Stamping Out Stamp Duty: Housing Mismatch and Welfare*

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Abstract

Property transaction taxes - also known as stamp duty - are widely viewed as an inefficient form of taxation. In this paper, we examine the welfare implications of removing stamp duty in a general equilibrium overlapping generation model with heterogeneous agents. Our model features an idiosyncratic shock to housing preferences which may create mismatch or induce households to move. We calibrate the model to the Australian housing market, and conduct counterfactual policy experiments where stamp duty is replaced with recurrent property or consumption taxes. We find that removing stamp duty raises household mobility and reduces the degree of housing mismatch substantially. When examining steady states we find that newborn households prefer entering an economy with a recurring property tax rather than one with stamp duty. In contrast, when examining the transition we find that existing households prefer replacing stamp duty with a consumption tax.

Keywords: Property transaction taxes; OLG model; Heterogeneous agents; Housing Mismatch, Welfare
JEL code: E60, H24, H31, R21, R28

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1 Introduction

Property transaction taxes - a tax imposed upon the sale of real estate, often known as *stamp duty* - are an important source of revenue for governments in many countries.[1] Within the OECD, over 1 billion people live in jurisdictions that implement some form of property transaction tax.[2] Yet, at the same time, these taxes are often viewed as inefficient and highly distortionary (Besley, Meads, and Surico, 2014 and Best and Kleven, 2017). By discouraging housing transactions, these taxes may reduce household mobility and contribute to a misallocation of housing across households. As a result, reforms that reduce or remove stamp duty are often proposed (Henry, Harmer, Piggott, Ridout, and Smith, 2009 and Boadway, Chamberlain, and Emmerson, 2010). In this paper, we study the quantitative implications of removing stamp duty on welfare in Australia.

We develop a heterogeneous agents general equilibrium overlapping generations (OLG) model with housing to examine the welfare effects of removing stamp duty. This type of models has become a standard framework to analyse the impact of policy on housing markets.[3] Our model consists of finitely-lived households that derive utility from non-durable consumption and housing services. Households face idiosyncratic income and mortality shocks in an incomplete market setting. Every period they choose non-durable consumption, housing services, and savings into a risk-free financial asset and a housing asset, subject to borrowing constraints, progressive stamp duty and other transaction costs of housing. A household can rent or purchase a home and a homeowner can lease out houses in the rental market. As in Sommer and Sullivan (2018), the choice of housing tenure leads to endogenous demand and supply in both rental and purchase markets, allowing house prices and rents to endogenously respond to policy reforms. This framework allows us to study the impact of stamp duty on house prices, rents, housing allocations and transitions, and welfare. Furthermore, households vary in income, wealth, and age, allowing us to study how welfare changes are related to these characteristics.

Stamp duty is a large transaction cost that may reduce housing turnover and cause households to remain in homes that are mismatched to their needs or preferences. To allow for this possibility, we assume that utility from home ownership is subject to match-specific preference shocks. As a result, in our model, two motives drive households to purchase a new home. First, as in standard OLG models with housing, households may

[1] In North America, these taxes are often known as a *land transfer tax*. In Australia, the UK, and European countries, such taxes are often called *stamp duty*.

[2] Sánchez and Andrews (2011) and Bahl and Wallace (2008) document that property transaction taxes are widely used in the OECD and developing countries.

[3] See Gervais (2002) for a seminal contribution or for more recent work, see: Chambers, Garriga, and Schlagenhauf (2009), Cho and Francis (2011), Floetotto, Kirker, and Stroebel (2016), Sommer and Sullivan (2018), and İmrohoroğlu, Matoba, and Tüzel (2018).

move to a new house to alter the quantity of housing services consumed. This is essentially a permanent income motive adjusted to account for transaction costs and credit constraints. Second, households may move house not because they are dissatisfied with the size or quality of their current home. Rather, their personal circumstances may have changed, so they seek a home of similar quality but in a different location or with different features. We describe this as *housing mismatch* and this occurs when households receive a negative housing preference shock. Preference shocks are a feature of İmrohoroğlu et al. (2018). In their work, households that receive a shock *must* move, while in our work a preference shock reduces utility and *may* cause households to move. Hence, changes in tax policy may alter the equilibrium degree of housing mismatch.

We calibrate the model to match key moments describing the Australian housing market. To discipline the role of match-specific preference shocks we use data on home value changes, the distance moved, and *reasons for moving* in the Household Income and Labour Dynamics Australia (HILDA) survey in the calibration.[4] We find that preference shocks play an important role in explaining household mobility. In the absence of preference shocks, the model has difficulty matching the rate at which owner-occupiers move house. Despite not being targeted, the model does well in matching the life-cycle profiles of home ownership, landlord rates, and wealth accumulation.

