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The Tax Treatment of Homeowners and Landlords and the Progressivity of Income Taxation*

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Abstract

This paper analyzes the connection between the asymmetric tax treatment of homeowners and landlords and the progressivity of income taxation using a quantitative overlapping generations general equilibrium model with housing and rental markets. Our model emphasizes the determinants of tenure choice (own vs. rent) and the household decision to supply housing services to the rental market. This formulation breaks the link between the rental price and the equilibrium interest rate and, hence, the aggregate supply of rental property responds differently to the direction of rental price changes, marginal tax rate changes, and maintenance cost changes. We show that the model replicates the key factors and the distributional patterns of ownership, house size, and landlords. The degree of progressivity in the income tax code has important implications for housing tenure and housing consumption. We find a movement toward a less progressive income tax code can generate sizeable increases in homeownership and welfare that result from the equilibrium effects and a portfolio reallocation mechanism absent in economies with a single asset (i.e. Conesa and Krueger (2006)). An examination of the removal of existing asymmetries in the tax code are found to have effects on housing that differ from those reported in the literature. We show that housing policy can increase the ownership rate of a particular segment of the population, but generate nontrivial distributional costs. The welfare increases are no larger than those found when the progressivity of the tax code is reduced.

Keywords: Incomplete markets, heterogeneous consumers

J.E.L. codes: E2, E6, R2

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Introduction

The use of the tax code to promote owner-occupied housing dates back to the Civil War era. The most prominent provisions of the current tax code argued to impact housing are: the deductibility from taxable income of mortgage interest payments and property taxes; the exclusion of the imputed rental value of owner-occupied housing from taxable income; and the special treatment of capital gains upon the sale of the house. The tax treatment of owner-occupied housing introduces a wedge into the decision to invest in housing relative to real capital as well as the decision on homeownership relative to renting. The impact of tax policy on these margins has been studied by many authors. For example, Laidler (1962), Aaron (1972), and Rosen (1972) employ Harberger methods for measuring excess burden to examine the efficiency losses of tax policy.[1] Other authors have used a general equilibrium approach to study this issue. Berkovec and Fullerton (1992) employ a static disaggregated general equilibrium model to study the implications of tax policy for housing and portfolio choices. They find that when all the tax advantages to homeownership are disallowed, the total quantity of owner housing consumption decreases by three to six percent as well as the fraction of owners. The benefits to homeowners from the mortgage interest rate and property tax deduction are found to be minimal. Gervais (2002) examines the taxation of housing in the context of a dynamic life-cycle economy with housing rental services provided by a rental firm. He finds that mortgage interest deductions or the taxation of imputed rents have very small distributional effects from a long-run perspective.

Most studies have ignored two important dimensions that can have implications for the quantitative assessment of these asymmetries. The first dimension is the responsiveness of the supply of rental property since renting is the alternative to owning. We argue that housing investment decisions are joint with the decision on how to use the services generated from this investment. Empirical evidence from the *Property Owners and Managers Survey* of the Census Bureau indicates that households or non-institutional proprietors own most of the rental property. Existing studies, in general, ignore this margin which has implications for rental supply responses by assuming a perfectly inelastic supply of rental services or a 'stand-in' rental firm with a perfectly elastic supply. With either specification changes in the asymmetric treatment of owner-occupied housing via income taxation have no effect in the supply of rental property.[2] We argue that this is not necessarily the case in a model where aggregate rental supply has a positive slope and there is endogenous entry/exit into this market. The second dimension is that the asymmetries in the tax treatment of housing can be magnified in the presence of nonlinear income taxation. Households can use housing consumption/investment goods to affect the marginal tax rate. In addition, since all landlords face different marginal tax rates their supply of rental units responds in a non-trivial manner to changes in the rental price. That includes changes in the number of rental units supplied by a given landlord as well as a change in the number of households that choose

[1] Aaron (1972) estimates the extent to which households' liability would change if the imputed net rent would be taxed. He finds that tax liabilities as a percentage of gross income would increase. While there is some tendency for this to be increasing in income, it is certainly not monotonic. One of the limitations of the approach it that assumes that gross imputed rents are independent of changes in the tax code.

[2] With a stand-in firm an arbitrage condition ties the rental price to the interest rate and the depreciation rate of rental property. In equilibrium, the net return on rental investment should be equal to the return on capital and the stock of rental-occupied housing is entirely determined by the demand for rental property. More importantly, only housing policies that affect maintenance cost will have an impact on the equilibrium rental price.

to rent property. The strategic component is relevant not to only understand the impact of housing policy in housing tenure and investment decisions, but changes in income taxation.

The objective of this paper is two fold. First, we examine the impact of the asymmetries of the tax treatment of owner and rental-occupied housing in the presence of nonlinear taxation. These asymmetries are introduced by allowing mortgage interest payments to be deductible from taxable income, and the exclusion of the imputed rental value of owner-occupied housing from taxable income. Second, we explore the determinants of the supply of rental property and its response to the existing tax provisions, changes in the progressivity of the tax code, and to alternative housing policies designed to increase the number of households that own the housing.

In order to analyze the posed issues, we construct a quantitative general equilibrium overlapping generations model with housing. Households face uninsurable labor income, life uncertainty, and borrowing constraints. They make decisions with respect to consumption of goods and housing services. Housing investment is part of the household's portfolio decision and differs from capital investment along several dimension. Housing investment is lumpy and indivisible, is subject to idiosyncratic capital gains shocks, requires a downpayment and long-term mortgage financing, and is subject to differential tax treatment. Households have the option to purchase housing services in the rental market. Mortgage loans are available from a financial sector that receives deposits from households and also loans capital to private firms. The production sector considers neoclassical firms that use capital and labor to produce a consumption/investment good and housing. The government has the role of taxing income and providing retirement benefits through a social security system and funds some exogenous level of expenditure. Income taxes are distortionary, especially as they pertain to mortgage finance. We estimate the structural parameters of the model to match certain moments in the U.S. economy. We show that the model replicates the key factors and the distributional patterns of housing ownership, housing consumption, and distribution of landlords.

The primary findings in this paper are:

- Modeling the supply of rental housing services as part of the household decision problem breaks the link between the rental price and the equilibrium interest rate. As a result, we find that the aggregate supply of rental property responds differently to the direction of rental price changes, marginal tax rate changes, and maintence cost changes. The rental firm paradigm does not capture these effects.

- The degree of progressivity in the income tax code has important implications for housing tenure and housing consumption. We find a negative and quantitatively significant relationships between the progressivity in the income tax code and homeownership and housing consumption. A reduction in the marginal tax rate even in the presense of the deductibility mortgage interest payments reduces the incentives to purchase larger housing units. In equilibrium, households increase saving which causes the interest rate to fall and average income increases. The income effect in conjunction with a lower mortgage rate allow young and low income households to purchase a house. The impact of the asymmetries in the tax code is minimized through a less progressive system welfare increases.

- We find that the welfare gains associated with a decrease in the progressivity of the income tax code are much larger than the gains reported in Conesa and Krueger (2006).

This suggests that the importance of income tax reforms are amplified in the presence of housing.

- The taxation of the imputed rental income from owner-occupied housing has a small but positive effect on housing consumption and increase the aggregate ownership rate. This result is due to our assumption that policy changes be revenue neutral combined with the rental supply response. These findings are in contrast with Berkovic and Fullerton (1992) and Rosen and Rosen (1980). If we hold prices constant, we find results similar to Rosen and Rosen's partial equilibrium results. This highlights the importance of a general equilibrium approach in this context.

- We find that the elimination of the mortgage interest deduction slighly reduces the consumption of owner-occupied housing, but has a positive effect on homeownership. This result is a consequence of the rental property supply response and the benefits from tax reduction that follows from the revenue neutrality assumption. These results differs from the findings of Rosen (1980) and Gervais (2002) who estimate an elimination of the mortgage interest deduction would reduce in the aggregate ownership rate, but supports Glaesser and Shapiro (2002) conjecture that this policy has a small, but not negative impact, in homeownership.

- We show that housing policy can increase the ownership rate of a particular segment of the population, but generates non-trivial distributional costs in terms of welfare. We consider two different housing policies designed to reduced the difficulty that some families have in accumulating a downpayment. We find that certain policies of this type can increase the homeownership rate and be welfare enhancing. However, the welfare increases are no larger than those found when the progressivity of the tax code is reduced.

This paper is organized into five sections. In the first section, we present some empirical facts that surround the decision to become an owner of rental property. The next section develops our model economy and explains how we estimate the model using calibration targets from the US economy. In the third section, we explore the determinants of the rental supply and decompose the intensive and the extensive margins. The fourth section employs the model economy to measure the effectiveness of these provisions, and its impact to changes in the degree of progressivity of income taxation. In the fifth section we evaluate the welfare implications of alternative housing policies. The final section concludes.

1 Empirical Evidence Rental Markets

The modeling decision on how rental housing services are provided to the marketplace has implications for tax policy analysis. We argue that the decision to supply rental property is entwined with the decision to invest in housing and the decision to consume housing services. Tax policy introduces wedges into these decisions creating implications for the supply of rental property. The rental firm construct ignores these tax implications. In this section, we examine data that pertains to the decision to supply rental property.

In 1996, the Census Bureau conducted a survey, the *Property Owners and Managers Survey* (POMS), with the purpose of increasing understanding of the rental housing market. The POMS sample includes 16,300 units which are rented or vacant for rent. Ninety percent of these properties are located inside metropolitan areas. Among all units, seventy-nine percent are residential. A rental unit is defined as a property rented for cash, and either occupied by someone other than the owner or vacant and available for rent. Two types of rental properties are included. The first type is the single-unit rental property which includes single-family detached or attached houses, condominium units, cooperative units, or mobile homes. The second type is multi-unit rental property which includes units in an apartment complex. We use this survey to assemble facts for model development and evaluation purposes.

We want to investigate whether households or firms are the main holders of rental property. This determines whether the landlord decision should be modeled from the point of view of a dynamic firm, or as part of the household problem. If a household is defined as noninstitutional investors, trustees for an estate, or a limited partnership, Table 1 indicates that households own over 90 percent of rental units.[3] While this data shows that households play an important role in the provision of rental housing services, we can not rule out the possibility that a few institutional firms account for a large percent of units rented. Such a finding would suggest the rental firm paradigm might be appropriate. In order to investigate this possibility, we examine ownership by the number of units owned. As can be seen, the noninstitutional investor still dominates rental ownership.

Table 1: Ownership and Rental Property

Type of Owner	**Total Units**	**Less than 5 Units**	**5 to 49 Units**	**50 or more Units**
Individual Investor, husband/wife	86.3	89.9	74.4	30.6
Trustee for Estate	2.0	1.9	2.6	1.0
Limited Partnership	2.8	1.7	5.5	25.4
General Partnership	2.9	2.2	5.2	12.9
Real Estate Investment Trust	0.7	0.6	1.2	2.6
Real Estate Corporation	1.6	1.0	3.7	10.9
Other Corporation	1.3	0.9	3.0	5.7
Non-profit or Church	0.7	0.3	2.0	6.1

Source: Property Owners and Managers Survey (POMS)

We examined data on the acquisition of rental property. POMS reports that 85.3 percent of the rental units were explicitly purchased while only 6.6 percent were inherited (or gifted). This indicates that bequests do not play an important role in the decision to become a landlord. Table 2 details how the purchase of rental property is financed. As can be seen, the vast majority (75 percent) of rental property is financed through a mortgage type loan. This suggests that in modelling the landlord decision the financing aspect of the decision is similar to the financing decision for an owner occupied unit. POMS also indicates that a downpayment is part of the landlord's financing package.

[3]POMS defines a noninstitutional owner to be individual investor (husband and wife), trustee for estate, limited partnership, and general partnership.

Table 2: Financing of Acquired Rental Property

Financing Method	Frequency	Percent
Mortgage Financed	4,046	75.5
Collateralized Borrowing	186	3.5
Cash	784	14.6
Some other manner	343	6.4
Total	5,359	100

Source: Property Owners and Managers Survey

The sources of the downpayment are bank cash deposits (61.6 percent), collateralized non property borrowing (8.3 percent), sale of other real estate (7.8 percent), and the sale of stocks and other savings vehicles (9.8 percent). Only 10 percent of the real estate acquisitions are not financed with a downpayment. These facts suggest that the landlord and owner occupied decisions should be modeled in a similar manner.

We are also interested in the characteristics of individual landlords along several dimensions. We would like to know how the provision of rental services varies with age and income (or wealth) of the household. In Table 3 we report the ownership of rental property - either single or multiple properties - by age. We observe

Table 3: Structure of Ownership of Rental Property by Age

Age Cohort	Percent who Own
25 and under	0.2
26 to 35	5.1
36 to 45	16.9
46 to 55	25.5
56 to 65	25.8
66 to 75	17.5
76 and older	9.0

Source: Property Owners and Managers Survey

that the average number of units exhibits a hump over the life-cycle with the peak occurring in the 56-65 age cohort. For our purposes, the major finding is that all age cohorts up to age 65 are represented in the rental market.

Table 4: Structure of Ownership of Rental Property by Income

Income Range	Percent who Own
Under \$10,000	6.0
\$10,000 to \$30,000	19.5
\$30,000 to \$50,000	20.5
\$50,000 to \$75,000	16.1
\$75,000 to \$100,000	8.9
Over \$100,000	29.0

Source: Property Owners and Managers Survey

Table 4 focuses on the ownership of rental property by income. As would be expected, households with income over \$100,000 account for the largest ownership percentage. A more interesting finding is that close to forty percent of rental properties are owned by individual's who earn between $10,000 and $50,000 in income. This indicates that a model should find the provision of rental services at all income levels.

