Additionally, the role of transaction costs are studied through a series of experiments where the magnitude of transaction costs are varied from the benchmark specification. Aggregate capital accumulation is estimated in each case. Findings presented in this paper show that in a model with no transaction costs, agents behave very similarly to the standard incomplete market Huggett-Aiyagari. However, increasing transaction costs from the benchmark specification causes weakly positive impact on the precautionary asset accumulation of agents.

The benchmark model overestimates the measure of transition of agents in presence of stochastic income shocks, pre-committed consumption and transaction costs as present in the economy. Consequently, to address this issue, a variation to the benchmark economy is considered. The model is extended to a generalized version where agents are exogenously restricted from the choice of housing every period. Due to the additional constraint on choice of housing consumption, agents increase their aggregate precautionary savings by almost 18% for the generalized model to replicate the measure of transition of agents in the data.

1.3 Related Literature

There is a growing interest in studying the role of the housing services in different perspectives of macroeconomic theory. Grossman and Laroque (1990) provide a framework for studying asset accumulation decisions where consumption is solely derived from the durable housing good and show that in the presence of adjustment costs, the agent reduces his fraction of wealth allocation to risky assets after investing in housing. Flavin and Nakagawa (2004) generalize Grossman and Laroque to incorporate nondurable consumption and generate implications of the habit persistence model such as smooth nondurable consumption. Current housing stock affects a household's degree of risk aversion and thereby the allocation of portfolio. Cocco (2004) focuses on the role of housing consumption in explaining the patterns of cross-sectional variation in the composition of wealth and the level of stockholdings. Liquidation costs reduce the frequency of housing adjustments. Yao and Zhang (2005) also find that the presence of liquidation costs creates a no-adjustment zone for housing services. They explicitly incorporate the rental market for housing services and show that investors purchase a house to benefit from ownership when they are no longer liquidity constrained.

Gervais (2002) focuses on the effects of preferential tax treatments on housing capital, but abstracts from uncertainty and transaction costs. Nakajima (2005) finds that a rise in earnings inequality can produce a substantial fraction of the rise in observed housing prices. Diaz et al. (2007) studies the difference between the user cost and rental price of housing to estimate the bias resulting non taxable imputed rents from housing and deductability of mortgage payments. Rios-Rull and Marcos (2006) try to replicate important macroeconomic aggregates like the distribution of earnings and of housing and non-housing wealth.

Vereshchagina (2008) finds that in a dynamic environment with same wealth levels, discrete adjustments make agents more tolerant to small risks relative to agents in model without discreteness. In a dynamic environment, with adequate savings and appropriate discount factor, consumers can choose to adjust the inflexible good and behave differently from consumers who do not expect to adjust in the near future.

The studies most closely related to this paper are Gruber and Martin (2003) and Vereshchagina (2008). Gruber and Martin (2003) investigate the role of illiquid durable consumption, which increases the precautionary motive for savings through an increase in *committed expenditure risk*. Their paper tries to match dispersion of wealth in the data and relative dispersion of financial to durable assets. The only asset considered in my benchmark economy is a risk-free asset and this paper focuses on reproducing the fraction of agents moving in the data in each period.

CHAPTER 2
A MODEL WITH CONSUMPTION COMMITMENTS

2.1 The Model

2.1.1 The Environment

I investigate a general equilibrium economy populated by infinitely lived continuum of heterogeneous agents. The model follows the standard Aiyagari(1994) and Huggett(1997) framework for studying the general equilibrium implications of uninsurable idiosyncratic earnings shock on capital accumulation, the market clearing risk-free rate of interest. The main difference in this paper relative to the standard incomplete market framework is the inclusion of a pre-committed consumption good like housing with transaction costs. The special features of the commitment good are explicitly modeled through the treatment of transaction costs and choices of housing available to agents in this economy. I focus on a stationary recursive equilibrium for agents in the benchmark economy.

2.1.1.1 Preferences

Agents derive utility from the consumption of a flexibly adjusted non durable good (e.g. food) and from a commitment good (e.g. housing) associated with costly adjustments. The preferences are represented by the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t)$$

where $\beta \in (0,1)$ is the intertemporal discount factor, c is the non-durable consumption good and h is the commitment consumption good housing. E_0 is an expectation operator conditional on information available at time 0. The period utility function is assumed to be strictly increasing and strictly concave satisfying Inada conditions in the arguments.

2.1.1.2 Endowments

Every period the agents receive labor endowments l. The labor endowment is stochastic and follows a finite state Markov transition process with transition probability

$$\pi(l^{'}|l) = Prob(l_{t+1} = l^{'}|l_t = l)$$

Idiosyncratic endowment uncertainty is generated by assuming that individual labor endowment shocks are independent across agents. Hence, there is no uncertainty over the aggregate labor endowment. To capture the heterogeneity in earnings as empirically reflected in the data, the agents are categorized into two permanent types. H and L describe high productivity and low productivity agents.