Using the calibrated model, we conduct policy experiments that replace stamp duty with either a consumption tax or a recurring property tax. These alternative policies have been debated in Australia.[5] We begin by studying the effects on prices, quantities, and household mobility. Stamp duty generates a wedge between the buyer and seller price of housing. In both experiments, removing stamp duty eliminates this wedge and raises the price that a seller receives but lowers the price that a buyer pays for a house. These price changes are associated with an increase in home ownership and reduced demand for rental properties which reduces the rental price of housing. The changes in prices and overall home ownership are small. However, the home ownership rate increases more significantly for households under age 35 and over age 76, suggesting that the removal of stamp duty helps younger, more credit-constrained households to become homeowners and allows older households to move into smaller owner-occupied housing instead of renting. At the same time, the removal of stamp duty raises household mobility substantially. The housing turnover rate increases by more than 50% and the rate at which homeowners transition between properties almost doubles in both experiments. The degree of mismatch in the housing market also decreases substantially.

We examine welfare by extending a standard consumption equivalent variation (*cev*)

[4]See Watson and Wooden (2012) for information about the HILDA survey.

[5]The state of New South Wales has a concrete proposal to replace stamp duty with a recurring property tax while Deloitte (2015) discuss the benefits of a transition from stamp duty to a consumption tax.

approach to include housing consumption and bequest provision. Replacing stamp duty with a revenue-neutral property tax would generate the same increase in welfare to newborn households as a *cev* of 0.45% over their lifetime. If stamp duty is replaced with a consumption tax, the welfare gain to newborn households is slightly lower at 0.24%. These welfare gains arise from several important mechanisms: 1) stamp duty raises the buyer price of housing and, as a result, exacerbates credit constraints. 2) Stamp duty hinders an efficient intratemporal allocation of resources for consumption. Due to transaction costs, households tend to underconsume housing relative to a frictionless environment. The presence of stamp duty exacerbates this distortion. 3) Stamp duty generates a lock-in effect when households are subject to preference shocks. In the presence of stamp duty, a greater proportion of owners are mismatched to their homes.

We decompose welfare changes from removing stamp duty into i) a direct effect associated with changes in tax policy, ii) a general equilibrium effect associated with changes in house and rental prices holding housing supply fixed, and iii) a further general equilibrium effect associated with price changes with variable housing supply. This decomposition exercise reveals that the direct effect of changing tax policy raises welfare. The general equilibrium effect with fixed housing tends to reduce the welfare gain but allowing housing supply to adjust moderates this effect.

We also study the instantaneous welfare effects on existing households of the tax policy change. A slim majority of households lose when stamp duty is replaced with a property tax. Almost 70% of households own houses, and these households face an increase in their tax burden when a property tax is imposed. As a result, many of these households are worse off under a recurring property tax. With a consumption tax, the tax burden is shared more evenly across all households and we find a small welfare gain, on average, with 56% of existing households preferring the policy change. These results highlight a tension that exists when removing stamp duty. If we consider newborn households entering the economy in steady state, there is a preference for replacing stamp duty with a property rather than consumption tax. On the other hand, when examining welfare over the transition, existing households prefer to replace stamp duty with consumption taxes (on average). This highlights a tradeoff that policy makers face when eliminating stamp duty that is not discussed in the existing literature.

Despite the large role of stamp duty in raising taxes there have been few papers that examine the impact of stamp duty on welfare in a dynamic OLG setting. The one exception we are aware of, is by Kaas, Kocharkov, Preugschat, and Siassi (2020). They find, using a similar life-cycle model, a reduction in stamp duty and an increase in labour income taxes in the German economy reduces the welfare of newborn individuals in steady

state.[6] Our model differs along several dimensions but here we highlight two reasons for the different welfare implications. First, our model features housing mismatch which is absent in their environment. The possibility of mismatch implies households may choose to remain living in an inappropriate home due to the transaction costs of moving. Removing stamp duty reduces these costs and may lead to more appropriate matches and hence, welfare gains. Second, in their model rental supply is determined by a competitive corporate sector so the rental price is determined by the user cost of housing. As a result, the removal of stamp duty *increases* both the (pre-tax) purchase and the rental price of housing. In contrast, in our model the supply of rental housing is determined by the investment of individual households which is motivated by the fact that households rather than institutional investors dominate the supply of rental properties in Australia. As stamp duty is removed, households move from renting to purchasing, which reduces rental demand. In equilibrium, there is a *decrease* in the rental price of housing. This is important since Kaas et al. (2020) highlight that the general equilibrium price effects are important in understanding the welfare loss in their environment. Our paper adds to the literature that emphasises the role of supply conditions when evaluating the response of prices and welfare to changes in the housing market (see for example Graham (2020) and Greenwald and Guren (2020)).

There are a few other studies that examine the quantitative effect of transaction taxes on housing market. Määttänen and Terviö (2022) study the heterogeneous welfare effects of housing transaction taxes using an assignment model. In contemporaneous work, Han, Ngai, and Sheedy (2022) examine the effect of stamp duty on owner-occupied and rental markets using a search model. While we share a similar objective as these papers, our OLG approach allows us to focus on income, wealth, and age heterogeneity. As a result, we highlight how steady state welfare changes are related to income and how tax reform interacts with wealth and age over the transition.