In sum, some of the important facts pertaining to the rental market are:

- Households or non-institutional proprietors own most of the rental property.
- The size distribution of landlords is skewed with more than fifty percent of the landlords owning less than five units.
- Most of rental properties are acquired and financed through a mortgage type loan.
- The probability of being a landlord increases with age and income.

These findings suggests that a theory that ignores the presence of the rental market as part of the housing investment decision could miss an important channel through which tax policy impacts decisions.

2 The Model

The economy is a general equilibrium overlapping generations growth model comprised of households, firms, a financial intermediary and government. Households derive utility from the consumption of goods and housing services. They face uninsurable mortality and labor income risks due to the lack of annuity markets and the absence of state contingent bonds. Households can partially insure by investing in a risk free financial asset and/or housing. The financial asset is denoted by a and offers a riskless return. Short-selling is precluded indicating that asset markets are incomplete. Investment in housing, h, differs from the financial asset along several key dimensions. Housing generates services which are marketable. In addition, housing is risky due to an idiosyncratic capital gain shock that is realized upon the sale of the property. Investment in housing is indivisible and requires financing through a long term mortgage. Mortgage contracts are available from a financial institution who receives deposits from the household. The financial firm also makes loans to firms in the form of capital investment. Firms use capital and labor to produce a good that can be used for consumption, capital or housing purposes. The government provides social security benefits to the retired by taxing the income of working households.

2.1 The Financial Intermediary and Mortgage Contracts

The financial intermediary is a zero profit firm. This firm receives deposits from households, a' and uses these funds to make loans to firms and households. Firms take out loans of capital to produce goods and households use long-term mortgages to finance the housing investment. Financial intermediaries receive mortgage payments, principal payments from those individuals who sell their home with an outstanding mortgage position, as well as the outstanding principal of individuals who unexpectedly die.

Since housing investment is large and indivisible, we assume that households are required to used long-term loans. The financial institution offers a uniform mortgage product to all households that desires to invest in housing. The mortgage contract is a function that specifies the length of the contract, the downpayment requirement, and the repayment schedule.

More precisely, the decision to purchase a house of value ph' requires a downpayment equal to $\chi \in [0, 1]$ percent of the value of the house. Hence, the total amount of borrowing is equal to $D_N = (1 - \chi)ph'$ where the subscript N denotes the length of the mortgage. We will denote z to be a vector of variables that pertain to the mortgage contract and include the downpayment fraction, χ, the length of the mortgage contract, N, the period remaining on the mortgage contract, n, and the mortgage interest rate, r^m.The repayment schedule is given by a mortgage payment function that depends on the vector z as well as the price of housing and the size of the housing investment relevant to the contract. We define the mortgage payment function as $m(z, p, h')$, and this payment is comprised of an interest payment, $I(z, p, h')$, and a principal (amortization) payment, $A(z, p, h')$. The remaining debt and equity positions are represented by $D(z, p, h')$ and $H(z, p, h')$, respectively.[4] If a household chooses to change their investment position, $h' \neq h$, their existing housing investment must be sold and a new housing position purchased.[5]

2.2 Households

Households are indexed by their asset holding, a, investment position in housing, h, remaining periods on the mortgage, n, the idiosyncratic income shock, ϵ, and age, j. We will summarize the household state by $\Lambda = (a, h, n, \epsilon, j)$. Households live a maximum of J periods, and survival each period is subject to mortality risk. The probability of surviving from age j to age $j + 1$ is denoted by $\psi_{j+1} \in (0, 1)$, with $\psi_1 = 1$.

Household's preferences are given by the expected value of the discounted sum of momentary utility functions:

$$E \sum_{j=1}^{J} \beta^{j-1} \psi_j u(c_j, d_j) \tag{1}$$

[4]According to American Housing Survey (AHS) and POMS, 91 percent of homeowners and 87 percent of landlords use fixed rate mortgages (FRM). This mortgage contract is comprised of an increasing amortization schedule of the principal, and a decreasing schedule for interest payments, so that the payment schedule is constant. That is,

$$m(z, p, h') = A_t + I_t,$$

and satisfies

$$m(z, p, h') = \frac{r^m}{[1 - (1 + r^m)^{-N}]} D_N.$$

The contract front loads the interest rate payments and back loads the principle payments where

$$A_t = m(z, p, h') - r^m D_t.$$

The laws of motion for debt and home equity are

$$D_{t-1} = (1 + r^m) D_t - m(z, p, h'), \qquad \forall t,$$

and

$$H_{t-1} = H_t + [m(z, p, h') - r^m D_t], \qquad \forall t,$$

where $H_N = \chi ph'$ denotes the home equity in the initial period.

[5]This assumption differs from the standard durable good model where individuals can expand the set of durables every period until they attain their desired level. In our model, households can purchase homes of different sizes, but they are forced to sell if they desire to buy a different unit. Since housing investment requires the use of a long-term mortgage contract, it becomes computationally infeasible to have households holding a housing portfolio with different mortgage balances.

where $0 < \beta < 1$ is the discount factor, c_j, is the consumption of goods at age j, d_j,is the amount of housing service consumption. The utility function is neoclassical and satisfies the standard properties of continuity and differentiability.

Housing investment is lumpy and indivisible, and the price of a unit of housing is p. The size of housing investment is restricted by the set $\mathcal{H}$ where $\mathcal{H} \equiv \{0\} \cup \{\underline{h}, ..., \overline{h}\}$, $\underline{h} < ... < \overline{h}$, $\underline{h}$ is the minimum housing investment , and $\overline{h}$ is the upper bound on housing investment. Housing investment, $h > 0$, generates a flow of housing services, s, that can be consumed. We assume a linear technology, $s = g(h') = h'$, that transforms the housing investment in the current period into housing services. A household can choose a dwelling size that is equal or less than the housing investment position The separation between housing investment and housing consumption allows us to formalize rental markets. Those households that have a positive housing investment can choose to consume all housing services $s = h' = d$, or pay a fixed cost $\varpi > 0$ and sell (lease) some services in the market equal to $h' - d$ at the rental price R. Homeowners that consume housing services equal to their housing investment position forgo rental income which captures the opportunity cost of owner-occupied housing explicitly in the budget constraint.

Net rental income earned from the housing investment y_r is defined as

$$y_r = \begin{cases} R(h' - d) - \varpi - x(h', d) & \text{if } d < h' \text{ and } h' > 0 \\ -x(h', d) & \text{if } d = h' \text{ and } h' > 0 \\ 0 & \text{if } h' = 0 \end{cases}$$

where the term $x(h', d)$ represents the housing maintenance expense. The rate that housing depreciates depends on whether housing is owner-occupied or rental-occupied. A homeowner that chooses a dwelling that this equal to their housing investment position incurs a maintenance expense equal to $x(h', d) = \delta_o p h'$ where δ_o represents the depreciation rate of owner-occupied housing. If a household chooses to pay the fixed cost to become a landlord, the maintenance expense depends on the fraction of services the household consumes and the fraction other households consume. Rental-occupied housing depreciates at $\delta_r > \delta_o$. The different depreciation rates are a result of a moral hazard problem that occurs in rental markets as renters decide how intensively to utilize the dwelling. That is, $x(h', d) = \delta_o p d + \delta_r p(h' - d)$. For renters $(h' = 0)$, the implied rental income is zero.

Households earn income in the labor market if they are under the age j^*, or from retirement benefits if they are of age j^* or older. Each household receives a time endowment that is inelastically supplied to the labor market until retirement. Households differ in their productivity for two reasons - age and period specific productivity shocks. We define υ_j as the labor productivity of an age j individual. The age profile of labor productivity is $\{\nu_j\}_{j=1}^{j^*}$. Households also draw a period specific earnings component, ϵ, from a probability space, where $\epsilon \in \mathcal{E}$. The realization of the current period productivity component evolves according to the transition law $\Pi_{\epsilon,\epsilon'}$. Thus, a worker's labor earnings in a given period is $w\epsilon\upsilon_j$ where w is the market wage rate. In addition to labor earnings, the gross return from the asset market investment is another source of income, and r is the net interest rate. We define the household's (non rental) income as:

$$y = \begin{cases} w\epsilon\upsilon_j + (1 + r)a + y_r + tr & \text{if} \quad j < j^*, \\ \theta + (1 + r)a + y_r + tr & \text{if} \quad j \geq j^*. \end{cases} \tag{2}$$

where θ is retirement benefit, and tr represents a lump-sum transfer from accidental bequests.

Sources of income are taxable. Labor income is subject to a payroll tax that is used to fund retirement benefits. Labor, (net) asset and rental income are subject to an income tax. The tax function could be nonlinear and allow for deductions from taxable income. We define $\widetilde{y}$ to be taxable income after deductions. Let Ω represent the set of deductions in the tax code with mortgage interest rate expenses being an example. Then, taxable income is defined as:

$$\widetilde{y} = \begin{cases} w\epsilon v_j + ra + R(h' - d) - \Omega & \text{if} \quad j < j^*, \\ \theta + ra + R(h' - d) - \Omega & \text{if} \quad j \geq j^*. \end{cases}$$

We define the total tax obligation of a household by $T(\widetilde{y})$.

The household's budget constraint depends on the state of the household, Λ, and we can isolate five possible budget constraints which depend on the housing state position, h, and the current housing position, h'. A household that rented housing services in the previous period, $h = 0$, and continues to rent housing services, $h' > 0$, has a budget constraint

$$c + a' + Rd = y - T(\widetilde{y}).$$

The second case focuses on the household who rented in the prior period, $h = 0$, but decides to invest in housing, $h' > 0$. The purchase of a home requires a downpayment, χ, a transaction cost, ϕ_b, and a mortgage with a mortgage payment of $m(z, p, h')$. The purchase of housing investment offers the household the option to earn rental income. The budget constraint for this case is:

$$c + a' + (\phi_b + \chi)ph' + m(z, p, h') = y - T(\widetilde{y}).$$

A third possible situation is the household who enters a period with a positive housing investment position, $h > 0$, and decides to sell off their entire investment position and rent housing services, $h' = 0$. The decision to sell property results in the household being subject to an idiosyncratic capital gain shock, $\xi \in \Xi$ that determines the final sales value that the homeowner receives when changing the size of the housing investment. This i.i.d. shock is not reveal until the house is sold. The unconditional probability of the shock is π_ξ. The sale of the house generates income, $p\xi h$, net of selling costs, ϕ_s, and remaining principle $D(z, p, h)$ which depends on whether the mortgage has been paid off or not.[6].

$$c + a' + Rd = y - T(\widetilde{y}) + (1 - \phi_s)p\xi h - D(z, p, h),$$

where ϕ_s is the transaction cost associated with selling a property. The decisions with respect to consumption, savings, and the dwelling size depends on the realization of the idiosyncratic capital gain shock, ξ.

The last two cases deal with a household that enters the period with a housing investment position, $h > 0$, and decides to continue to have a housing position, $h' > 0$. A key issue is whether the household decides to change their housing position. If the household decides to maintain their housing position, $h = h'$, the budget constraint is:

$$c + a' + m(z, p, h) = y - T(\widetilde{y})$$

In this situation, the household must make a mortgage payment if $n > 0$.

[6]As our analysis will be conducted at the steady state, other than the differences between buying and selling transaction costs, there are no differences in the purchase and selling prices of housing.

If the household decides to either up-size or down-size their housing investment position, (i.e., $h \neq h, h > 0, h' > 0$), the budget constraint becomes:

$$c + a' + (\phi_b + \chi)ph' + m(z', p, h') = y - T(\widetilde{y}) + (1 - \phi_s)p\xi h - D(z, p, h)$$

The current period choices are impacted by the idiosyncratic capital gains shock.

We can combine the various budget constraints into one general budget constraint if we define several indicator variables. Let I_o be an indicator function that is equal to one if the household has a positive housing investment position and zero otherwise. Let I_c be an indicator function that is equal to one if h does not equal h' and zero otherwise. Given these definitions, the general budget constraint is:

$$\begin{aligned} c + a' + I_o I_c[(\phi_b + \chi)ph' + m(z', p, h')] + (1 - I_c)I_o m(z, p, h) + (1 - I_o)Rd = \\ y - T(\widetilde{y}) + I_c[(1 - \phi_s)p\xi h - D(z, p, h)]. \end{aligned} \tag{3}$$

2.3 Firms

In this economy, a representative firm produces a good in a competitive environment that can be used either for consumption, government, capital purposes, or housing purposes. The representative firm produces goods using a constant returns to scale technology $F(K, L)$ where K and L denote the amount of capital and labor utilized. The aggregate resource constraint is given by

$$C + K' + I_H + G + \Upsilon = F(K, L) + (1 - \delta_K)K \tag{4}$$

where C, K, G, I_H and Υ represent aggregate consumption, the aggregate capital stock at the beginning of the next period, aggregate government spending, aggregate housing investment and various transactions costs, respectively.[7] The parameter δ_K denotes the depreciation rate for physical capital.

2.4 Government

In this economy, the government engages in a number of activities: finances some exogenous government expenditure; provides retirement benefits through a social security program; and redistributes the wealth of those individuals who die unexpectedly. We assume that the financing of government expenditure and social security are run under different budgets.