2.1.1.3 Technology

An aggregate production technology produces output in this economy. The technology uses capital stock K and labor supply N to produce an output Y. The production function is a standard constant returns to scale technology which satisfies the standard concavity conditions. The technology is given by

$$Y = F(K, N)$$

Capital depreciates at rate δ. A single representative firm associated with the technology maximizes profit every period Competitive markets ensure that firms operate a constant returns to scale technology. Therefore, individual labor earnings wl are a product of individual labor endowments and the marginal product of labor. Firms rent capital from households at the rate R. Since, firms are competitive, the return on risk-free capital assets r held by agents must be equal

$$r = R - \delta$$

. Output can be costlessly transformed into consumption goods, housing services and capital investments goods. Therefore the price of housing services will be equivalent to the consumption good which is normalized to unity.

2.1.1.4 Housing

Agents have access to housing choices each period. Housing choices in this economy can be rental arrangements or homeownership.[1] Agents pay a fixed amount h which can be broadly interpreted as rental or mortgage payments. Agents can potentially choose and pre-commit to a different housing every period before the realization of the stochastic endowment shock they will receive next period. There is a strictly positive transaction cost associated with the adjustment of the housing.[2] Agents need to bear a cost of $\eta(h, h^{'})$ while shifting from h to $h^{'}$.

2.1.2 Agent's Problem

In this economy, agents save in the form of risk-free asset, which is the only instrument available for self insurance. The asset can be interpreted as savings in risk free bonds that offer an interest rate r which translates into claims on consumption goods. The agent faces a borrowing constraint such that capital asset holdings cannot be negative. Moreover, agents have to pay a fixed amount each period for consumption of housing. Given wage rate w and interest rate r, the agent supplies labor inelastically and choose capital asset holdings and housing over time

[1] For the purpose of this study, rental spaces and houses are not considered different.

[2] Transaction costs can be interpreted as sales tax while buying a house and brokerage fees while selling a house: see Diaz and Luengo-Prado(2007)

to maximize the expected discounted value of utility.

2.1.2.1 Recursive Representation

An agent's state space at any time can be described by an individual state vector $x \in X$. $x = (a, h, l)$ indicate agent's asset holdings a, housing consumption h and labor endowment l. The individual state space is defined as $X = A \times H \times L$, where $A = [\underline{a}, \overline{a}]$, $H = [\underline{h}, \overline{h}]$. The budget constraint for an agent receiving interest payments and labor earnings can be stated as follows:

$$c + h + a^{'} + \eta(h, h^{'}) \leq wl + a(1 + r)$$

where $c > 0, a > 0$

$$\eta(h, h^{'}) = 0 \ if \ h^{'} = h$$
$$\eta(h, h^{'}) > 0 \ if \ h^{'} \neq h$$

At the beginning of each period, an agent in state h and a receives an endowment shock l . The agent simultaneously chooses consumption c, asset holdings $a^{'}$ and pre-commits to housing $h^{'}$ for next period. The dynamic programming problem for the agent with the value function $V(a, h, l)$ is stated as follows:

$$V(a, h, l) = \max_{c, a^{'}, h^{'}} U(c, h) + \beta EV(a^{'}, h^{'}, l^{'})$$

subject to $c + h + a^{'} + \eta(h^{'}, h) \leq wl + a(1 + r); \ c \geq 0, a^{'} \geq 0$

2.1.3 Equilibrium

This study evaluates the aggregate measure of precautionary savings and does not concentrate on the dynamic properties of interest rates or follows the transition of agents. Therefore, I focus on a stationary equilibrium with invariant measure of agents.

Agents are heterogeneous in their asset holdings a, housing consumption h, labor endowment l in the economy and are restricted to choose from discrete sets for housing and assets. Hence, the measure of agents is characterized over discrete grid points. Let ψ^* be the invariant probability measure of agents.