As an alternative to stamp duty, we consider the ongoing taxation of property in our counterfactual experiment and find a significant steady state welfare gain. Property taxation combines the taxation of land and capital improvements to land. Land taxes have a long history as been viewed as efficient (see for example, George, 1879 and Banzhaf and Lavery, 2010), whereas the efficiency of taxation on capital improvements has been more controversial.[7] There is an emerging literature on the optimal taxation of housing. Olovsson (2015) in a Ramsey setting with housing and home production and Balke (2022) in an

[6] This result is somewhat surprising given that labour income is exogenous so that labour income taxes are non-distortionary.

[7] See Judd (1985), Chamley (1986), Aiyagari (1995) and Erosa and Gervais (2002) for alternative views. Conesa, Kitao, and Krueger (2009) find in a calibrated OLG model with heterogeneous agents and incomplete markets that the optimal capital income tax is significantly positive.

OLG model with housing find that strictly positive recurrent property tax rates on housing are optimal. Instead of discussing the optimal taxation on housing, our work provides a comparison of two different forms of taxation on housing, an upfront transaction tax versus recurrent property taxes, both in steady state and over the transition.

The rest of the paper is organized as follows: Section 2 provides a set of empirical facts which further motivates our study. Section 3 presents the model. Section 4 describes the calibration strategy and provides further validation of the calibration. Section 5 discusses the quantitative results, including the price and quantity effects of removing property transaction taxes and its impacts on housing mismatch and welfare. Section 6 concludes.

2 Data and Evidence

In this section, we provide an overview of how the Australian housing market has changed over time. Consistent with many OECD countries, house prices in Australia have increased dramatically since the early 2000s. In most of Australia, this increase has coincided with an increase in the effective stamp duty rate and stamp duty revenue. At the same time, the housing market has become less dynamic. This loss of dynamism is reflected in a lower housing turnover rate and a decline in the rate at which households transition to new owner-occupied homes. We also provide evidence of the importance of mismatch in the housing market by using novel aspects of the HILDA survey. We use these empirical observations to motivate our structural analysis.

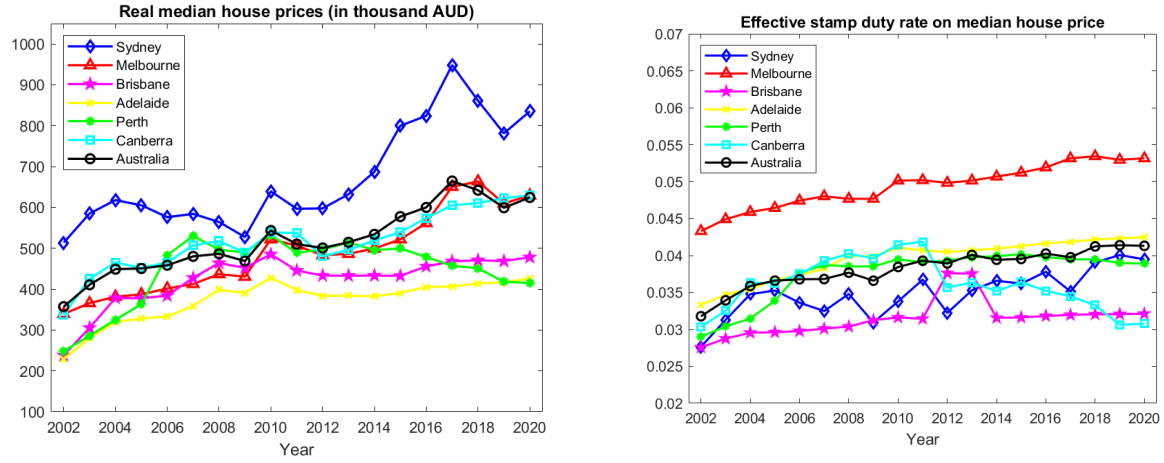
House prices and stamp duty. In Australia, stamp duty is imposed on buyers of properties and it is administered at the state level. It plays a significant role in state revenue, accounting for 21% of state government revenue but only 5.4% of total government revenue. Each state sets out a different schedule of marginal tax rates. These schedules are progressive, in the sense that the marginal tax rates increase with house prices. For instance, in Victoria, the marginal tax rate varies from 1.4% for houses priced below AUD 25,000 to 6.5% for houses priced above AUD 2,000,000.[8] For most states, there have only been minor changes in tax schedules over time. An exception is the Australian Capital Territory (ACT) which has gradually reduced stamp duty rates since 2012.

The left panel of Figure 1 shows a large increase in house prices in major capital cities from 2002-2020. House prices have increased in real terms, as well as relative to rental prices. This increase has been caused by a number of factors including a decline in interest rates and supply constraints. The decline in interest rates has allowed households to borrow larger amounts and have raised loan-to-income ratios.[9] The right-panel shows

[8] For a detailed cross-country comparison, refer to Appendix C in Kaas et al. (2020).