The government provides social security benefits to retired households. The benefit, θ, is based on a fraction, $\overline{\theta}$, of the average income of workers. These payments are financed by taxing the wage income if employed households at the tax rate τ_p. Since this policy is self-financing, the tax rate depends on the replacement ratio $\overline{\theta}$. The social security benefit can be defined as:

$$\theta \equiv \overline{\theta} \sum_{j=1}^{j^*-1} \sum_{i} \mu_j w v_j \epsilon / \sum_{j=1}^{j^*-1} \mu_j$$

where μ_j is the size of the age j cohorts. The social security budget constraint is:

$$\tau_p \sum_{j=1}^{j^*-1} \sum_{i} (\mu_j w v_j \epsilon) = \theta \sum_{j=j^*}^{J} \mu_j. \tag{5}$$

[7] The definition of aggregate housing investment and total transactions cost are define in the appendix.

In the general budget constraint, revenues are collected from income taxation. Since income taxes are not linear we define $t(\Lambda)$ to be the tax obligations of each households based in their position in the state space. Then, this budget constraint can be written as:

$$G = \int \mu_j t(\Lambda)\Phi(\Lambda), \tag{6}$$

and the term $\Phi(\Lambda)$ represents the measure of households.

The government also has the responsibility to collect the physical and housing assets of those individual who unexpectedly die. Both of these assets are sold and any outstanding debt on housing is paid off. The remaining value of these assets is distributed to the surviving households as a lump sum payment, tr. This transfer can be defined as

$$tr = \frac{Tr}{1-\mu_1}$$

where Tr is the aggregate (net) value of assets accumulated over the state space from unexpected death and is defined as[8]

$$Tr = \int \mu_j(1-\psi_j)a(\Lambda)\Phi(d\Lambda) + \sum_{\xi\in\Xi}\pi_\xi \int \mu_j(1-\psi_j)[(1-\phi_s)p\xi h(\Lambda) - D(\Lambda)]\Phi(d\Lambda). \tag{7}$$

2.5 Market Equilibrium

This economy has four markets: the asset market, labor market, the rental of housing services market, and the goods market. All these markets are assumed to be competitive. The goods market clearing condition is defined by equation (4). In the labor market, labor demand is determined by the marginal product of labor, $F_2(K,L)$.Labor is inelastically supplied and determined by $L = \sum_{j=1}^{j^*-1}\mu_j v_j \epsilon$.

The asset market clearing condition in this model is complicated by the presence of mortgages, unexpected death and idiosyncratic capital gain shocks. In an attempt to clarify, we introduce some additional notation that distinguishes whether a decision is impacted by an idiosyncratic capital gain shock. Let $I_s(\Lambda)$ be an indicator value that is equal to one when the housing investment position is sold and zero otherwise. The total amount of capital available to firms, K', can be written as

$$\begin{aligned} K' = & \int_{I_s(\Lambda)=0} \mu_j a'(\Lambda)\Phi(d\Lambda) + \pi_\xi \int_{I_s(\Lambda)=1} \sum_{\xi\in\Xi} \pi_\xi \mu_j a'_\xi(\Lambda)\Phi(d\Lambda) \\ & - \int_{I_s(\Lambda)=0} \mu_j(1-\chi)ph'_\xi(\Lambda)\Phi(d\Lambda) - \int_{I_s(\Lambda)=1} \sum_{\xi\in\Xi} \pi_\xi\mu_j(1-\chi)ph'_\xi(\Lambda)\Phi(d\Lambda) \\ & + \int_{I_s(\Lambda)=0} \mu_j m(z)\Phi(d\Lambda) + \int_{I_s(\Lambda)=1} \sum_{\xi\in\Xi} \pi_\xi\mu_j m(x)\Phi(d\Lambda) \\ & + \int_{I_s(\Lambda)=0} \mu_j D(\Lambda)\Phi(d\Lambda) + \int_{I_s(\Lambda)=1} \mu_j(1-\psi_j)D(\Lambda)\Phi(d\Lambda). \end{aligned} \tag{8}$$

[8] In the formulation, the new born generation does not receive a lump sum transfer as we endow these individuals with capital assets as observed in data. In this model the aggregate mass of households of age 1 is μ_1 and total population is normlized to one.

where $\Phi(d\Lambda) \equiv \Phi(da \times dh \times dn \times d\epsilon \times dj)$.

The first line on the right hand side of the equation captures the savings deposited by households to the financial intermediary. The first of these terms measures household deposits if the housing position is not sold while the second term on this line allows deposit decisions to be impacted by the idiosyncratic capital gain shock when the housing position is sold. From the total of household deposits, new mortgage loans must be subtracted. The second line on the right hand side measures new mortgages, and allows for differences created by idiosyncratic capital gains shocks. In the third line, mortgage payments received by the financial intermediary are measured. This includes payments received by first-time buyers and existing homeowners who continue to make payments on their mortgage, as well as those homeowners who sell property and have a new mortgage payment which is affected by the idiosyncratic capital gain shock. The last line on the right hand side of the equation captures the outstanding mortgage principle from those households who sell their house as well as the payment of outstanding debt of households who unexpectedly die with outstanding principle.

The last market determines the price of rental-occupied housing. This condition is determined by the aggregate amount of housings services made available by landlords and the total demand of rental housing services. That is

$$\int_{I_s(\Lambda)=0} \mu_j [h'(\Lambda) - s(\Lambda)] \Phi(d\Lambda) + \int_{I_s(\Lambda)=1} \sum_{\xi \in \Xi} \pi_\xi \mu_j [h'_\xi(\Lambda) - s_\xi(\Lambda)] \Phi(d\Lambda) = \tag{9}$$
$$\int_{I_s(\Lambda)=0} \mu_j s(\Lambda) \Phi(\Lambda) + \int_{I_s(\Lambda)=1} \sum_{\xi \in \Xi} \pi_\xi \mu_j s_\xi(\Lambda) \Phi(\Lambda)$$

This definition accounts for the effect of the idiosyncratic capital gains shock for both the landlord and the renter that just sold a property.

A formal definition of the recursive equilibrium is provided in the appendix.

3 Parameterization and Baseline Results

In order to evaluate the model, parameters must be specified. We choose to estimate most of the parameters using an exactly-identified Method of Moments approach. That is, we solve for the parameters that are consistent with some key properties of U. S. economy observed in 1994-96. This choice is motivated by the fact that *Property Owners and Manager Survey* is only available for this time period. Disaggregate housing data is available biannually from the *American Housing Survey* and use the 1995 survey.

3.1 Description of Functional Forms and Parameters

Functional Forms: Our choice of the utility function departs from the usual specification of a constant relative risk aversion utility function with a homothetic aggregator between consumption of goods and housing services. This preference structure is not consistent an increasing ratio of housing services/ consumption ratio by age which is observed in the data, [see Jeske (2005) for a detailed discussion].[9] We assume that preferences over the

[9] We also find that such a momentary utility function generates insufficient movements in housing position as well as introducing some counterfactional implications for the rental market.

consumption of goods and housing services can be represented by a period utility function of the form:

$$U(c,d) = \gamma \frac{c^{1-\sigma_1}}{1-\sigma_1} + (1-\gamma)\frac{d^{1-\sigma_2}}{1-\sigma_2}$$

where σ_1, and σ_2 determine the curvature of the utility function with respect to consumption and housing services, respectively. The relative ratio of σ_1 and σ_2 determines the growth rate of the housing to consumption. A larger curvature on consumption implies that the marginal utility of consumption declines faster than the marginal utility of housing services. Consequently, when household income increases over the life-cycle, households choose to allocate a larger fraction of resources to housing services. We choose to set $\sigma_1 = 3$ and $\sigma_2 = 1$ and estimate and the preference parameter γ.

The representative firm uses a Cobb-Douglas technology to produce a good that can be used either for consumption, housing investment, or capital good investment. We assume that the aggregate production function is of the Cobb-Douglas form, $F(K, L) = K^{\alpha}L^{1-\alpha}$. The capital share parameter is set to 0.29. This value is calculated by dividing private fixed assets plus the stock of consumer durables less the stock of residential structures by output plus the service flows from consumer durables less the service flow from housing.[10]

Population structure: Each period in the model is taken to be three years. An individual enters the labor force at age 20 (model period 1) and lives till age 83 (model period 23). Retirement is assumed to be mandatory at age 65 (model period 16). Individuals survive to the next period with probability $\psi_{j+1.}$These probabilities are set at survival rates from the National Center for Health Statistics, *United States Life Tables* (1994). The size of the age specific cohorts, μ_j, needs to be specified. Because of our focus on steady state equilibrium, these shares must be consistent with the stationary population distribution. As a result, these shares are determined from $\mu_j = \psi_j \mu_{j-1}/(1+\rho)$ for $j = 2, 3, ..., j$ and $\sum_{j=1}^{J} \mu_j = 1$, where ρ denotes the rate of growth of population. Using resident population as the measure of the population, we set this the three year growth rate to 3.643 percent.

Endownments: Workers are assumed to have an inelastic labor supply, but the effective quality of their supplied labor depends on two components. One component is an age-specific, $\upsilon_{j,}$ an is designed to capture the "hump" in life cycle earnings. We use data from U.S. Bureau of the Census, "Money, Income of Households, Families, and Persons in the Unites Stated, 1994," *Current Population Reports*, Series P-60 to construct this variable. The other component captures the stochastic component of earnings and is based on Storesletten, Telmer and Yaron (2004). We discretize this income process into a five state Markov chain using the methodology presented in Tauchen (1986). The values we report reflect the three year horizon employed in the model. As a result, the efficiency values associated with each possible productivity value ϵ are

$$\epsilon \in \mathcal{E} = \{4.41, 3.51, 2.88, 2.37, 1.89\}$$

and the transition matrix is:

$$\pi = \begin{bmatrix} 0.47 & 0.33 & 0.14 & 0.05 & 0.01 \\ 0.29 & 0.33 & 0.23 & 0.11 & 0.03 \\ 0.12 & 0.23 & 0.29 & 0.24 & 0.12 \\ 0.03 & 0.11 & 0.23 & 0.33 & 0.29 \\ 0.01 & 0.05 & 0.14 & 0.33 & 0.47 \end{bmatrix}.$$

[10] A data appendix is available the details the calculation of this parameter as well as other parameters used in the paper.

Each household is born with an initial asset position. The purpose of this assumption is to account for the fact that some of the youngest households who purchase housing have some wealth. Failure to allow for this initial asset distribution creates a bias against the purchase of homes in the earliest age cohorts. As a result we use the asset distribution observed in *Panel Study on Income Dynamics* (PSID) to match the initial distribution of wealth for the cohort of age 20 to 23. Each income state has assigned the corresponding level of assets to match the nonhousing wealth to earnings ratio.

Housing: The housing market introduces a number of parameters. The purchase of a house requires a mortgage and downpayment. In this paper we focus on 30 year fixed rate mortgage. As a result of the assumption that a period is three years, we set the mortgage length, N, to ten periods. The downpayment requirement, χ, is set to twenty percent.[11] Buying and selling property is subject a transaction costs. We assume that all these costs are incurred at purchase and set $\phi_s = 0$ and $\phi_b = 0.06$. Because of the lumpy nature of housing, the specification of the second point in the housing grid determines the minimum house size, $\underline{h}$. The specification of this grid point has implications for the timing of the homeownership decision and thus wealth portfolio decisions. To avoid having the choice of this variable having inadvertent implications for the results, we determine the size of this grid point as part of the estimation problem. As previously explained, housing depreciates at rates which depend on whether the property is owner occupied or rented. The values for δ_o and δ_r are estimated. The parameter ϖ affects the number of households that choose to become landlords. Determination of the this parameters is difficult as we have little direct evidence on the number of households who own rental property. An indirect measure is to calculate the number of homeowners that report rental income. In the AHS in 1995, approximately ten percent of the sampled homeowners claim to receive rental income. As a result, we choose to set ϖ to 0.05.

We used data from the 1995 *American Housing Survey* to quantify the i.i.d. capital gain shock. To calculate the probability distribution for this shock we measure capital gains based on the purchase price of the property and what the property owner believes to be the current market value. This ratio is adjusted for the holding length to express the appreciation in annualized terms. Then, we estimate a kernel density and then discretize the density in three even partitions. The average annualized prices changes ranging from lowest to highest are -6.6, -1.4, and 10.5 percent. These values are adjusted to be consistent with a period being defined as three years. In order to test the robustness of the data from the *American Housing Survey,* we employed a similar approach using 1995 Tax Roll Data for Duval County in Florida. Jacksonville is the major city in Duval County. This data follows real estate properties as opposed to individuals. As a result, we can calculate annualized capital gains based in actual sales. We find very similar estimates for the idiosyncratic capital gains shock using this data source.

Government and the Income Tax Function: The government enters the model in a number of ways. Income is provided to retired individuals through a social security program. We assume the retirement program is self-financed through a payroll tax on the earnings of workers. After retirement, households receive a transfer based on some fraction of the average labor income. The replacement ratio is set at thirty percent which results in a payroll tax on the worker of 5.25 percent. Government spending is financed through a tax on income. In order to get a more accurate assessment of housing policy wedges, we want the income

[11] The American Housing Survey in 1993-95 presents data that shows that the average downpayment is approximately twenty percent.

tax code to be a good approximation of the actual tax code for the US. Gouveia and Strauss (1994) estimated a functional form for the US federal income tax code that is theoretically motivated by the equal sacrifice principle. The actual taxes paid by a household, $T(\widetilde{y})$, are based on adjusted gross income, and is determined by the functional form

$$T(\widetilde{y}) = \eta_0(\widetilde{y} - (\widetilde{y}^{-\eta_1} + \eta_2)^{\frac{-1}{\eta_1}}),$$

where (η_0, η_1, η_2) are policy parameters. The marginal income tax rate is

$$T'(\widetilde{y}) = \eta_0(1 - (1 + \eta_2\widetilde{y}^{\eta_1})^{-\frac{1}{\eta_1}-1}).$$

This functional form is very flexible and allows lump-sum taxes ($\eta_1 = -1$), proportional ($\eta_1 \to 0$), or progressive taxes ($\eta_1 > 0$) as special cases. The parameter η_0 is a scaling factor that determines the level of the tax brackets and the marginal tax rate but does not impact the curvature of the tax function. The parameter η_2 depends on units of measurement used to measure income and determines the size of income deduction. Gouveia and Strauss estimate the policy parameters and find that $\eta_0 = 0.258$, $\eta_1 = 0.768$, and $\eta_2 = 0.003710$. In the benchmark economy we use the same parameter estimates used by Gouveia and Strauss for η_1 but η_2 is set to 0.3710 to accommodate the model measurement units. The parameter η_0 is endogenously determined when solving the model to target the ratio of federal government expenditure-GDP observed in 1994.[12] In all policy simulations, this parameter is adjusted to generate the same amount of tax revenue as the baseline economy. The adjusting the other parameter would change the progressivity of the tax code or the size of deductions across experiments making comparisons more difficult. Following the provisions of the income tax code in the U.S. we allow mortgage interest payments and maintence expenses for rental property. However, the imputed rental value of owner-occupied housing does not generate a tax obligation although rental income is taxed.