The probability measure $\psi^*(a, h, l)$ is invariant over time if it satisfies:

$$\psi^*(a^{'}, h^{'}, l^{'}) = \sum_{l} \sum_{a:a(a,h,l)=a^{'} h:h(a,h,l)=h^{'}} \pi(l^{'}|l)\psi^*(a, h, l)$$

A formal definition of the recursive stationary equilibrium is given in the Appendix A. As has become standard in the study of dynamic general equilibrium models, the stationary equilibrium satisfies

1. Distribution of agents is stationary:

$$\psi^*(a^{'}, h^{'}, l^{'}) = \sum_{a,h} \sum_{l} \pi(l^{'}|l)\mathcal{I}(a^{'}, h^{'}, a, l, h)\psi^*(a, h, l)$$

   where the indicator function $\mathcal{I}(a^{'}, h^{'}; a, l, h)$ is defined as :

$$\mathcal{I}(a^{'}, h^{'}, a, l, h) = \begin{cases} 1 & \text{if } a^{'} = a(a, h, l) \text{ and } h^{'} = h(a, h, l); \\ 0 & \text{otherwise.} \end{cases}$$

2. Markets for assets and goods clear:

$$\sum_{a,h} \sum_{l} \psi(a, h, l)a(a, h, l) = K^*$$

$$\sum_{a,h} \sum_{l} (c(a, h, l) + h(a, h, l) + \eta h(a, h, l))\psi(a, h, l) + \delta K^* = F(K^*, N)$$

where K^* is the aggregate capital stock and N is the total labor supply in the benchmark economy.

2.2 Calibration Of The Benchmark Model

The benchmark model is calibrated to the US economy. The model period is taken to be one year. The calibration aims at replicating aggregate and cross-sectional key elements from the data. The heterogeneity in earnings is captured through fixed effects and uninsurable idiosyncratic shocks across two types of agents. The fraction of income spent on housing services is a focal point in the calibration to evaluate the importance of the housing. The other objective model aims to match is the fraction of people moving in each period. The following section describes the parameters chosen for the benchmark economy. In general, parameters are carefully chosen from standard macroeconomic literature as well as estimated to reproduce key observations of the steady state. The parameters for the benchmark model are presented in Table 2.1.

2.2.1 Preferences

The value of the discount factor β is chosen such that the model's capital output ratio matches that of the US economy. The notion of capital in this model includes physical capital and housing capital. In this model, β equivalent to 0.955 achieves the capital-output ratio of 3.0.

The period utility function is of constant relative risk aversion type with γ as the coefficient of risk aversion. The particular functional form considered is

$$U(c,h) = \frac{(c^{1-\mu}h^{\mu})^{1-\gamma}}{1-\gamma}$$

The parameter μ captures the share of housing in the utility function. It is calibrated to match the fraction of income spent on housing and the transition of agents in the data in each period. The value is estimated to 0.20.[3]

The risk aversion coefficient γ for the baseline model is chosen to be 1.5 in accordance to the microeconomic studies reviewed by Mehra and Prescott (1985).

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[3]For homethetic utility functions, μ depicts the fraction spent on housing services in total consumption expenditure. The related value from Aguiar and Hurst (2008) who calculate the share of non durable housing services is found to be 0.26.

2.2.2 Technology

Output is produced using a Cobb-Douglas production technology

$$F(K,N) = K^{\alpha}N^{1-\alpha}$$

The capital share of output α is set at 0.36.[4]

Each period the stock of capital depreciates at the rate δ. Gervais (2002) reports depreciation rate for business capital from Fixed Reproducible Tangible Wealth (1993) data. δ is equal to 8.09%.[5]

2.2.3 Earnings And Heterogeneity

The heterogeneity in labor earnings are estimated from the Earnings of the Civilian Population, US Census. The agents are categorized in two groups by their educational qualifications. Agents endowed with high productivity have an educational attainment of more than 1 year of college. Alternatively, the highest educational standard of agents with low productivity is less than 1 year of college.[6]

The labor endowments of agents in j^{th} group are estimated by the following earnings process:

$$\ln(l_j) = \ln(\lambda_j) + \ln(\hat{l}_j)$$

where j=Low type L or High type H.

The log earnings of an agent of type j in period t can be separated into two components. The first component λ_j is the value of relative earnings in each group and constitutes the fixed effect of earnings as a result of their educational qualifications. The data on the relative income of high productivity workers to

[4] Aiyagari (1994) parameter specification is maintained to compare the results of the benchmark economy with the standard incomplete market model

[5] Depreciation rate for business capital is a weighted average of the depreciation of business structures and producer durables

[6] The Earnings of Civilian Population, US Census Data is described in Appendix B

the low productivity workers $\frac{\overline{l_H}}{\overline{l_L}}$ is estimated at 1.799. Hence, a high productivity worker earns nearly 1.8 times more than a low productivity worker in the benchmark economy.