[9] Figure A–1 in Appendix A.3 shows the loan-to-income ratio, rent index, and price-to-rent ratio over

Figure 1: Real house prices (left) Stamp duty rate (right) from 2002 to 2020



Notes: House price data are from the Australian Bureau of Statistics (ABS). House prices are deflated using the Consumer Price Index released by the ABS (base year is 2012). State level effective stamp duty rates are obtained by applying the median house price of each capital city to the stamp duty schedule for the corresponding state.

that the increase in house prices has led to a significant increase in the effective stamp duty rate. For instance, from 2002-2020, the stamp duty on a median priced home in Sydney increased from 15% to 30% of average annual household disposable income.

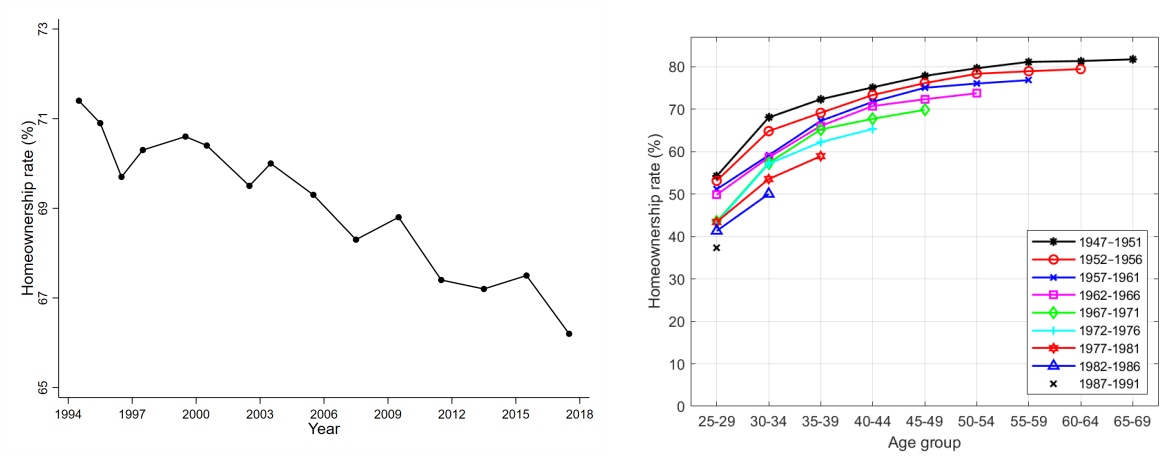
Home ownership. As prices have increased there has been a steady decline in the home ownership rate, as shown in Figure 2 (left panel). In 1994, 71.4% of households owned or were in the process of purchasing a home. By 2017, this percentage had fallen to 66.2%. The right panel of Figure 2 reproduces a figure provided by the Australian Institute of Health and Welfare that describes how home ownership evolves as individuals age for different birth cohorts.[10] Over time, home ownership rates for younger households have decreased significantly as they have found it increasingly difficult to purchase a home. This could reflect that higher house prices and stamp duty burden raise the upfront cost of purchasing a home. As such, it takes longer to save the downpayment required to become a homeowner.

Household mobility. We report two measures of mobility that reflect the dynamism of the housing market. The first is the housing turnover rate, defined as the number of property sales relative to the total number of dwellings. Leal et al. (2017) report the turnover rate has declined from 8% in the early 2000s to 5% in 2016. Our second measure, following

time. For further discussion on Australian housing market trends, see Cho, Li, and Uren (2021) and RBA (2021).

[10]See https://www.aihw.gov.au/reports/australias-welfare/home-ownership-and-housing-tenure.

Figure 2: Home ownership rate over time (left) and by birth cohort and age group (right)



Source: ABS ; Australian Institute of Health and Welfare

Table 1: Housing Transition Rates in Australia from 2002-2017

	O2O	R2O	O2R	R2R
Average rates (annual)	2.5%	5.2%	2.1%	14.7%
Relative shares	21.8%	15.5%	18.3%	44.4%

Source: Household Income and Labour Dynamics Australia. Authors' calculation.
Notes: The first row displays the average annual transition rates for different moves. The second row shows the relative shares of each type of move out of total moves.