The entire set of parameters that we set are presented in Table 5 in annualized terms.

[12] The Gouveia and Strauss tax function was estimated for the period 1979-1989. As our model is calibrated for the period 1994-1996, we acknowledge some inconsistency. However, since our focus is on the importance of various margins impacted by housing policy, we do not feel this inconsistency is a major problem.

Table 5: Calibrated Parameter Value
(annualize values reported)

Parameter	Value
Demographics:	
J	83
J^*	65
ρ	0.012
Preferences:	
σ_1	3.00
σ_2	1.00
Technology:	
α	0.29
Housing:	
χ	0.20
N	30
ϕ	0.06
ξ	[-0.1982, -0.04458,0.3105]
Government	
η_1	0.7680
η_2	0.3710

3.2 Estimation and Performance of the Baseline Model

We estimate seven parameters using an exactly-identified Method of Moments approach. The estimation of the structural parameters in not separated from the computation of equilibrium. This means three additional nonlinear equations (asset market, government budget constraint, and accidental bequest) have to satisfied along with the moments observed in the data. The parameters that need to be estimated are the depreciation rate of the capital stock, δ, the depreciation rate for rental units, $\delta_{r,}$ the depreciation rate for ownership units, δ_o, the relative importance of consumption goods to housing services, γ, and the individual discount rate, β, the minimum size of the smallest housing investment position, $\underline{h}$, and the tax function parameter η_0. We identify these parameter values so that the resulting aggregate statistics in the model economy are equal to seven targets observed in the U.S. economy.

1. The ratio of capital to gross domestic product: 2.541. This is the average for the period 1958-2001 where we define the capital stock as private fixed assets plus the stock of consumer durables less the stock of residential structures so as to be consistent with capital in the model. Output is GDP plus service flows from consumer durables less the service flow from housing.[13]

2. The ratio of the housing capital stock to the nonhousing capital stock: 0.43. The housing capital stock is defined as the value of fixed assets in owner and tenant residential property.

3. The ratio of investment in capital goods to output: 0.135.

4. The ratio of the investment in residential structures to housing capital stock: 0.121.

[13]We estimated services flows using procedures outlines in Cooley and Prescott (1995).

5. Housing consumption relative to nonhousing consumption: 0.23. This is the average between 1990 and 2000 but the number does not vary greatly over the period. Housing services are defined as personal consumption expenditure for housing and non housing consumption is defined as nondurable and services consumption expenditures net of housing expenditures.

6. Federal government expenditure relative to output: 0.074.

7. The homeownership rate in the period 1994 is 0.64 percent.

The estimated parameters expressed in annual terms are presented in Table 6. The model performs quite well in matching the seven targeted moments. The implied targets generated by the model solution are within one percent error for all the observed targets.

Table 6: Estimation of Model (Annualized Values)

Statistic	**Target**	**Model**	**%Error**
Ratio of wealth to gross domestic product (K/Y)	2.541	2.5446	0.143
Ratio of housing stock to fixed capital stock (H/K)	0.430	0.4266	-0.792
Housing investment to housing stock ratio (x_H/H)	0.040	0.0403	-0.388
Ratio housing services to consumption of goods (Rd/c)	0.230	0.2291	-0.411
Ratio fixed capital investment to output $(\delta K/Y)$	0.135	0.1353	0.339
Homeownership rate	0.640	0.6370	-0.468
Government expenditure to output $(T(\widetilde{y})/Y)$	0.074	0.0742	-0.005

Variable	**Parameter**	**Estimate**
Individual discount rate	β	0.9749
Share of consumption goods in the utility function	γ	0.9541
Tax function coefficient	η_0	0.1974
Depreciation rate of owner occupied housing	δ_o	0.0340
Depreciation rate of rental housing	δ_r	0.0749
Depreciation rate of capital stock	δ_k	0.0428
Minimum house size	$\underline{h}$	1.4726

Since the model has been estimated to replicate the aggregate moments we explore whether reasonable housing statistics are generated. The model could be evaluated along a number of dimensions. We focus on the distribution of ownership rates by age; the distribution of housing consumption measured in square feet by age and household income; and the implications for the rental market. In Table 7 we summarize how the homeownership rate, the distribution of landlords, and housing consumption vary by age. We also report how housing size varies by income.

Table 7: **Summary of Aggregate Results**

Variable	**Homeownership Rate**				
by Age Cohorts	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
AHS Data	33.2	67.7	78.4	80.3	73.5
Benchmark	33.1	73.5	86.4	91.3	66.5

Variable	**Distribution of Landlords**				
by Age Cohorts	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
POMS Data	4.2	27.4	42.8	19.6	6.0
Benchmark	21.7	33.7	24.1	13.8	6.6

Variable	**Sqft. Owners**[1]				
by Age Cohorts	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
AHS Data	1,854	2,220	2,301	2,088	2,045
Benchmark	2,147	2,297	2,429	2,514	2,362
by Income Quintiles	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
AHS Data	1,867	2,211	2,699	3,037	3,091
Benchmark	2,254	2,192	2,773	3,887	4,242

[1] Owner occupied house size is measured in terms of square feet.

Data is from the *American Housing Survey* and *Property Owners and Manager Survey.* The model captures the hump-shaped behavior of ownership as the fraction of homeowners increases by age until retirement. Downsizing in the older cohorts is observed, but participation are overstated for the middle age cohorts. This can be due to the fact that in a model with only idiosyncratic labor income shock, most households eventually end up becoming homeowners. Since a focal point of housing policy is the participation of the younger households, we report the homeownership rate for households age 35 and under. The data indicates an ownership rate of 33.2 percent for all households under 35 while the model generates a corresponding homeownership rate of 33.1 percent. When studying the impact of the current tax treatment of homeowners and landlords we pay particular attention to this age group.

We are also interested in determining whether the model generates reasonable participation behavior in the supply of rental housing services. In Table 7 we report how the participation of household who are also landlord varies by age. The data for this distribution is based on data from the 1995 *Property Owners and Managers Survey.* We observe that the distribution of landlords exhibits a hump which occurs between age 50 and 64. The model generates a humped shaped participation pattern. However, the peak in the hump occurs somewhat earlier than in the model.

A frequent question is why have house sizes increased in the United States. One response is the current tax code which provides incentives to consume large units of owner-occupied housing. If this issue is to be addressed, it is important to inquire whether the model generates distributions of the consumption of housing services similar to what is actually observed. Some papers measure housing consumption using expenditure to measure housing services. Others just report the ratio with respect to goods consumption (defined in a broad sense). We report housing consumption in terms of square feet - the measure most frequently used to measure house size. We find that the model generates two important features observed in the data. The house size implied in the model are consistent with house sizes observed from either an age or income distribution perspective. The largest average size house occurs in households between age 50 and age 64. The average house size for this cohort is 2,301 square feet. The model generates an average house size for this cohort of 2,429 square feet. For the youngest age cohort, the average size of a house in the data is 1,854 square feet, whereas our model finds that the average size house for this cohort is 2,147 square feet. Hence, we do find evidence that the model overpredicts housing size. If housing size is examined by an income perspective, data shows that house size increases with income. The average size house of a homeowner in the lowest income quintal is 1,867 square feet while the average size house at the highest income quintal is 3,091 square feet. The model finds that home size tends to increase with income. However, the model once again overpredicts house size. The relatively smaller house size observed in the data for the top income quintiles may partially explained by the top coding, as well as the under sampling, of high income households in the *American Housing Survey.*

The Supply of Rental Property

3.3 Individual key determinants

One of the contributions of this paper is the endogeneity of the supply of rental property. In this section, we explore the key determinants of the decision to supply housing services to the rental market. We must now be more precise with respect to the income tax deductions that are allowed. The tax code treats the services generated by the housing investment and the treatment of maintenance expenses asymmetrically over individuals and this has ramifications for the decision to supply rental property. We introduce this distinction by defining κ_o to be the fraction of service income consumed by owner-occupied housing that is taxable and and κ_r the fraction of services rental income that is taxable. In the current U.S. tax code, these coefficients have the value of $\kappa_o = 0$ and $\kappa_r = 1$. In addition, we allow for differential treatment toward the deductibility of maintenance expenses. The terms ι_o and ι_r represent the fraction of maintenance expense from owner and rental occupied housing, respectively, that are deductible. In the current tax code in the U.S., $\iota_o = 0$, and $\iota_r = 1$. As a result of these modifications, the definition of taxable income becomes

$$\widetilde{y} = \begin{cases} w\epsilon v_j + ra + \kappa_r R(h' - d) + \kappa_o Rd - \iota_r \delta_r p(h' - d) - \iota_o \delta_0 pd - \Omega & \text{if} \quad j < j^*, \\ \theta + ra + \kappa_r R(h' - d) + \kappa_o Rd - \iota_r \delta_r p(h' - d) - \iota_o \delta_0 pd - \Omega & \text{if} \quad j \geq j^*. \end{cases}$$

where Ω represents other deductions.

The first-order condition for a household that has a positive housing investment $h' > 0$ and chooses to pay the fixed entry cost ($\varpi > 0$) to become a landlord is

$$\frac{U_d}{U_c} = \underbrace{R - p(\delta_r - \delta_o)}_{\text{Nontax Effect}} + \underbrace{T'(\widetilde{y}) \left[\underbrace{p(\iota_r \delta_r - \iota_o \delta_o)}_{\text{Maintenance Expense}} - \underbrace{R(\kappa_r - \kappa_o)}_{\text{Housing Services}} \right]}_{\text{Taxation Effect}}, \tag{10}$$

where U_c and U_d represents the marginal utility with respect consumption c, and housing services flows d, respectively. The right hand side of this expression has several nonstandard components. The first term labeled as the "Nontax Effect" captures the net benefit of supplying an additional unit of rental property to the market. The rental price of a unit of housing services, R, measures the benefit to a household of forgoing a unit of housing services. This benefit is reduced the greater the spread in the depreciation rate for rental and owner-occupied housing, $\Delta\delta = (\delta_r - \delta_o)$. In the absence of tax considerations, the effective cost of owner-occupied housing services is $R_o = R - p(\delta_r - \delta_o)$. The implicit moral hazard problem makes renting more expensive than owning. In addition, the nonlinear income tax code adds an additional effect, which we label as the "Taxation Effect." This effect arises from the asymmetric tax treatment toward who consumes the housing services and the deduction of owner-occupied and rental-occupied maintenance expenses. The benefit from supplying services to the rental market is reduced the larger the spread in the fraction of rental housing service income relative to owner-occupied housing service income. The benefit for supplying housing services to the rental market is increased the larger the rental maintenance expense deduction relative to the owner-occupied maintenance deduction.

Under the current tax code, the income from the consumption of rental-occupied housing services is taxable while the income of owner-occupied serviced is not taxable. In contrast, rental maintenance expenses are deductible, but owner-occupied maintenance expenses are not deductible. In other words, $\kappa_o = \iota_o = 0$, and $\kappa_r = \iota_r = 1$ and the first order condition reduces to:[14]

$$\frac{U_d}{U_c} = R(1 - T'(\widetilde{y})) + p[T'(\widetilde{y})\delta_r - \triangle\delta].$$

The first term on the right hand side indicates that the failure to tax owner-occupied housing services reduces the effective cost of this type of housing. This wedge introduces a bias towards owner-occupied housing. When the imputed rental income from owner-occupied housing is taxed at the same rate as rental housing, $\kappa_o = \kappa_r$, then the asymmetry in the tax code is eliminated. The second term on the right hand side focuses on the deductibility of maintenance expenses for rental occupied housing. This deduction introduces a bias towards rental property, and increases the opportunity cost of owner-occupied housing as the deduction for rental maintenance expenses is forgone when consuming additional owner-occupied housing.

Any tax code impacts decisions via a level effect and a marginal effect. The tax provisions impact adjusted gross income. This is a level effect. The progressivity of the tax code effects the size of the impact of the various asymmetries. For example, under a more (less) progressive tax code, the tax savings of some of these provisions are larger (smaller). The standard assumption in the literature is to ignore the progressivity of the tax code, thus implying the marginal tax rate is zero, $T'(\widetilde{y}) = 0$. The first order condition is reduced to:

$$\frac{U_s}{U_c} = R - p\triangle\delta.$$

This expression is similar to an arbitrage condition that has to be satisfied for all the individuals that participate in the rental market supplying property. For the optimal level of consumption and housing services, $\{c^*, d^*\}$, the implied ratio of marginal utilities $\vartheta = U_{d^*}/U_{c^*}$ determines the equilibrium rental rate $R^* = \vartheta + p\triangle\delta$. If household preferences are homothetic, the ratio of consumption to housing services is constant across individuals. In the absence of nonlinear taxation all the landlords have the same ratio. Under non-homothetic

[14]The U.S. tax code allows for accelerated depreciation of rental property suggesting that $\iota_r \geq 1$.

preferences, the ratio is not constant, and individuals with higher income are likely to consume more housing since it is a luxury good. Consequently, the rental supply response will vary depending on the income and age of the household.