Table 2.1: Parameter Values

	Parameter	Symbol	Value
Preferences	Discount Factor	β	0.95
	Coefficient of Relative Risk Aversion	γ	1.50
	Housing share in utility	μ	0.20
Endowment	Persistence of shock	ρ	0.97
	Variance of the Innovation term	σ_{ϵ}^2	0.02
	Relative Earnings	λ	1.79
Technology	Capital share of output	α	0.36
	Depreciation rate	δ	0.08
Housing	Lowest Level of housing	$\underline{h}$	0.10
	Highest Level of housing	$\overline{h}$	5.00
	Transaction Cost	$\eta(h, h')$	25%

Note: Table shows parameter values estimated for benchmark model

The second component of the earnings process $\hat{l_j}$ is the persistent shock to earnings to capture idiosyncratic uninsurable random shocks to the earnings process. It is assumed to follow a Markov chain specification with three states to match the first order autoregressive representation for the logarithm of endowment shocks:

$$\ln(\hat{l}_j^{'}) = \rho \ln(\hat{l}_j) + \epsilon_j^{'}$$

where ρ is the persistence parameter set at 0.97. The innovation term is ϵ_j which follows a normal distribution with mean zero and variance $\sigma_\epsilon^2 = 0.02$.[7]

2.2.4 Housing Services

The minimum housing size $\underline{h}$ is estimated to match the share of housing services in income before taxes for the poorest income level considered in the benchmark economy. The estimate is calculated from Table 2: Average Annual Expenditures from Consumer Expenditure Survey.[8] The fraction $\frac{\underline{h}}{y_l}$ is computed to be approximately 50%. The highest housing level $\overline{h}$ is chosen at 5.0 to match the higher limit of earnings of the highest income level of agents in the benchmark economy.

Empirical data from CPS shows estimate for moving due to idiosyncratic reasons to be at most 36% for agents with rental arrangements and approximately 6% for agents with mortgage payments.[9] Compiled together, the percentage of movers in each period is approximately 16%. The transaction costs for home-owners derived from the Consumer Expenditure Survey (CEX) is approximately 7% of the value of house.[10]

The economy typically constitutes of 68% of home-owners and 36% of renters. Renters generally have transaction costs based on the flow of housing services chosen

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[7] The values of ρ and σ_ϵ^2 are commonly used in macroeconomics literature: Storesletten, Telmer,Yaron (2004)

[8] The components of CEX data is described in Appendix B

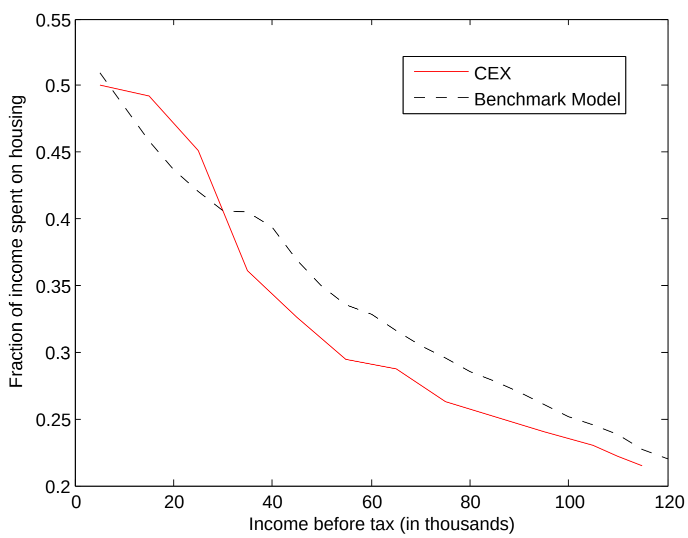
[9] Reasons for Move, Current Population Survey is described in Appendix B.

[10] Gruber and Martin (2003) estimate transaction costs from CEX data. Transaction costs typically constitute of selling costs, realtor fee and buying costs.

in the period while home-owners construct transaction costs from the stock of housing owned. For purposes of this study, a composite transaction cost is estimated with homeowners' transaction costs based upon the transformed present value of the flow of housing in each period.[11] The composite transaction costs are estimated at 20-22%. To match the twin objectives of the fraction of income spent on housing and transition of agents each period, transaction costs are calibrated at 25% in the model to be consistent with the data.

2.3 Benchmark Economy

Figure 2.1: Model v/s Data: Fraction of Income spent on Housing services



Note: Graph shows declining trend in frac of income spent on housing

[11]The incomplete market interest rate of 4% is used for the present value calculation of the flow of housing services. Transaction costs per unit of housing service for home-owners are calculated as follows: $68\%\ of\ home-owners * 6\%\ movers * \frac{7\%\ transaction\ costs}{4\%\ interest\ rate}$

Figure 2.1 depicts the declining trend of the fraction of income spent on housing with increase in income levels. The figure matches the data through two channels: (i) the parameter of lowest level of housing $\underline{h}$ is estimated to reproduce the fraction of income spent on housing by the lowest income group in the benchmark economy, (ii) at higher income levels, agents have higher earnings and larger asset holdings that reduce the inflexibility of housing consumption. The estimate of the share of housing consumption as defined in the underlying preference structure μ and transaction costs play an important role in this figure.