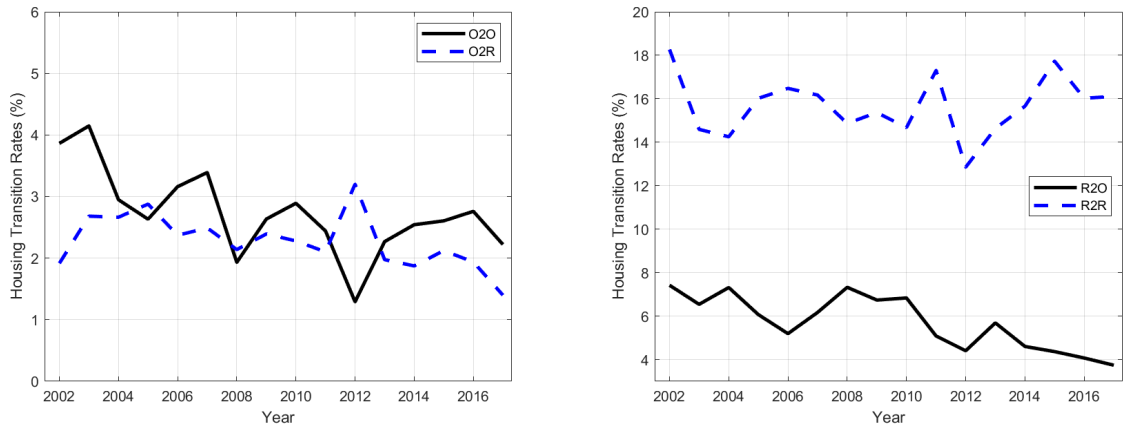
Bachmann and Cooper (2014), evaluates household mobility by studying transition rates. We use the HILDA survey to divide moving households into four different categories: 1) owner-to-owner (O2O); 2) renter-to-owner (R2O); 3) owner-to-renter (O2R); 4) renter-to-renter (R2R). The O2O and O2R transition rates in a particular year are calculated as the total O2O and O2R transitions divided by the number of homeowners in the previous year. The R2O and R2R transition rates are defined analogously.[11]

Table 1 reports the average annual transition rates over the sample period and the relative shares of each type of move, out of total moves. It shows that mobility is significantly higher among renters who are moving into new rental housing. These R2R transitions account for 44% of all moves despite renters only comprising 33% of the population. The average rates at which homeowners and renters are moving into a new owner-occupied house, and hence subject to stamp duty, are 2.5% and 5.2%, respectively.

Figure 3 shows how housing transition rates have evolved. The left panel shows that both O2O and O2R transition rates have decreased over time. In particular, the O2O transition rate declined from 4.1% in 2003 to 2.2% in 2017. The paths of R2O and R2R

[11]We consider the period from 2001 to 2017 and households aged between 21 and 84. Further details about the HILDA survey and our sample selection procedure are in Appendix A.1.

Figure 3: Housing transition rates over time: O2O-O2R (left) R2O-R2R (right)



Source: Household Income and Labour Dynamics Australia, Authors' calculation.

transition rates are depicted in the right panel of Figure 3. While the R2R transition rate remained steady at around 15%, the R2O transition rate declined from 7.4% in 2002 to 3.7% in 2017. We conclude that the housing market has become less dynamic.

How should we interpret these results? Although this is not crucial for our later quantitative analysis,we believe that a trend decline in interest rates has allowed households to borrow larger sums for house purchases and boosted house prices. This, and potentially other factors, has contributed to a significant rise in house prices relative to the general price level and income. Due to the progressive nature of the stamp duty schedules, the size of transaction taxes has increased in the purchase market. Although we do not present causal evidence, as that is beyond the scope of this paper, we conjecture that the increase in stamp duty is at least partly responsible for a decline in household mobility. Several empirical studies have documented a causal effect of increases in stamp duty schedules on reducing household mobility in other countries.[12] Our context is different: increases in house price generate stamp duty bracket creep and raise effective stamp duty rates. These higher stamp duty rates should, at least in theory, discourage household mobility.

Housing preference shocks as a motivation for moving. The existing literature on housing markets has emphasised two separate motivations for moving. OLG models focus upon a permanent income motive: households select house size based on their current income, wealth, and future expected income, taking into account transaction costs and credit constraints. As households accumulate wealth or benefit from unexpected positive shocks to their income, they may upsize their house, while negative shocks may cause

[12]See Hilber and Lyytikäinen (2017), Eerola, Harjunen, Lyytikäinen, and Saarimaa (2021), and Han et al. (2022) as examples.

downsizing. In this theory, O2O housing transitions reflect changes in desired consumption of housing services, that in turn, are driven by changes in lifetime resources. We describe these as *size-quality transitions* since households seek to alter their consumption of housing services by moving into either a smaller or larger sized home or by moving to a home with better or worse quality.

Another literature treats the housing market as a frictional search market (Wheaton, 1990 and Ngai and Sheedy, 2020). In these models, transactions occur not because of changes in lifetime resources but rather due to changes in preferences for idiosyncratic features associated with their residence. In this view, houses are differentiated products with varied characteristics even if they sell for a similar price. Furthermore, preferences may change over time, resulting in households becoming mismatched to their home. As a result, households may sell a property and move to a new property of similar size or quality. We describe such moves as *mismatch transitions*.[13]

We view the possibility of mismatch as important to our economic question. A potential cost of stamp duty is that it may create a lock-in effect: households mismatched to their current home are prevented from moving due to transaction costs. Ignoring this mechanism could bias our estimates of the welfare effects of removing stamp duty. Hence, one of our key aims is to determine how important preference shocks are relative to changes in permanent income in driving transitions.