The interaction of the endogenous rental supply decision in an environment where households face non-homothetic preferences, and a progressive tax code represent some of the main differences of between our formulation and the literature. Gervais (2002) and Nakajima (2003) assume the rental market is determined by a 'stand-in' rental firm. This firm takes deposits from investors and makes mortgage loans to homeowners. The maximization problem of this firm results in an arbitrage condition that ties the rental price, R, to the interest rate and the depreciation rate of rental property, $r + \delta_r$. This condition implies that in equilibrium, the return from rental investment should be equal to the return on capital. Consequently, in this context the stock of rental-occupied housing is entirely determined by the demand for rental property. Only housing policies that reduce the maintenance cost via subsidies have an impact on the equilibrium rental rate. In contrast, Ríos-Rull and Sánchez-Marcos (2005) consider an endowment economy with a fixed supply of owner-occupied housing. The role of this assumption is to magnify price effects by eliminating movements in aggregate quantities. In our model the rental rate is determined in rental market and depends on the individual response of landlords. Hence, the rental price does not need to be tied to the equilibrium interest rate.

3.4 Rental supply decomposition

The modelling of supply of rental services as part of the household decision problem has implications for the supply response to a rental price change. If the supply of rental property is very elastic, a small change in the price of rental housing will increase supply along two dimensions. Households participating the rental housing market can choose to increase their supply of housing services in the rental market. This response occurs at the intensive margin. Some households that were not supplying rental property at the original price may find it beneficial to become a landlord and supply rental property. This response occurs at the extensive margin. Since we are interested in understanding the impact of changes in the economic environment for the aggregate supply of rental property, we develop a framework that allows us to quantify the intensive and extensive margin impacts.

The aggregate supply of rental property, $S(Z)$, conditioned on a vector, Z, comprised of parameters and relative prices, is simply the sum of individual household's rental supply decisions by type weighted by the measure of each type of household. A household's rental supply decision can be defined as $d_r(\Lambda; Z) \equiv g(h') - d(\Lambda; Z)$ where $\Lambda = (a, h, n, \epsilon, j)$. The the supply of rental housing services can be written as:

$$S(Z) = \int d_r(\Lambda; Z)\Theta(\Lambda; Z),$$

We want to measure the rental housing service supply response if an element in z changes, holding the remaining elements constant. The total rental supply response from a change in the $i - th$ element while all other elements remain unchanged, $\partial S(Z)/\partial Z_i$, can be decomposed into the response of households who supplied rental housing and continue to supply rental services after the change in Z_i, the response of households who previously did not supply rental services and decide to supply rental services, and households who decide to cease supplying rental services. In order to quantify this decomposition, we define the set of households who supply rental housing services by Ω^r and the partition this set into individuals who continue supply rental services, Ω^r_C, new household entrants Ω^r_N, and household departures Ω^r_X.The aggregate supply response from a change in one element in z_i is defined as $S(Z_i) - S(Z)$, and can be decomposed into

$$S(Z_i) - S(Z) = \int_{\Omega^r_C} \Theta(\Lambda; Z)(d_r(\Lambda; Z_i) - d_r(\Lambda; Z)) + \int_{\Omega^r_C} (\Theta(\Lambda; Z_i) - \Theta(\Lambda; Z))(d_r(\Lambda; Z) - S(Z))$$
$$+ \int_{\Omega^r_C} (\Theta(\Lambda; Z_i) - \Theta(\Lambda; Z))(d_r(\Lambda; Z_i) - d_r(\Lambda; Z))$$
$$+ \left[\int_{\Omega^r_N} \Theta(\Lambda; Z_i)(d_r(\Lambda; Z_i) - S(Z)) - \int_{\Omega^r_X} \Theta(\Lambda; Z)(d_r(\Lambda, Z) - S(Z)) \right]$$

The first term measures the intensive margin of landlords who continue to supply rental services after the change in Z_i and is calculated by weighting the change in individual supply by the pre-change measure. The second term captures the extensive margin response associated with the change in mass of households that choose to become landlords in a particular position in the state space Λ, while holding their rental supply response constant. Since both the measure of households and the rental supply decisions can change, the third term - a covariance factor - captures the simultaneous change in individual supply and the mass of landlords in each position of Λ. The terms in the bracket capture net entry. That includes the contribution of new landlords minus the participation of those landlords that choose to exit the rental market.

Table 8: Rental Supply Decomposition

	Rental Price		**Tax Parameter**		**Spread Depreciations**	
	$\triangle R = 4\%$	$\triangle R = -4\%$	$\eta_1 = 4\%$	$\eta_1 = -4\%$	$\triangle\delta = 4\%$	$\triangle\delta = -4\%$
Margin	%Δ	%Δ	%Δ	%Δ	%Δ	%Δ
Intensive (Change Supply)	0.827	-0.024	0.061	-0.060	-0.401	0.343
Extensive (Change Mass)	0.044	-0.011	-0.045	2.099	-0.037	0.007
Covariance	-0.091	0.020	-0.038	-1.375	0.057	0.043
Net Entry	5.469	-3.824	-0.004	-1.135	-1.713	1.719
Entry Effect	5.628	-3.837	0.419	-0.829	-1.730	1.775
Exit Effect	-0.159	-0.013	-0.423	-0.305	0.017	-0.055
Total	6.250	-3.839	-0.026	-0.471	-2.094	2.113

Next, we use the model to measure the size of these effects in response to an exogenous change in the rental price, R, the progressivity of the tax code, η_1, and the size of moral hazard captured by the spread in depreciation rates $\triangle\delta$. A four percent increase in the rental price results in a positive supply response of 6.25 percent. Most of this change is due to new household's deciding to supply housing services to the rental market. This can be seen in the size of the entry effect. We also find that the intensive margin accounts for thirteen percent of the total supply response. If the rental price declines four percent we find that supply declines 3.84 percent. Almost the entire supply response to due to the negative entry effect in the household's decision to supply rental property. This indicates the supply response to a rental price change is not symmetric.

The spread in the depreciation rates on rental and owner-occupied housing is a measure of moral hazard in the rental market. A four percent decline in the rental depreciation rate under the assumption that the rental price is held constant results in a 2.11 percent increase in the supply of rental services as homeowners see an increase in the net return to supplying housing services to this market. This supply response is dominated by new entrants. Households supplying rental services prior to the change in spread increase their position in the rental market and this accounts for approximately sixteen percent of the total supply response. An increase in the depreciation rate spread decreases the supply and the magnitude of the response is essentially the same.

In order to examine the role that taxes play, we change the parameter η_1 which influences the marginal tax rate. The result of changing this parameter is complex due to the interaction of income and substitution effects coupled asymmetries in the tax code. A four percent decrease in the parameter η_1 results results in a 0.47 percent decline in the supply of rental services. The tax rate decline causes an increase in the supply of services on the extensive margin. However, the decline in supply due to the intensive margin response and net exit offset the former effect. In essence, the decline in the marginal rate seems be generating an income effect that slightly dominates the various substitution effects. If this tax parameter is increased by four percent, the overall supply response is essentially zero. This does not mean that decisions are not affected by a change in this parameter as we see a number of household's exiting the market. However, these household's are replaced by new entrants On the intensive margin, the supply response is positive. The combined extensive response and the covariance effect offset the intensive margin effect. In other words, the marginal tax rate change has distributional implication depending on the household state.

4 Tax Treatment Analysis

In this section, we examine the effects of the tax treatment on homeowners and landlords. First, we explore how the effects of the asymmetric tax treatments are modified when the progressivity of the income tax code is changed. Second, we examine the implications of the elimination of asymmetries in the tax treatment between owner and rental-occupied housing. In both cases we analyze the compatibility of the experiments with the objective of housing policy to foster owner-occupied housing.

4.1 Tax Progressivity Analysis

We begin by exploring the implications of changes in the progressivity of the income tax code for housing tenure decisions, and the supply of rental property. At the household level, a change in the degree of progressivity modifies the incentives to purchase large homes as high income and wealthy households can use the mortgage deduction to change the marginal tax rate. As a result, a reduction in the marginal tax rate reduces the incentives to purchase larger homes, and has implications for the supply of rental property.[15] The change in progressivity also impacts revenue collection. We assume that the policy changes are revenue neutral and allow the tax function parameter η_0 to vary so that the government revenue remains unchanged. This assumption is not innocuous as the income effects associated with a different tax burden can potentially dominate the substitution effect associated with the tax rate change.

[15] The first-order conditions for renters is $U_d/U_c = R$, so the progressivity of the income tax code does not distort the consumption of housing services.

We investigate the importance of the degree of progressivity in the tax code by considering three different cases. We consider a proportional income tax code where the marginal tax rate is zero, $T'(ay) = 0$, a tax code that is more progressive than the Gouveia-Strauss formulation embedded in the benchmark model, and a tax code with optimal progressivity as suggested by Conesa and Krueger (2006).[16] In Table 9 we present the aggregate results from these alternative tax structures. All analysis is conducted under the assumption that mortgage interest rate expenses are deductible and the housing services of owner-occupied housing is not subject to taxation.

Table 9: Progressivity Income Tax and Housing

	Interest Rate	Rental Price (% change)	Ownership Aggregate	Ownership Under 34	Ownership Income Q1
Benchmark	5.44%	-	63.7	33.1	32.0
No Progressivity	5.04%	-2.35	69.2	36.9	35.7
More Progressivity	5.82%	9.94	59.1	29.2	29.3
C-K Progressivity	5.14%	3.21	68.6	36.1	36.9

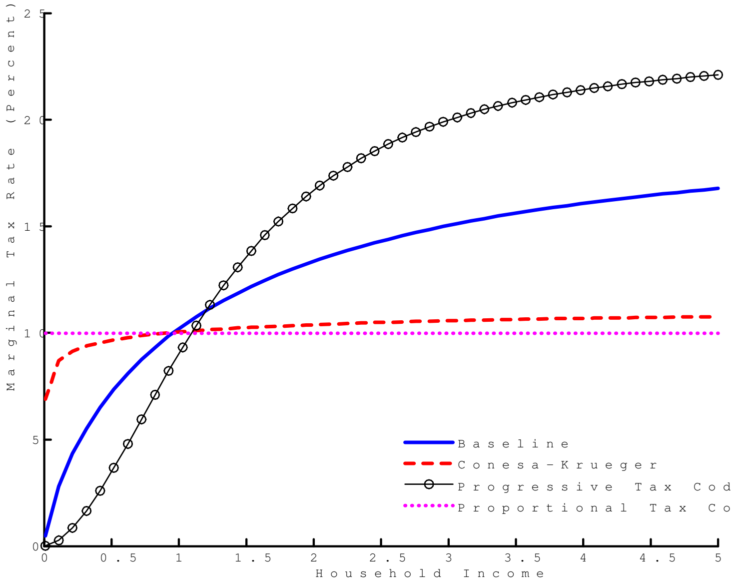
	Gini After Tax Income/Wealth	Avg. Owner Size	Avg. Rental Supply	Mass Landlords	Welfare $\lambda_{cd}\vert\lambda_c$
Benchmark	0.241/0.531	2,348	1,310	17.07	-
No Progressivity	0.253/0.527	2,444	1,311	18.74	4.1|4.5
More Progressivity	0.227/0.535	2,329	1,107	12.67	-3.4|-3.7
C-K Progressivity	0.251/0.529	2,496	1,132	14.16	3.2|3.5

The model indicates that changes in the marginal tax rate affects relative prices (interest rate and rental price) as well as altering the impact of the tax provisions that favor owner-occupied housing. Under a proportional tax program, the marginal tax rate is reduced and the equilibrium interest rate falls 40 basis points and the rental price falls 2.4 percent. With Conesa-Krueger's (C-K) optimally progressive tax structure, the interest rate falls 38 basis points, but the rental price increases 3.2 percent. These responses clearly show that in an environment where the supply of rental housing is elastic, rental price movements are not tied to the equilibrium interest rate. The decline in the interest rate under both tax structures is a result of the increase in individual savings. This increase is large enough to lower the interest rate despite the increase in borrowing needed to support the increased participation in the owner-occupied housing market. With the larger amount of funds being directed to the productive sector, average income increases when progressivity is reduced. This mechanism explains why the relationship between progressivity and ownership is negative and quantitatively large. The complete elimination of progressivity results in the ownership rate increasing from 63.7 to 69.2 percent. If progressivity is increased from that in the benchmark economy, we find the aggregate homeownership rate declines to 59.1 percent.

Changes in participation rates from either an age or income perspective mirror the aggregate results. When progressivity in the tax code falls, the participation of youngest cohort and lowest income quintile increases. If progressivity is increased beyond that in the benchmark economy, the homeownership rates fall. Much of the change in participation rates of the youngest and poorest households is a consequence of the revenue neutrality assumption.

[16] Conesa and Krueger formulation abstracts from housing and rental markets. Consequently, their tax code might not be optimal in our context. In addition, in their paper the labor supply is elastic whereas in this paper households inelastically supply labor until retirement age.