Table 2.2: Selected Statistics

	Data from CEX	Benchmark Model
$mean(\frac{h}{y})$	0.327	0.337
$corr(h, y)$	0.945	0.914
$corr(\frac{h}{y}, y)$	-0.925	-0.986
$Frac\ of\ movers$	16%	15.78%

Note: Table makes comparison of Data with Benchmark

Table 2.2 reports selected statistics of the benchmark economy when compared with the CEX data. The model is able to replicate the statistics for the average fraction of income spent on housing services $mean\frac{h}{y}$, the correlation between expenditure on housing services and income $corr(h, y)$ and the correlation between the fraction of housing expenditure in income and levels of income $corr(\frac{h}{Y}, Y)$. Furthermore, the model replicates the fraction of agents moving in the data in each period.

The benchmark economy studied here can be compared to a complete market model where representative agents receive a constant endowment every period. The resulting full insurance net return to capital is equivalent to the rate of time preference and is equal to 5.26%.[12]

Table 2.3: Statistics of Benchmark Economy and Aiyagari Model

	Benchmark Economy	Aiyagari Specification
r	3.35%	4.38%
K	100	87.308
$variance \ln c$	0.1074	0.1062

Note: Table shows interest rate, volatility in consumption

Not surprisingly, the heterogeneous agent in the model with incomplete market generates higher aggregate savings than the complete market case. The uninsurable idiosyncratic shocks lead to a net return of capital that is less than the rate of time preference. The standard results of the behavior of agents in the benchmark economy is summarized in the first column of Table 2.3. The agents have a net return of capital at 3.35%. The incomplete market arrangement generates increase

[12]In full insurance complete market model $r = \frac{1-\beta}{\beta}$

precautionary capital accumulation on an aggregate as implied by the higher value for K relative to the full insurance complete market case. The implications of the benchmark economy are further discussed in terms of capital accumulation, volatility in non durable consumption, magnitudes of transaction costs by conducting quantitative experiments in the next section.

CHAPTER 3
THE QUANTITATIVE IMPORTANCE OF CONSUMPTION COMMITMENTS

The magnitude of the impact of housing consumption is quantitatively evaluated in comparison to the standard incomplete market model. Further, the role of transaction costs is studied through comparative statics analysis for different rates of transaction costs. Unless stated otherwise, in each experiment, the parameters remain the same as in the benchmark economy.

3.1 Standard Incomplete Market Model

In order to highlight the properties of the benchmark model with housing good, it is contrasted with standard incomplete market model framework.[1] The Aiyagari (1994) model specification used as comparison with the benchmark economy is given by

$$U(c) = \frac{c^{1-\gamma}}{(1-\gamma)}$$

subject to $c + a^{'} \leq wl + a(1+r)$ where c is the consumption of nondurable good every period. The results from this experiment appear in the second column of Table 2.3.

The net return to capital in Aiyagari model is 4.38% and is lower than the full insurance case. Therefore, the benchmark economy exhibits a moderately higher level of aggregate precautionary savings in comparison to the Aiyagari case. Overall, the presence of housing consumption in an otherwise incomplete market framework results in higher aggregate precautionary savings by nearly 13% when compared to the Aiyagari specification. The inflexibility in housing also creates a slightly higher

[1] Aiyagari(1994), Huggett(1997).

volatility in non-durable consumption as seen in the benchmark economy.

In Aiyagari model, the constant relative risk aversion is given by

$$\frac{-cU''(c)}{U'(c)} = \gamma$$

like in a standard case of homothetic preferences where the consumption good can be viewed as a composite of both inflexible and non durable consumption.

In order to explain the results in Table 2.3, let us assume an extreme case where the housing consumption is completely inflexible. The above risk aversion measure becomes

$$\frac{-cU''(c)}{U'(c)} = \gamma(1-\mu) + \mu$$

Since μ is a positive fraction mapped from the data, risk aversion *decreases* with the addition of the inflexible housing if $\gamma > 1$. Hence, intuitively, one could expect a lower aggregate precautionary savings each period. For a fixed inflexible consumption of housing, agents do not need to pre-commit to a different housing good every period and therefore the volatility in non-durable consumption should decrease.

In the dynamic environment of the benchmark economy, agents can potentially adjust housing in presence of favorable income shocks by pre-committing to a choice of housing based on their current state and expectation about the future idiosyncratic shock. It turns out, despite seemingly lower risk aversion in the analyzed benchmark economy, aggregate capital accumulation is *higher* with pre-committed housing good and transaction costs. This effectively occurs because the forces associated with housing commitment dominate reduced risk aversion in agents. Housing is selected prior to the realization of the uninsurable shock and therefore pre-commitment and transaction costs magnify savings response of agents towards idiosyncratic risks.