In our calibration (to be discussed in Section 4), a key moment we will try to match is the percentage of O2O transitions that arise due to preference shocks that create mismatch. We estimate this using data from the HILDA survey. In particular, households report their reason for moving and a full list of possible reasons is provided in Appendix A.2.[14] These self-reported reasons for moving do not directly identify whether an O2O move is a size-quality transition or a mismatch transition. For example, a household may say that they are moving to start a new job. A new job may indicate an increase in permanent income that could motivate a move to a better-quality home. In this case, this should be classified as a *size-quality transition*. Alternatively, the new job may be far from their current home, and the household may move to a similar quality home closer to their new workplace. This would reflect a change in the valuation of idiosyncratic features of the house (here, the location) and should be classified as a *mismatch transition*.

However, some reasons for moving can be classified without controversy. In the HILDA survey, 55% of households engaged in an O2O transition described their reason for mov-

[13] A size-quality transition reflects a mismatch between an owner's preferred house size and the size of their current house. Here we use *mismatch transition* to denote a mismatch between preferences and house characteristics that are, unlike size and quality, not modelled explicitly.

[14] The exact question asked is "If you have moved during the last 12 months, what were the main reasons for leaving your previous address?". The HILDA survey provides greater disaggregation of responses to this question than the PSID, which allows us to estimate the degree of mismatch.

Table 2: Characteristics of O2O movers by reason for moving

	Preference		Size/quality	
	(1)	(2)	(3)	(4)
Distance moved (km, median)	33	105	4	6
%Δ in house value (+, median)	40.9	36.0	50.9	15.8
%Δ in house value (−, median)	-23.1	-18.0	-8.6	-24.2
% of hhs with +Δ in house value	56.8	58.7	88.8	25.7
%Δ in income (median)	3.1	3.2	6.2	3.7
Age (median)	54	59	39	62

Notes: This table reports, for O2O transitions by different *reasons for moving*, the median distance moved, median percentage changes in self-reported house value conditional upon an increase or decrease in house value, the proportion of movers reporting an increase in house value, the median percentage change in income, and the median age of movers. Columns (1) to (4) represent the following reasons: (1) seeking change of lifestyle; (2) to be closer to friends and/or family; (3) to get a larger/better place; and (4) to get a smaller/less expensive place.

ing as a desire "to get a larger/better place" or "to get a smaller/less expensive place". We view these reasons as consistent with *size-quality transitions*. On the other hand, 21% of households state that the main reason for moving is "seeking change of lifestyle" or "to be closer to friends and/or family". We view these transitions as compatible with *mismatch transitions*.[15] We also note that these two types of transitions differ significantly along several dimensions, as reflected in Table 2. In particular, households motivated to move to a "larger/better place" typically have larger increases in the self-reported house value, are younger, and move smaller distances than households where transitions are motivated "to be closer to friends and/or family" or those "seeking change of lifestyle".

This suggests the following approach to classify the remaining transitions. We first estimate a discrete-choice logit model to determine whether a transition is a *size-quality* or a *mismatch* transition using the reasons for moving that we view as uncontroversial. We then apply this estimated discrete-choice logit model to the remaining 24% of O2O transitions that are unclassified. For each unclassified transition, we use the estimated model to calculate the probability that this transition is a *size-quality* transition. We aggregate these probabilities to obtain the proportion of transitions due to *size-quality* reasons. Overall, we estimate that 72.7% of O2O transitions are due to *size-quality* reasons and the remaining 27.3% are due to *mismatch*. Details are in Appendix A.2.

Taking stock. We summarise the empirical facts as follows. First, house prices and the burden of stamp duty have increased considerably since the early 2000s. Second, home

[15]Some might argue that transitions motivated by a change in lifestyle could reflect employment or lifetime income changes and could be classified as a size-quality transition. We do not see large contemporaneous changes in income when people move for this reason in our sample

ownership and household mobility have decreased over time. Finally, we use the reasons for moving and other characteristics associated with transitions to highlight the relative importance of *size-quality* versus *mismatch* transitions.

3 Model

Our model is similar to Cho, Li, and Uren (2023). The economy comprises of a large number of finitely lived households. Households receive utility from a non-durable consumption good, housing services, and bequest provision. Housing services can be obtained by renting or purchasing a durable housing asset. Households supply labour inelastically and face idiosyncratic risk in their labour income. They can partially insure themselves by saving. These savings can be in the form of a risk-free financial asset or in the form of housing assets. Purchasing houses is subject to stamp duty and other transaction costs. Homeowners also face preference shocks that affect the utility they receive from their existing home. The supply of housing is determined by a competitive construction sector that alters the stock of housing in response to changes in house prices. House prices and rents are determined endogenously by equating supply and demand in the purchase and rental markets.

3.1 Households

Demographics. Time is discrete. There is a continuum of households. The age of a household is denoted by a and each household has a maximum age of A. The probability a household survives into next period is age dependent. Let κ_a denote the probability of surviving to age $a+1$ conditional on current age a. The population size remains constant as newborn households enter the economy to replace those who die.