Figure 1: Progressivity Income Tax and Housing



In Figure 1, the the implied marginal tax rates for the various tax structures are presented. Because the marginal tax rate under a proportional tax code is zero, we graph the average tax rate that is endogenously determined at a ten percent level by this tax code. As can be seen, under a more progressivity tax code, the marginal tax rates for low income households decreases and increases for middle and high income groups. Under the Conesa and Krueger's (2006) tax code, the coefficients in the Gouveia and Strauss tax function are chosen so as to maximize social welfare in their model economy. As can be seen, their tax coefficients imply that the optimal income tax structure should be less progressive than the tax structure of the baseline model, but more progressive that a proportional tax system. We see that compared to the proportional tax schedule, the marginal tax rates are higher for high income households and somewhat lower for low income households.

Each of tax code structures have implications for the equilibrium wage and average income. If the tax code is changes to be proprotional, average income increases 6.9 percent. The C-K 'optimally' progressive tax code results is a 5.9 percent increase in average icome. A more progressive tax structure leads to a 5.9 decrease in average income. Given the implications that the alternative tax has for average income, the implications for the distribution of income or wealth is an obvious next question. We use the Gini coefficient to measure inequality. We find that a change in the progressivity of the income tax has a small effect in the Gini coefficient for income and even smaller for wealth. Castañeda et al. (2003) report higher values for the Gini coefficient of earnings and wealth. The difference is due to three factors. First, our model is incapable of generating sufficient high wealth concentration at the very top of the distribution since bequests are rule out. Second, wealthy households are not allow to repay faster their mortgage obligations and that increases their liabilities with the financial intermediary. Finally, we measure after tax earnings and wealth.

Table 9 indicates that the degree of progressivity of the tax code has implications for house size, the supply of housing services to the rental market and the mass of landlords. The key to understanding these results is the interplay of average income and price effects. The income reduction under a more progressive tax system reduces both the ownership rate and the average house size. From a distributional perspective, both the ownership rate and house size need not decline under a more progressive tax system as the tax benefit of a mortgage deduction increases at larger marginal tax rates. We will further develop this point when we discuss the distributional implications of progressivity. Under a less progressive tax system, the magnitude of the increase in housing consumption is similar to the magnitude of the increase in net income which ranges between 5 to 6 percent. The specification of nonhomothetic preferences accounts for this relationship since as income increases the share of housing expenditures grows. This is partially due to the fact that housing is modeled as a luxury good and the Engel curves are non linear. Although not reported in the paper, we find that when housing is less of a luxury good the effects on house size are smaller. The difference between the proportional tax system and the Conesa-Krueger tax structure is partially related to the deduction of mortgage interest rates. Under a proportional income tax, the marginal benefit of buying a larger house with larger interest payments is zero. With the C-K income tax code, the marginal benefit is small but positive.

The progressivity of the income tax has quantitative effects for the decision to supply housing services to the rental market. The direction of these effects depends on several variables such as the rental price and the interest rate. Although not presented in the Table 9, the average size of rental property is closely related to average income. Under a less progressive tax code, net average income increases between 6 and 7 percent, and average consumption of rental-occupied housing increases between 10 to 30 percent.

A formal approach to evaluate the implications of different progressivity of the tax code is to conduct a welfare analysis. In order to measure changes in aggregate welfare associated with different tax code structures, we employ a consumption equivalent welfare approach (CE). Given the specification of the preferences, there is no close form solution to calculate the consumption equivalence. As a result, we have to solve a nonlinear functional equation $\mathcal{F}(W(c), W(c_B), \lambda_c) = 0$, where λ_c denotes the consumption equivalence value, and where $W(c)$ represents the expected lifetime welfare of an agent being born into a stationary equilibrium implied by the policy.[17] We compute the welfare compensation by considering a constant increase in goods consumption and housing services, $\mathcal{F}(W(c,d), W(c_B, d_B), \lambda_{cd}) = 0$. This calculation is made to generate results that are comparable with Conesa and Krueger (2006) findings. Their model has only one argument, consumption goods, in the preference function. Reductions in the amount of progressivity in the income tax increases welfare by 4.5 percent in terms of consumption equivalence, and 4.1 percent when the compensation includes goods consumption and housing. By contrary, an increase in the marginal tax rate reduces welfare between 3.4 to 3.7 percent. The optimal progressivity increases welfare but not as much as the proportional income tax.

The findings in this section highlight two important results associated with a reduction in marginal tax rates. First, the welfare gains associated with a change in the progressivity of the income tax are much larger than the gains reported in Conesa and Krueger (2006). They find that implementing the optimal progressivity increases welfare around 1 percent. Our result suggests that these effects are amplified in the presence of housing. The main reason is that the reduction in the marginal tax rate reduces the asymmetries in the tax treatment

[17] More formally, the social welfare function $W(\cdot)$ is defined as

$$W(\cdot) = \sum_s \pi_s v(0, 0, 0, \epsilon, 1)$$

where the value function of a new born with no asset or mortgage holding obligation is weighted by the unconditional probability of the idiosyncratic productivity shock.

between owner-occupied and rental housing, and eliminates the incentive to purchase large homes. Since housing becomes relatively less attractive, households choose to invest in the productive sector. Aggregate output and consumption increases. In an economy with a single asset this portfolio reallocation mechanism is absent, and the efficiency gains are only due to consumption smoothing and changes in the labor supply. The second important finding is that the asymmetries in the tax treatment of housing can be magnified in the presence of nonlinear income tax. For example, an increase in the marginal tax rate magnifies the effects of the tax provisions that benefit homeownership, and reduce the aggregate ownership rate. In contrast, a reduction in the marginal tax rate reduces the effective asymmetries resulting in an increase in the homeownership rate. These effects become more obvious as we discuss the distributional effects of income taxation for housing consumption which are summarized in Table 10.

Table 10: Distributional Effects Progressivity Income Tax and Housing

Variable			**Sqft. Owners**		
by Income Quintiles	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Benchmark	2,239	2,197	2,773	3,887	4,242
No Progressivity	2,432	2,237	2,923	3,899	4,288
% change	(8.6)	(1.8)	(5.4)	(0.3)	(1.1)
More Progressivity	2,068	2,222	2,660	3,840	4,318
% change	(-7.6)	(1.1)	(-4.1)	(-1.2)	(1.8)
C-K Optimal Progressivity	2,386	2,361	3,045	4,116	4,622
% change	(6.6)	(7.5)	(9.8)	(5.9)	(9.0)
by Age Cohorts	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
Benchmark	2,147	2,297	2,429	2,514	2,362
No Progressivity	2,279	2,313	2,497	2,741	2,635
% change	(6.1)	(0.7)	(2.8)	(9.0)	(11.6)
More Progressivity	2,233	2,313	2,451	2,325	2,057
% change	(4.0)	(0.7)	(0.9)	(-7.5)	(-12.9)
C-K Optimal Progressivity	2,337	2,401	2,550	2,731	2,603
% change	(8.8)	(4.5)	(5.0)	(8.6)	(10.2)
			Welfare CE(λ_{cd})|CE(λ_c)		
	20-34	**35-49**	**50-64**	**65-74**	**75-89**
No Progressivity	2.9|3.1	6.3|7.3	6.9|8.1	7.6|9.1	6.3|7.3
More Progressivity	-2.3|-2.5	-5.2|-5.8	-6.0|-6.8	-6.1|-6.9	-7.0|-7.7
C-K Optimal Progressivity	2.1|2.3	5.1|5.9	5.7|6.7	6.5|7.7	5.4|6.2

The model finds that the changes in house size are asymmetric in all the experiments. For example, with a proportional tax system the increase in average house size for the lowest income quintile is 8.6 percent, 5.4 percent for the third, and 1.1 percent for the highest income. This pattern is due to the behavior of retired households. Many of these individuals receive a large share of their income from assets and rental property, and they prefer to maintain a more stable relationship between the consumption of housing and goods. Households in lower tax brackets choose to bias consumption towards housing. We observe that household's in the highest income decile response positively to changes in the degree of progressivity. A tax code with lower progressivity allows these individuals benefit from a larger income which offsets the loss of benefits from the mortgage deduction. Under a more progressive tax code with larger marginal tax rates, households choose to bias there consumption toward the consumption of goods. The model predicts both effects to be approximately one percent. However, the combination of high income with the optimal progressivity maximizes the impact of housing consumption for this group. The percent change of housing consumption over the life cycle also varies across individuals in a non-trivial manner. This is a result of the interaction between changes in labor and nonlabor income over the life-cycle pattern of accumulation. In all three experiments, individuals that have the highest responsiveness to the tax code are retired households as well as the youngest age cohort. This is partially due to the income effects associated to the relatively low taxation faced by these groups of individuals. The middle age individuals bear higher marginal tax rates and their response is smaller. The changes in progressivity maintain the hump-shaped behavior of housing consumption, but the response to changes in the degree of progressivity has a u-shaped pattern.

The final section of the table discusses the welfare gains by age groups. The first number considers a welfare compensation of consumption goods and housing services, whereas the second only considers the consumption goods compensation. We observe that the welfare gains affect households by different magnitudes. Despite the reduction in average home size for households between age 35 and 74 in the proportional tax case, the welfare increase is quantitatively significant. Following the same logic, these are the individuals that receive the largest losses, in addition to the oldest cohort, when the income tax schedule becomes more progressive. Despite the increase in the average owner-occupied house size these individuals are worse off than in the baseline economy. The results suggest that the individuals that take advantage of the asymmetric treatment of owner-occupied housing also benefit the most with its effective elimination through tax incentives.[18] The welfare gains from the housing provisions in the tax code has the lowest impact in the younger cohorts, since the impact in the average house size is relatively small.

4.2 Asymmetries in the Tax Treatment of Housing

4.2.1 Taxation of Owner-Occupied Housing Service Flows

Many economists argue that the primary distortion in the current tax code is the treatment of housing services. Under the cuurent tax code, income from the rental of housing services is subject to taxation, but the implicit income from owner-occupied housing is not subject to taxation. This policy introduces an asymmetry between the tax treatment of owners and landlords that favors the consumption of owner-occupied housing services while reducing the incentive to supply rental property. The implications of this asymmetry has been studied in the literature. Rosen and Rosen (1980) estimate the effects of excluding imputed rents of owner-occupied housing, the deductibility of property taxes and mortgage interest payments on tenure decisions. They find that if all benefits from ownership are eliminated, the proportion of homeowners would drop about 4 basis points. Using a general equilibrium framework where income is exogeneous, Berkovic and Fullerton (1992) find that average housing consumption would reduce between 3 and 6 percent. More recently, Gervais (2002), who employs an overlapping generations general equilibrium model, finds that taxing imputed rents of owner-occupied housing would increase the stock of business

[18]These tax provisions towards housing are still in place. However, when the marginal tax rate is zero homeowners loss of the tax benefits of choosing a larger dwelling. This is the case since the marginal tax rate does not depend on higher interest mortgage payments, and the failure to tax the implicit rental income from owner-occupied housing is irrelevant.

capital over six percent as well as decreasing the stock of housing eight percent. The effect on homeownership is not discussed.

Our framework offers some advantages over the existing literature. In contrast with Rosen and Rosen (1980), and Berkovic and Fullerton (1992), housing is both a consumption and an investment good. Income is endogenously determines in the model. With respect to Gervais (2002) and Nakajima (2003), we allow labor income risk and allow the supply of rental housing services to be endogenously determined. In our formulation we can address the impact of taxing services flows for housing tenure, housing consumption, and the supply of rental property.

The asymmetry in the tax treatment between homeowners and landlords with respect to the taxation of housing services is clear if the first order conditions from the household's optimization problem are once again examined. For those individuals that pay the fixed cost ϖ to become a landlord, their decision is determined by:

$$\frac{U_d}{U_c} = R(1 - \kappa_r T'(ay)) + p[T'(ay)\delta_r - \triangle\delta].$$

The terms on the right hand side capture the tax treatment of housing services and the deduction of maintenance expenses. This expression shows that the failure to tax housing services reduces the effective cost of owner-occupied housing. This wedge introduces a bias towards owner-occupied housing. When the imputed rental income from owner-occupied housing is taxed at the same rate as rental housing, then this asymmetry would be eliminated. The second term on the right hand side focuses on the wedge introduced by the asymmetric treatment of maintenance expenses. When owner and rental occupied housing services are taxed at the same rate, ($\kappa_r = 1$), the first-order condition reduces to:

$$\frac{U_d}{U_c} = R - p\triangle\delta + pT'(ay)\delta_r.$$

The remaining asymmetry arises from the treatment of maintenance expenses The term $p\triangle\delta$ lowers the opportunity cost of owner-occupied housing and reduces the incentives to supply rental housing. However, the tax term increases the opportunity cost since landlords give up the deduction from rental maintenance expenses. The importance of these two effects will vary with income levels.

We employ the model to measure the quantitative importance of these asymmetries. We consider the case where the imputed income of the service flows from owner-occupied housing, (measured as Rd), is fully taxable so that $\kappa_o = \kappa_r = 1$. Table 11 summarizes the aggregate implications of this policy change relative to the the benchmark economy.