3.2 Role Of Transaction Costs

To quantify the impact of transaction costs on the savings motive of agents, the benchmark model is compared with two other models: framework with $\eta = 0\%$ and $\eta = 50\%$. The results appear in Table 3.1.

Table 3.1: Role of Transaction Costs

	$\eta = 0\%$ cost	Benchmark 25% cost	$\eta = 50\%$ cost
r	4.05%	3.35%	3.06%
K	91.072	100	104.127
$\frac{T}{Y}$	0	5.3%	9.8%
$mean\frac{h}{y}$	0.251	0.337	0.374
$var\ln h$	0.0486	0.0481	0.0480

Note: Comparison of Models with 0% and 50% transaction costs

The first model is modified to a framework with no transaction costs ($\eta = 0\%$). The model considers a housing good that is not inflexibly adjusted anymore. However, agents still pre-commit to housing next period but do not need to pay any transaction cost to move. The other model takes the opposite extreme view by doubling the transaction costs associated with adjustments (η=50%).

The level of capital accumulation clearly indicates that aggregate precautionary savings increase with the increase in transaction costs. The model with 0%

transaction costs has higher returns to capital as compared to the benchmark economy. This model is very similar to the Aiyagari specification in Table 2.3 in terms of capital accumulation and shows nearly 9% decline in assets even though agents still need to pre-commit to housing next period. Since they do not have to pay transaction costs, the average expenditure on housing is higher than in the benchmark economy. The variability in housing consumption also increases in the absence of transaction costs.

Alternatively, the model with 50% adjustment costs have a modest impact on the savings pattern of agents. The precautionary savings increase by nearly 4% relative to the benchmark economy. Transaction costs in the benchmark economy amount to nearly 5% of the total output. But in the model with 50% transaction costs model, agents in the aggregate spent nearly 9% of the total output to adjustment costs. The volatility in housing consumption decreases weakly with increase in transaction costs.

3.3 Differing Bounds Of $\underline{h}$

This experiment studies the impact of a change in the lower bound of housing available in this economy. The minimum housing levels available to agents differs in this experiment. The two extreme cases considered are model specifications with fraction of income spent on housing by the lowest income group to be $\frac{\underline{h}}{y_l}$ equal to 25% and 75%. The results are shown in Table 3.2.

It is interesting to note the savings pattern declines slightly with increased lower bound on housing services. The basic intuition for slight changes arises from the calibration of this experiment. Since the change of lower bound is associated with necessary changes in the lowest asset level and lowest level of housing on the

Table 3.2: Differing Bounds of $\underline{h}$

	Low $\frac{h}{y_l} = 25\%$	Benchmark $\frac{h}{y_l} = 50\%$	High $\frac{h}{y_l} = 75\%$
r	3.67%	3.35%	3.12%
K	95.75	100	103.25

Note: Comparison of Benchmark with two other extreme bounds

computational grid, the equilibrium effects therefore show a slight change in levels of asset accumulation.

3.4 Differing Degrees Of Risk Aversion

This experiment modifies the benchmark model with an increase in the degree of risk aversion. The coefficient of relative risk aversion is increased to $\gamma = 5$. The results are shown in Table 3.3.

Table 3.3: Differing degrees of Relative Risk Aversion

	Benchmark	High Risk Aversion	Aiyagari specification
r	3.35%	1.25%	1.95%
K	100	137.68	122.84
$var \ln c$	0.1074	0.0169	.0993

Note: Table shows effect on savings with increased risk aversion

In the dynamic environment of the benchmark economy, housing is selected prior to the realization of the uninsurable shock and therefore pre-commitment and transaction costs magnify savings response of agents towards idiosyncratic risks. With increase in risk aversion, agents increase their precautionary asset accumulation by nearly 38%. In the case of higher risk aversion for the standard incomplete market Aiyagari model, the asset accumulation is higher by 22% when compared to the benchmark model.

3.5 Conclusion

In macroeconomic literature, precautionary savings held for the sole purpose of smoothing consumption across different contingencies have been quantitatively studied in an incomplete market framework. The contribution of this paper is to estimate the magnitude of precautionary savings for agents in the presence of consumption commitments. Analytical findings indicate that savings behavior is amplified in the presence of pre-commitment in housing and associated transaction costs despite reduced risk aversion in agents.

Relative to the standard incomplete market model, the benchmark economy introduces housing associated with transaction costs. In each period, agents after the realization of the idiosyncratic shock, decide on the choice of housing for next period. Agents also pay transaction costs to accommodate the choice of a new housing consumption. A recursive stationary equilibrium is calibrated for the benchmark economy to capture and reproduce key distributional elements from the data.