Preferences. Households receive utility from consuming non-durables, c_a, housing services, $\tilde{h}_a$, and leaving a bequest, b. The flow utility is given by

$$u(c_a, \tilde{h}_a) = \frac{\left(c_a^{\alpha}(\lambda \tilde{h}_a)^{1-\alpha}\right)^{1-\sigma}}{1-\sigma} \tag{1}$$

where α measures the preference for non-durable consumption and the coefficient of relative risk aversion is σ. Following De Nardi (2004), a warm-glow bequest motive is introduced to match asset accumulation over the life cycle. The utility derived from leaving a bequest is

$$\nu(b) = \vartheta \frac{(b+\underline{b})^{1-\sigma}}{1-\sigma} \tag{2}$$

where b is the size of the bequest, which equals the remaining assets of the deceased household, ϑ is a measure of the strength of the bequest motive, and $\underline{b}$ determines the extent to which bequests are a luxury good.[16] Households maximise expected discounted lifetime utility, with a discount facor $\beta \in (0,1)$.

The parameter λ is a preference shifter that affects the utility received from housing services. This shock is introduced so that owning a home may increase utility from housing services above that received from renting but some homeowners can become *mismatched*, which may reduce their utility from ownership and provide an incentive to move house. Consequently, we set $\lambda = 1$ if a household rents, and let $\lambda \in \{1+\xi, 1-\xi\}$ be stochastic if they own. Here, $\xi > 0$ describes the benefit of living in a well-matched home and the penalty of living in a poorly-matched home. A household in a newly-purchased home starts with a favourable match ($\lambda = 1+\xi$). If the household remains at this dwelling, λ follows a two-state Markov process with transition matrix

$$\Pi = \begin{bmatrix} \pi_{hh} & 1-\pi_{hh} \\ 1-\pi_{ll} & \pi_{ll} \end{bmatrix},$$

where π_{hh} (π_{ll}) denotes the probability of remaining in the high (low) state over a single period. This preference shock is a novel aspect of our model related to shocks used by Floetotto et al. (2016) and İmrohoroğlu et al. (2018). In their work, households *must* move after receiving a shock. In our work, when faced with reduced utility from ownership, households make a rational decision to move or not. As a result, removing stamp duty may alter the degree of mismatch in the housing market which, in turn, affects welfare.

Income and endowments. Households supply labour inelastically and receive idiosyncratic labour income in every period of life. The income process is given by:

$$\log y_{i,a} = \eta_a + z_{i,a} \tag{3}$$

where η_a is a deterministic age-dependent component and $z_{i,a}$ is idiosyncratic. We assume that $z_{i,a}$ follows an AR(1) process:

$$z_{i,a} = \rho z_{i,a-1} + u_{i,a}, \qquad u_{i,a} \sim N(0, \sigma_u^2). \tag{4}$$

In the calibration, equation (4) is approximated with a finite Markov chain so that $z \in \mathcal{Z} \equiv \{z_1, ..., z_J\}$. Households are born with endowments of initial housing and financial assets drawn from an exogenous joint distribution that we calibrate to match the distribution of housing and financial wealth among young households.

[16] A bequest motive helps the model match a realistic level of home ownership in the later stages of the life cycle. We assume that bequests are collected by the government to fund government consumption which does not enter into the household utility function.

Housing demand. Households select whether to rent or own their homes. Homeowners may rent out a portion of their housing asset and become landlords. The quantity of housing a household owns is given by h. If $h = 0$, the household is a renter and they choose a quantity of housing $\tilde{h}$ to rent. A homeowner with $h > 0$ selects a quantity of housing services $\tilde{h}$ to consume, with $h \geq \tilde{h}$. Any remaining housing asset, $h - \tilde{h}$, is rented out. This structure allows a homeowner to transform their housing from rental to owner-occupied or vice versa. It allows households to become landlords and supply rental housing without increasing the complexity of the model and is commonly used in recent literature (e.g., Floetotto et al., 2016; Sommer and Sullivan, 2018; and Kaas et al., 2020).[17] The endogenous prices of purchasing and renting a unit of housing are p and p^r, respectively. We will refer to p as the house price or the seller price and p^r as the rental price throughout the paper.

Following Gervais (2002) and Cocco (2005), we assume there is a minimum purchase and minimum rental size denoted by h_{min} and h^r_{min}, respectively. We assume that $h^r_{min} < h_{min}$, reflecting that renters often share housing while homeowners do not. The presence of a minimum purchase size increases the importance of credit constraints and may shift the composition of ownership towards older and wealthier households.

Stamp duty and other housing costs. Housing transactions incur both a selling and a buying cost. These are given by

$$TC(h_{-1}, h) = \begin{cases} 0 & \text{if } \; h_{-1} = h \\ SD(ph) + \phi^b ph + \phi^s ph_{-1} & \text{if } \; h_{-1} \neq h \end{cases}$$

Buyers incur both stamp duty, given by the function $SD(ph)$, and other costs of purchasing a home, such as search costs, captured by a constant fraction ϕ^b of the house price. To capture the progressive nature of stamp duty rates in the data, we let the stamp duty function $SD(ph)$ take the following specification:

$$SD(ph) = ph - \phi_{sd}(ph)^{1-\tau_{sd}} \tag{5}$$

which is often used in the literature (e.g. Heathcote, Storesletten, and Violante, 2017) to model progressive taxation. In this formulation, the parameter ϕ_{sd} captures the level of tax while τ_{sd} captures the degree of progressivity. The presence of stamp duty introduces a wedge between the buyer and seller price, p. We will describe the price inclusive of stamp duty, as the effective purchase price or buyer price of housing.