Table 11: Taxation of Owner-Occupied Housing Services

	Interest Rate	Rental Price (% change)	Ownership Aggregate	Ownership Under 34	Ownership Income Q1
Benchmark	5.44%	-	63.7	33.1	32.0
Tax Services	5.21%	-1.83	66.9	35.5	34.46

	Gini After Tax Income/Wealth	Avg. Owner Size	Avg. Rental Supply	Mass Landlords	Welfare $\lambda_{cd}\|\lambda_c$
Benchmark	0.241/0.531	2,348	1,310	17.07	-
Tax Services	0.244/0.527	2,381	1,323	19.25	4.3|4.7

In terms of prices, the taxation of owner-occupied housing services results in a twenty-three basis point decline in the interest rate and a 1.83 percent decline in the rental rate. The interest rate impact suggests that households are redirecting resources from housing to business capital, thus reducing part of the crowding-out effect associated with the tax asymmetry. However, the taxation of the imputed rental income of owner-occupied housing provides an additional source of revenue. Under our assumption that tax policy should be revenue neutral, the average and marginal tax rate can be reduced. The reduction in taxation combined with an increase in average net income of one percent generates an small increase in the consumption of owner-occupied housing from 2,348 to 2,381 square feet. The 1.4 percent increase in housing consumption contrasts with the decline (3 to 6 percent) predicted by Berkovic and Fullerton (1992). We also find the aggregate ownership rate and the ownership rate for households under age 35 increases 5.0 percent and 7.5 percent, respectively. These results differs from Rosen and Rosen (1980) who predict a reduction in the aggregate ownership rate. Gervais' assumptions about the rental market prevents a direct measurement of the effects of this policy on ownership. None of these papers measure the impact for the supply of rental property or the consumption impacts for renters. The elimination of the asymmetric treatment of housing increases the fraction of landlords and generates incentives to supply more rental property. This increase occurs despite a two percent reduction in the rental price and is due the reduction in marginal tax rates.

Figure 2: Asymmetries Tax Treatment of Housing

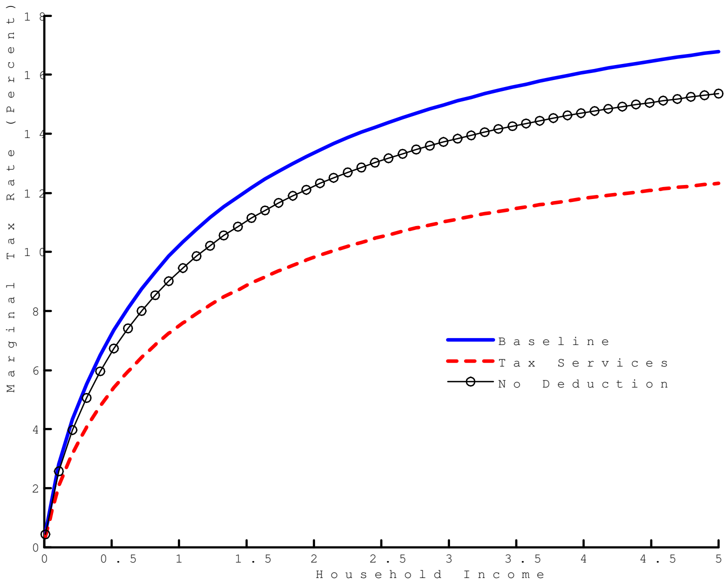


Figure 2 examines the implied marginal tax rates if owner-occupied housing services are taxed. The solid line presents the marginal tax rates from our benchmark model where GS tax structure is employed, and owner-occupied housing services are not taxed. If the imputed rental income from owner occupied housing is taxable and the assumption of revenue neutrality is maintained, the marginal tax rate is reduced over all income levels. This explains why landlords receive higher after tax rental income, despite lower rental rates. In addition, the average rental size increases by twenty-four percent.

The distributional implications of taxing owner-occupied housing services are presented in Table 12. The average consumption of owner-occupied housing increases over all income quintiles and in almost age groups, but the effect is not symmetric. The key factor is that even though all the marginal tax rates are scale down, the change in the definition of taxable income puts some households in a higher tax bracket. Thus most groups do not experience the same change in housing consumption. For example, we find that for the lowest income quintiles the increase is around 4.0 percent, whereas for the highest income quintiles ranges between 0.5 and 3.5 percent. If we consider life-cycle effects, the effects are more uniform with the exception of the second cohort and this age group maintains their housing size. In sum, the elimination of the asymmetry in the tax treatment between owner and rental occupied housing eliminates an unnecessary wedge in the economy that in conjunction with revenue neutrality should imply no reduction in housing consumption. The response of this policy depends on the strength of income effects that results in higher consumption of housing services. Welfare increases over all cohorts. The smallest benefit occur in the youngest age cohorts.

Table 12: Distributional Effects Taxation of Owner-Occupied Housing Services

Variable			**Sqft. Owners**		
by Income Quintiles	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Benchmark	2,239	2,197	2,773	3,887	4,242
Tax Services	2,331	2,206	2,860	3,905	4,390
Percent Change	4.1	0.4	3.1	0.5	3.5
by Age Cohorts	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
Benchmark	2,147	2,297	2,429	2,514	2,362
Tax Services	2,226	2,292	2,432	2,616	2,464
Percent Change	3.7	-0.2	0.1	4.1	4.3
			Welfare CE(λ_{cd})|**CE**(λ_c)		
	20-34	**35-49**	**50-64**	**65-74**	**75-89**
Tax Services	3.8/4.1	5.0/5.7	5.0/5.8	5.7/6.8	4.9/5.6

The distributional results substantially differ from those of Berkovic and Fullerton (1992). They found welfare losses for some individuals. Their finding is due to the fact that benefits from the reduction in the marginal tax rates do not offset the cost of moving into a higher tax bracket as taxable income increases. We do not observe this because of the important life cycle effects and the recognition that housing is an investment good.

4.2.2 The home mortgage interest deduction

One of the hallmarks of U.S. housing policy is the deductibility of mortgage interest payments for those households who itemize. This deduction creates an incentive to both own and consume more housing. The view among practitioners is that the removal of the interest deduction would result in less owner occupied housing consumption and thus smaller home sizes. Homeownership would be lower since the incentives to own have been reduced. Under revenue neutrality, the elimination of the deduction should result in a tax reduction. This effect is often ignored. Rosen (1979) and Rosen and Rosen (1980) are among of the first to examine the quantitative impact of the removal of this deduction. They find the homeownership rate would decline by four basis points. They do point out that their results could be somewhat biased as housing only serves as a consumption good and has no investment role.

They also ignore the equilibrium and the taxation effects associated to the elimination of this deduction. More recently, Gervais (2002) employs a general equilibrium life-cycle model where housing is both a consumption and investment good. In his model, the tax system introduces a wedge that makes owning preferable to renting. He finds that the elimination of the mortgage interest deduction under the assumption of revenue neutrality would reduce the aggregate homeownership by 4.2 basis points.

We use our model to measure the impact on ownership and housing consumption when mortgage interest payments are no longer deductible. Table 13 summarizes the effect on the main economic aggregates. We find that the elimination of this deduction has a positive effect on ownership. The aggregate ownership and the ownership for households under age 35 increases around one basis point. The small magnitude is a consequence of the revenue neutrality assumption. For the marginal household, the reduction in their tax bracket essentially keeps their after tax income unchanged. For younger households, the increase in the price of rental housing makes owning a relatively more attractive option. When combined with the income effect accompanying the tax reduction, the homeownership rate for younger households increases. This result contrasts with the findings of Rosen and Rosen (1980) and Gervais (2002) who find a large negative impact in homeownership. Our finding provides quantitative support to Glaesser and Shapiro's (2002) conjecture that the mortgage deduction has very small impact in home ownership.

Table 13: Elimination Mortgage Deduction

	Interest Rate	Rental Price (% change)	Ownership Aggregate	Ownership Under 34	Ownership Income Q1
Benchmark	5.44%	-	63.7	33.1	32.0
No Deduction	5.38 (-1.16)	0.28	64.7	33.9	33.2

	Gini After Tax Income/Wealth	Avg. Owner Size	Avg. Rental Supply	Mass Landlords	Welfare $\lambda_{cd}\|\lambda_c$
Benchmark	0.241/0.531	2,348	1,310	17.07	-
No Deduction	0.241/0.529	2,346	1,314	17.72	1.3|1.4

The elimination of the mortgage interest deduction reduces the consumption of owner-occupied housing, but this reduction is very small. The increase in the price of rental housing generates a 3.8 percent increase in the fraction of homeowners that choose to become a landlord and the average number of square feet supplied. The elimination of the home mortgage interest deduction causes the marginal buyer to have higher income and wealth thus increasing ownership but consuming slightly smaller homes. On the other hand, the marginal household that is forced into rental property has more income and wealth as compared to the household who was a renter in the benchmark case. Hence, they can afford larger dwellings. The quantitative effects to the elimination are tied to the fact that the average gross income only increases by 0.3 percent, and the marginal tax rates (see Figure 2) are reduced by a smaller magnitude than compared to the taxation of owner-occupied housing services. Despite the reduction in housing consumption, welfare increases 1.3 percent compared to the benchmark economy. It is important to stress that in this model the interest rate and the rental price are not linked by an arbitrage condition as in Gervais (2002). The increase in the rental price, the decrease of the interest rate, and the reduction in marginal tax rates account for the difference in our results from other studies.[19]

In principle, one would think that the relatively small price movements that we observe would make partial equilibrium analysis appropriate. In order to examine this possibility, we solve the model holding prices at the benchmark level and ignore the income effects associated to the revenue neutral assumption. In this case we find a larger negative effect in ownership rates as the aggregate ownership rate falls from 63.7 percent in the benchmark case to 60.4 percent when the deduction is removed. The homeownership rate for younger households falls from 37.5 percent to 33.5 percent (these results are not displayed in the Table 13). Under these restrictive assumptions, we find that approximately 5 percent of the homeowners in the economy own because of the existence of the mortgage deduction. Rosen and Rosen's (1980) partial equilibrium analysis implies a 6 percent change. The similar magnitude suggests that the more restrictive assumption in Rosen and Rosen is the holding of prices and taxation effects constant.[20]

Another issue is whether the mortgage deduction allows high earning households to purchase larger houses. The distributional effects of eliminating this provision in the tax code are presented in Table 14. When examining house size by income and age cohorts, we find that the average house size decreases in all cases except one, but the quantitative effects are very small. In most cases the reduction in housing consumption ranges between 0.5 to 2.0 percent. This policy affects households housing tenure and investment decisions along different dimensions. High income and wealthy households loose the ability to use the mortgage deduction to reduce the marginal tax rate. In addition, the redefinition of taxable income places some of young households in a higher tax bracket. As a result these individuals end up buying smaller homes, but the effects are quantitatively very small. Nevertheless, for the other income and age groups the reduction in the marginal tax rate compensates them for the removal of the mortgage deduction and housing consumption increases. In general, we find that the elimination of the mortgage interest deduction has very small but asymmetric implication for average consumption of owner-occupied housing.

[19] This result crucially depends on the response of the rental rate. If the interest rate and the rental price, the elimination of the mortgage deduction should reduce both at the same rate. The combined equilibrium effects of lower prices for rental housing and a less favouring tax treatment implies a reduction in homeownership. For example, Gervais (2002) finds that the elimination of the deduction reduces the aggregate ownership rate in 5.7 percent. However, when these two prices are not directly related the effects in homeownership are different.

[20] In this model all homeowners deduct mortgage interest payments. In the U.S. tax code only a fraction of the homeowners itemize. If we allow households to choose the standard deduction, the impact of the removal of this provision would be somewhat smaller, but they would be clearly bounded below by the partial equilibrium findings.

Table 14 Distributional Effects Eliminating Mortgage Deduction

Variable	Sqft. Owners				
by Income Quintiles	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Benchmark	2,239	2,197	2,773	3,887	4,242
No Deduction	2,275	2,199	2,807	3,966	4,232
Percent Change	1.61	0.09	1.22	2.03	-0.23
by Age Cohorts	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
Benchmark	2,147	2,297	2,429	2,514	2,362
No Deduction	2,146	2,297	2,416	2,527	2,363
Percent Change	-0.05	0	-0.5	0.52	0.04
			Welfare CE(λ_{cd})/CE(λ_c)		
	20-34	**35-49**	**50-64**	**65-74**	**75-89**
Tax Services	1.1/1.2	1.6/1.8	1.6/1.9	1.6/1.8	1.9/2.1

From an aggregate perspective, welfare increases by 1.3 percent. The welfare implications of this policy change are presented in the bottom portion of Table 14. The distributional effects of eliminating this tax provision are similar for individuals age 35 and above. The younger cohorts have the smallest welfare increase. This is a direct consequence of two factors. Approximately two thirds of these individuals are renters and do not benefit from the deduction. In addition, the marginal tax rate is relatively low since their income does not change much. To obtain a larger effect for these individuals, housing policies may have to be directed toward renters.

5 Housing Policy: Individual Housing Accounts and Tax Credits

In this section, we use the model to illustrate the implications of policies designed to benefit a particular segment or group in the economy. We show that housing policy can increase the ownership rate of a particular segment of the population, but generates non-trivial distributional costs in terms of welfare. We consider two different housing policies designed to reduced the difficulty that some families have in accumulating a downpayment. The first policy is related to Olsen's (2006) proposal for a housing voucher program for low income households. This proposal allows households that can afford the mortgage payments, but have insufficient resources to accumulate the downpayment to enter into homeownership. We consider a policy that gives homeowners a tax credit that covers some percentage of the downpayment requirement as a way to mitigate the burden of the downpayment constraint. The second policy considers the effects of implementing Individual Housing Accounts (IHA). This policy is motivated by policies in Europe where individuals who are not homeowners can take advantage of tax sheltered individual housing accounts (IHA's) that are intended to be savings vehicles for the accumulation of the downpayment. The IHA's accounts are similar to Individual Retirement Accounts (IRA's). The idea is that both the principal and the interest payments in an IHA would be exempt from progressive income taxation. This policy would be limited to current renters with the intent to stimulate ownership. In principal this policy does not have an age restriction, but it could be restricted only to young families.