In presence of housing associated with transaction costs, the benchmark economy exhibits a higher precautionary asset accumulation on an aggregate of nearly

13% when compared to the stylized Aiyagari specification. Since, there are no channels to insure against the shock next period, the pre-commitment on housing adds to the element of precautionary savings pattern of agents. The transaction costs can potentially eliminate the possibility of a move given the endowment shock and asset position of agents. The benchmark effectively reproduces the fraction of income spent on housing in the data across different levels of income of agents present in the model economy. Furthermore, the benchmark matches the fraction of agents moving in the data in each period.

In recent times, habit formation models have been studied in incomplete market framework to quantitatively evaluate the magnitude of precautionary savings. The issue of habit formation in presence of consumption commitment good like housing would be worth pursuing in future work. The notion of pre-commitment associated with transaction costs in the presence of habit persistence can potentially have a significant impact in the form of higher aggregate precautionary savings behavior.

APPENDIX A
DEFINITION AND COMPUTATIONAL PROCEDURE

A.1 Definition Of Equilibrium

An agent's state space at any time is described by an individual state vector $x \in X$. $x = (a, h, l)$ indicate agent's asset holdings a, housing consumption h and labor endowment l. The individual state space is defined as $X = A \times H \times L$, where $A = [\underline{a}, \overline{a}]$, $H = [\underline{h}, \overline{h}]$, $L = [l_1, l_2, l_3]$. Let ψ^* be the invariant measure of agents and $\mathcal{I}(.)$ be the indicator function.

A recursive stationary equilibrium is a set of decision rules, $c(a, h, l), a(a, h, l), h(a, h, l)$ and corresponding value functions $V(a, h, l)$, aggregate capital K^* and labor N, prices, r^* and w, and invariant probability measure ψ^* of agents such that the following conditions hold:

1. Given factor prices,the decision rules for agents are optimal and solve:

$$V(a, h, l) = \max_{c,a',h'} U(c, h) + \beta EV(a', h', l')$$
$$subjectto\ c + h + a' + \eta(h, h') \leq wl + a(1 + r)$$

2. Factor prices are competitively determined.

$$r = F_1(K, N) - \delta$$
$$w = F_2(K, N)$$

3. Market clearing conditions hold:

   Factor markets clear:

$$\sum_{a,h} \sum_{l} \psi(a, h, l)a(a, h, l) = K^*$$
$$\sum_{a,h} \sum_{l} \psi(a, h, l)l = N$$

   Goods market clear:

$$\sum_{a,h}\sum_{l}(c(a,h,l)+h(a,h,l)+\eta h(a,h,l))\psi(a,h,l)+\delta K^{*}=F(K^{*},N)$$

4. The distributions of agents is stationary :

$$\psi^{*}(a^{'},h^{'},l^{'})=\sum_{a,h}\sum_{l}\pi(l^{'}|l)\mathcal{I}(a^{'},h^{'},a,l,h)\psi^{*}(a,h,l)$$

where the indicator function $\mathcal{I}(a^{'},h^{'};a,l,h)$ is defined as :

$$\mathcal{I}(a^{'},h^{'},a,l,h)=\begin{cases}1 & \text{if } a^{'}=a(a,h,l) \text{ and } h^{'}=h(a,h,l);\\ 0 & \text{otherwise.}\end{cases}$$

A.2 Computational Procedures

To solve the agent's decision problem describes in the Section 2.1, I follow a value function iteration approach. The individual state space contains two endogenous variables (housing and assets) as well as exogenous idiosyncratic shock. Given a pair of prices (r,w), I solve for the agent's problem. The Markov transition probabilities for three state spaces are generated through the Tauchen algorithm. There are 100 grid points considered for both asset and housing grid positions. For an initial guess of value function V_0 and each asset position on the grid, I numerically solve for the housing policy function $h(a,h,l)$ that maximizes the intermediate expected value function. The policy function of assets $a(a,h,l)$ gives the overall maximum of the value function and I get an updated V_1. If V_1 and V_0 are close enough, the function reaches a fixed point. If they are not, I iterate on to get a V_n close to V_{n-1}.

To solve for the invariant distribution of agents, I choose an initial distribution ψ_1. I compute the probability measure of agents for next period ψ_2 using consistent policy functions and the Markov transition matrix. If ψ_2 is not close to ψ_1, the process is iterated upon for an invariant distribution of ψ^{*}.

Given policy function and the invariant measure of agents, I compute aggregate assets in the economy. This may not be consistent with the aggregate capital as implied by the given prices (w, r). Hence, an initial r_0 is chosen from the interval $r_1 < r_2$ where r_0 is the midpoint of the interval. If the asset market does not clear, I update to a new interest rate r using the bisection method. For example, if $\sum_{a,h} \sum_l \psi(a, h, l) a(a, h, l) > K^*$, then r_0 is new upper bound of the interest rate interval and the new r is the midpoint of the interval r_1 and r_0. The above procedure is repeated till aggregate assets are very close to the capital stock.

APPENDIX B
DATA

B.1 NIPA Data

The parameter μ in the utility function is calibrated from Real Personal Consumption Expenditures by Major Type of Product, (Chained Dollars) from NIPA Table 2.3.6. for the years 1990 to 2009. In the benchmark economy, μ is the share of the inflexible housing good in the utility function. From first order condition of homothetic preferences,

$$\frac{h}{c} = \frac{\mu}{1-\mu}$$

Intuitively, the marginal rate of substitution of housing with respect to non-durable consumption is given by $\frac{\mu}{1-\mu}$. The parameter helps to generate and match the data for the declining trend in fraction of income spent on housing services as income levels increase.

From the NIPA Table 2.3.6, Total Expenditure on housing services is computed from:

1. Housing (line 14)
2. Household operation (line 15)
3. Furniture and Household equipment (line 4)
4. Other Household Durable goods (line 5)

For the denominator of the fraction, Personal consumption expenditures (line 1) excluding housing services is calculated.

The estimate of $\mu = 0.26$ closely matches the Aguiar and Hurst (2008) findings of the share of non durable housing services in the consumption data.

B.2 Consumer Expenditure Survey CEX Data

The CEX data is used for figure 2.1 in Chapter 2 to plot the fraction of income spent on housing services for increasing levels of income.

In this data, a consumer unit comprises either: (1) all members of a particular household who are related by blood, marriage, adoption, or other legal arrangements; (2) a person living alone or sharing a household with others or living as a roomer in a private home or lodging house or in permanent living quarters in a hotel or motel, but who is financially independent; or (3) two or more persons living together who use their income to make joint expenditure decisions. Financial independence is determined by the three major expense categories: Housing, food, and other living expenses. To be considered financially independent, at least two of the three major expense categories have to be provided entirely, or in part, by the respondent.

Income is the combined income of all consumer unit members (14 years of age or over) during the 12 months preceding the interview. Money income before taxes is the total money earnings and selected money receipts during the 12 months prior to the interview date. Money income includes the following components:

1. Wages and salaries
2. Self-employment income
3. Social Security, private and government retirement
4. Interest, dividends, rental income, and other property income
5. Unemployment and workers' compensation and veterans' benefits
6. Public assistance, supplemental security income, and Food
7. Regular contributions for support

Housing is a major expenditure in the consumer units. In the benchmark model, housing consists of the following:

1. Owned dwellings includes interest on mortgages, interest on home equity loans and lines of credit, property taxes and insurance, refinancing and prepayment charges, ground rent, expenses for property management and security, homeowners' insurance, fire insurance and extended coverage, expenses for repairs and maintenance contracted out, and expenses of materials for owner-performed repairs and maintenance for dwellings used or maintained by the consumer unit. Mortgage principal repayments are payments of loans.
2. Rented dwellings includes rent paid for dwellings, rent received as pay, parking fees, maintenance, and other expenses.
3. Other lodging includes all expenses for vacation homes, school, college, hotels, motels, and other lodging while out of town.

B.3 Census Data

The benchmark economy captures the heterogeneity in earnings from the macroeconomic data. The agents are categorized in two groups by their educational qualifications. Agents assumed to have high productivity have an educational attainment of more than 1 year of college. Alternatively, the highest educational qualification of low agents with low productivity is less than 1 year of college.

The fixed effects component of earnings of agents are estimated from Table 4: Earnings of the Civilian Population 18 to 64 Years by Educational Attainment, Age and Work Status: 2003-2009. The low type agents have mean annual earnings of \$11,901 and they constitute of 0.495 fraction of the entire civilian population of the model. The high type agents have at least some college experience of over 1 year. The mean annual earnings of the high type agents are \$21,413 and they constitute

0.505 fraction of the population. On an average, high productive agents earn 1.8 times more than low productive agents.

B.4 Current Population Survey (CPS) Data

The generalized version of the benchmark economy reproduces the fraction of people moving in each period in the data. The measure of people moving in each period is estimated from Tables 2-11: Reasons for Move and Choice of Current Residence–Occupied Units and Table 2-12: Income Characteristics–Occupied Units from Current Population Survey (CPS) data, 2003-2009. The main reason for leaving previous unit were:

1. New job or job transfer
2. To be closer to work/school/other
3. financial/employment related
4. Needed larger house or apartment
5. Choice of Present Neighborhood
6. Convenient to job
7. Convenient to leisure activities
8. Convenient to public transportation
9. Good schools
10. Looks/design of neighborhood.

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