The effectiveness of both policies towards ownership is an open question. Critics argue that while the policy chould shorten the time period that families need to save up for the downpayment, the impact of either policy might be small as many low income households will have problems meeting regular mortgage payments. In addition, these policies can introduce important distortions into the portfolio allocations of renters.

We employ the model to evaluate these two policies. The implementation of the first policy works by giving a tax credit that amounts to 50 percent the downpayment for a house of size, $\underline{h}$, while the second proposal allows a tax sheltered individual savings accounts for the individuals who are not homeowners and are under the age of 35.[21] In the experiments we maintain the existing tax code (i.e. interest deductions) and impose the revenue neutrality assumption. The results from these experiments are presented in Table 15.

Table 15: Aggregate Effects of Individual Housing Accounts

	Interest Rate	Rental Price (% change)	Ownership Aggregate	Ownership Under 35	Ownership Income Q1
Benchmark	5.44%	-	63.7	33.1	32.0
IHA	5.15(-5.4)	-1.3	69.0	30.0	39.1
Tax Credit	5.31(-2.6)	5.9	68.9	40.9	31.45

	Gini Income/Wealth	Avg. Owner Size	Avg. Rental Supply	Mass Landlords	Welfare $\lambda_{cd}\|\lambda_c$
Benchmark	0.241/0.531	2,348	1,310	17.1	-
IHA	0.243/0.531	2,426	1,191	16.5	4.3/4.8
Tax Credit	0.245/0.537	2,620	1,104	10.0	0.2/0.3

The introduction of Individual Housing Accounts results in a large increase in the aggregate homeownership rate. This increase might appear surprising since the homeownership rate for households under age 35 falls from 33.1 percent to 30.0 percent. For households in this age cohort, the IHA's creates an incentive to save rather than invest in housing. As a result, this age group delays their participation into market. The aggregate increase in the participation rate is due to the increase in the ownership rate in the other cohorts. The participation rate for households between age 35 and 49 increases by 15 percent. The reduction in the interest rate follows from the increase in savings generated by this program, and the crowding-out effect for business capital due to the financing of housing is reduced. The combination of an increase in household savings and lower interest rates partially accounts for a 3.3 percent increase in house size. Under this policy, the equilibrium rental price is lower and the fraction of individuals that choose to become landlords falls. The average rental unit is smaller. Overall, both aggregate welfare and welfare for each age cohort increases. Disaggregate welfare measures are presented in Table 16.

[21] Since the state space in the model is rather large, we abstract from introducing an additional asset that is subject to a different tax treatment where the proceedings of the asset are only used to purchase a house. We make some shortcut simplifications by assuming that savings of households of age 35 and less are not taxed. That would be equivalent to assume IHA where withdrawing the money to not purchase a house is not penalized. However, we think this assumption might increase the changes for households that receive negative income shocks to purchase a house.

Table 16 Welfare Distributional Effects

	Welfare $\mathbf{CE}(\lambda_{cd})/\mathbf{CE}(\lambda_c)$				
by Age Cohorts	**20-34**	**35-49**	**50-64**	**65-74**	**75-89**
IHA	4.0/4.3	5.0/5.7	4.9/5.7	5.1/6.0	3.1/3.6
Tax Credit	0.2/0.3	0.7/0.8	-0.4/-0.5	-0.4/-0.5	-1.8/-2.1

The introduction of a tax credit for one-half the downpayment on the purchase of a minimum size house also results in a large increase in the aggregate homeownership as the rate increases 5.2 basis points. The policy successfully increases the participation rate for first time buyers, (i.e., households under age 35) from 33.1 percent to 40.9 percent. Since the entry cost into the housing market is reduced, individuals spend more on housing. The average house size increases by roughly twelve percent. The combined effect of the increase in ownership and larger housing units generates a revenue deficit derived from the number of individuals using the tax credit and the mortgage deduction. To maintain revenue neutrality, the average and marginal income tax must increase. This is clearly seen in Figure 3 where the marginal tax rates are clearly greater that those in the benchmark economy. The implementation of tax credits has a marginal increase in aggregate welfare. However, as can be seen in Table 16, welfare does not increase over all age cohort. While welfare increases for the youngest age cohorts, welfare declines for the oldest age cohorts. For these latter age cohorts, the marginal tax rates have increases, and smaller amounts of housing services are consumed. The overall effect of the policy is clearly redistributive.

6 Conclusions

In this paper, we analyze the effects of the asymmetric tax treatment of homeowners and landlords. We construct a quantitative general equilibrium overlapping generations model that stresses tenure choice (renting vs. owning), housing investment decisions (financial assets vs. housing), and the decision to supply rental housing services. We present empirical evidence from the *Property Owners and Managers Survey* that indicates that modeling the of the rental supply decision should be at the household level. We also show that this modeling strategy eliminates the possibility of reducing the rental supply to an arbitrage condition. As a result, the rental supply response is critically affected by the interaction of the progressivity of the income tax code, and the implicit magnitude of the moral hazard effect measured by the spread between the maintenance cost of owner and rental occupied housing.

The model predicts a negative and quantitatively significant relationship between the progressivity of the income tax and ownership and housing consumption. Our findings suggest that the asymmetries in the tax treatment of housing can be affected by the presence of nonlinear taxation. For example, the model suggest that the impact of these asymmetries are minimized with a less progressive system which increases welfare. Interestingly, we find that the individuals that take advantage of the asymmetric treatment of owner-occupied housing also benefit the most with its effective elimination. In addition, we also find that the welfare gains associated with a change the progressivity of the income tax are much larger than the gains reported in Conesa and Krueger (2006). This suggests that the importance of income tax reforms are amplified in the presence of housing and indicate that taxation and savings issues should not be considered in an environment that abstracts from housing.

With respect to the elimination of the asymmetries in the tax treatment of housing, we find that the taxation of the imputed rental income from owner-occupied housing has a very small effect in housing consumption but increases the aggregate ownership rate of 3.2 basis points. The distributional effects in housing consumption and welfare are not symmetric across households. With respect the other asymmetry, we find that the elimination of the mortgage deduction has a small but positive effect in homeownership. This result is a consequence of the supply response of rental property that is disconnected from the interest rate and the revenue neutral assumption. The model predicts a no effects in the average house size and very small distributional effects. Finally, we explore the quantitative impact of the introduction of tax sheltered individual housing accounts (IHA) and tax credit for the downpayment. We find that these policies can be effective to foster owner-occupied housing, but the welfare implications can be very different. For example, the tax credit only increases the welfare of the relatively young families that have difficulties to accumulate the downpayment at the expense of the other households. However, IHA foster an increase in the aggregate level of savings that reduces the interest rate and generates sizeable welfare gains across all households.

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7 Appendices

7.1 Stationary Equilibrium

In the model economy, we restrict ourselves to stationary equilibria. The individual state variables are asset holdings, a, housing investment holdings, h, mortgage status, n, labor productivity status, ϵ, and age j. The aggregate state of the economy at time t is completely described by the joint measure Φ over asset positions, housing investment positions, mortgage status, productivity state, and age where $\Lambda = (a, h, n, \epsilon, j)$. Let $a \in \mathbb{R}_+$, $h \in \mathbb{R}_+$, $n \in \mathcal{N} = (1, 2, ..., N)$, $\epsilon \in \mathcal{E} = \{\epsilon_1, \epsilon_2, \epsilon_3, \epsilon_4, \epsilon_5\}$, $j \in \mathcal{J} = (1, 2, ..., J)$, and let $\mathcal{S} = \mathbb{R}_+ \times \mathbb{R}_+ \times \mathcal{N} \times \mathcal{E} \times \mathcal{J}$. Let $B(\mathbb{R}_+)$ be the Borel $\sigma-$algebra of $\mathbb{R}_+$, and $P(\mathcal{N})$, $P(\mathcal{E})$, $P(\mathcal{J})$ the power sets of $\mathcal{N}, \mathcal{E}$,and $\mathcal{J}$, respectively. Let $\mathcal{M}$ be the set of all finite measures over the measurable space $(\mathcal{S}, B(\mathbb{R}_+) \times B(\mathbb{R}_+) \times P(\mathcal{N}) \times P(\mathcal{E}) \times P(\mathcal{J}))$.

Definition (Stationary Equilibrium): Let $I_s(\Lambda)$ be an indicator value that is equal to one when the housing investment position is sold and zero otherwise, I_o be an indicator function that is equal to one if the household has a positive housing investment position and zero otherwise, and I_c be an indicator function that is equal to one if h does not equal h' and zero otherwise. Given a set of time-invariant fiscal policy arrangements $\{G, \tau_y(\eta_0, \eta_1, \eta_2), \tau_p(\overline{\theta})\}$, and initial conditions, a stationary equilibrium is a collection of value functions, $v(a, h, z, n, \epsilon, j,)$: $\mathcal{A} \times \mathcal{H} \times \mathcal{Z} \times \mathcal{M} \times \mathcal{E} \times \mathcal{J} \rightarrow \mathbb{R}$; and decision rules for the household, $\{a', h', z', c, d : S \rightarrow \mathbb{R}_+\}$ if $\mathrm{I}_s = 0$ or $\{a'_\xi, h'_\xi, z'_\xi, c_\xi, d_\xi : S \rightarrow \mathbb{R}_+\}$ if $\mathrm{I}_s = 1$, aggregate outcomes $\{K, N\}$; prices $\{r, p, R, r^m\}$; stationary population and invariant distribution $\Phi(a, h, z, n, \epsilon, j)$ such that

1. Given prices, $\{r, p, R, r^m\}$, policies, transfers, and initial conditions, the value function v and decision rules c, s, a', and h' solve the recursive formulation of consumer's problem as specified by

$$v(a, h, n, \epsilon, j) = \max_{\substack{(c,s,a',h') \\ I_r \in \{0,1\}}} \left\{ u(c, s) + \beta\psi_{j+1} \sum_{\epsilon' \in \mathcal{E}} \pi(\epsilon, \epsilon') v(a', h', n', \epsilon', j+1) \right\}$$

subject to

$$\begin{gathered} c + a' + I_o I_c[(\phi_b + \chi)ph' + m(z', p, h')] + (1 - I_c)I_o m(z, p, h) + I_o x(h', d) + (1 - I_o)Rd = \\ y - T(\widetilde{y}) + I_c[(1 - \phi_s)p\xi h - D(z, p, h)] \\ c, s, a', h' \geq 0 \text{ and } s \leq g(h'). \end{gathered}$$

where $n' = \max\{N - 1, 0\}$.

2. The social security program is self-financing with the tax rate determined by equation (5).

3. The general government balances as specified by equation (6).

4. Transfers are defined in equation (7).

5. The asset market is defined by equation (8) clears.

6. The rental market as defined by equation (9) clears.

7. The goods market condition is defined as:

$$C + K' - (1 - \delta)K + I_H + G + \Upsilon = F(K, N)$$

where C, $K' - (1 - \delta)K$, I_H, G, Υ represent aggregate consumption expenditures, aggregate investment in fixed capital, aggregate investment in housing goods, government expenditure, and aggregate total transaction costs. These variables are equal to:

$$C = \int_{I_s(\Lambda)=0} \mu_j c(\Lambda)\Phi(d\Lambda) + \int_{I_s(\Lambda)=1} \sum_{\xi \in \Xi} \pi_\xi \mu_j c_\xi(\Lambda)\Phi(d\Lambda)$$

where I_H represents the investment housing goods,

$$\begin{aligned} I_H = & \int_{I_s(\Lambda)=0} \mu_j h'(\Lambda)\Phi(d\Lambda) + \int_{I_s(\Lambda)=1} \sum_{\xi \in \Xi} \pi_\xi \mu_j h'_\xi(\Lambda)\Phi(d\Lambda) \\ & - [\int \mu_j h(\Lambda)\Phi(d\Lambda) - [\delta_o(\int_{\substack{I_s(\Lambda)=0 \\ s(\Lambda) \geq h'(\Lambda)}} \mu_j h'(\Lambda)\Phi(d\Lambda) + \int_{\substack{I_s(\Lambda)=1 \\ s(\Lambda) \geq h'(\Lambda)}} \sum_{\xi \in \Xi} \pi_\xi \mu_j h'(\Lambda)\Phi(d\Lambda)) \\ & - \delta_r(\int_{\substack{I_s(\Lambda)=0 \\ s(\Lambda) < h'(\Lambda)}} \mu_j h'(\Lambda)\Phi(d\Lambda) + \int_{\substack{I_s(\Lambda)=1 \\ s(\Lambda) < h'(\Lambda)}} \sum_{\xi \in \Xi} \pi_\xi \mu_j h'(\Lambda)\Phi(d\Lambda))] \end{aligned}$$

and Υ denotes resources allocated to total transaction and fixed costs,

$$\Upsilon = \int_{I_s(\Lambda)=0} \mu_j \phi_B h'(\Lambda)\Phi(d\Lambda) + \int_{I_s(\Lambda)=1} \sum_{\xi \in \Xi} \pi_\xi \mu_j \phi_B h'(\Lambda)\Phi(d\Lambda)$$
$$+ \varpi \int_{I_s(\Lambda)=0} \mu_j \Phi(d\Lambda) + \varpi \int_{I_s(\Lambda)=1} \sum_{\xi \in \Xi} \pi_\xi \mu_j \phi_B \Phi(d\Lambda)$$

8. The labor market clears where labor demand, as determined by the firm's first order condition, is equal to labor supply.

9. Letting T be an operator which maps the set of distributions into itself aggregation requires
$$\Phi'(a', h', z, n-1, \epsilon', j+1) = T(\Phi),$$
and T be consistent with individual decisions. We will restrict ourselves to equilibria which satisfy:
$$\Phi' = T(\Phi)$$