Sellers incur a constant fraction ϕ^s of the house's selling price as real estate agent fees and other costs of selling. Note that homeowners who move into a new house incur both selling and buying costs. Homeowners also incur maintenance expenses to offset physical

[17] This allows the model to have a single state variable to describe total housing instead of two separate state variables: one for owner-occupied and another for investment housing.

depreciation of housing. The maintenance cost is a constant fraction δ of the house value. Landlords incur an additional fixed per-period cost ζ associated with finding tenants and managing the rental property. These transaction costs generate a decision rule for housing asset, as illustrated in Appendix C.1, that resembles the (S,s) rule for consumption of durable goods discussed in Grossman and Laroque (1990).

Financial assets. Households may trade a risk-free financial asset. They can save by purchasing this asset ($s > 0$) or borrow ($s < 0$) using their home as collateral subject to a loan-to-value constraint:

$$s \geq -(1-\theta)ph, \qquad 0 < \theta < 1 \tag{6}$$

where $1-\theta$ is the maximum loan-to-value ratio. Savers receive an interest rate of r, while borrowers face an interest rate of $r+m$, where m is a mortgage premium. We assume Australia is a small open economy and consider both r and m as fixed constants.

Taxable income. The total taxable income of a household is given by:

$$Y = y_a(z) + rs_{-1}\mathbb{1}_{\{s_{-1}>0\}} + NRI \tag{7}$$

where $y_a(z)$ denotes the household's income which depends on her age a and realization of idiosyncratic income shock, z. The term $rs_{-1}\mathbb{1}_{\{s_{-1}>0\}}$ is the interest income from financial assets where $\mathbb{1}$ is an indicator function that takes a value of 1 if its argument is true and zero otherwise. The last term, NRI, stands for net rental income (if the household is a landlord) which is defined as

$$NRI(h,\tilde{h},s) \equiv \left[(p^r - p\delta)(h-\tilde{h}) + (r+m)s\left(\frac{h-\tilde{h}}{h}\right)\mathbb{1}_{\{s<0\}} - \zeta\right]\mathbb{1}_{\{h>\tilde{h}\}} \tag{8}$$

The NRI consists of three components: rental income earned after paying maintenance costs, a deduction of the interest expenses on mortgages for housing investment purposes, and a fixed cost associated with being a landlord.[18]

Dynamic programming problem. At the beginning of a period a household observes their income shock and housing preference shock, if an owner. They then decide on their housing tenure status. That is, whether to (i) rent, (ii) stay in their current house, or (iii) move to a new house. Following their housing tenure decision, a household selects non-durable consumption c, housing consumption $\tilde{h}$, saving or borrowing s, and housing assets to purchase h, if moving. These decisions depend upon the equilibrium prices, (p, p^r),

[18] Australia does not allow mortgage interest deductions for owner-occupied housing but does allow for a deduction for investment housing. As a result, we assume a certain proportion of total debt, $\frac{h-\tilde{h}}{h}$, is deductible as an investment expense while the remaining proportion is associated with interest expenses on owner-occupied housing which is not deductible.

and the household's age a, income shock z, existing housing assets h_{-1} and savings s_{-1}, and the housing preference shock λ. We define a state vector, $x \equiv (a, z, s_{-1}, h_{-1}, \lambda)$, and write the value functions as

$$V(x) = \max\{V^{\text{renter}}(x), V^{\text{stayer}}(x), V^{\text{mover}}(x)\} \tag{9}$$

A renter's problem is as follows:

$$V^{\text{renter}}(x) = \max_{c,\tilde{h},s} u(c,\tilde{h}) + \beta \left[\kappa_a \mathbb{E}_{z'|z} V(x') + (1-\kappa_a)\nu(b)\right] \tag{10}$$

subject to

$$\begin{aligned} &c + s + p^r \tilde{h} + TC(h_{-1}, 0) + \delta p h_{-1} + T(Y) \\ &\qquad\qquad = y_a(z) + p h_{-1} + (1 + r + m\mathbb{1}_{\{s_{-1}<0\}}) s_{-1}, \\ &b = s \geq 0, \end{aligned}$$

where $x' \equiv (a+1, z', s, 0, 1)$, $Y = y_a(z) + r s_{-1}\mathbb{1}_{\{s_{-1}>0\}}$, and $T(Y)$ is the income tax paid to be described below. A renter chooses consumption of nondurables and housing services, and savings subject to a flow budget constraint. As a renter does not own housing assets, they cannot borrow, so $s \geq 0$.

A homeowner who stays in her existing home sets $h = h_{-1}$ and solves:

$$V^{\text{stayer}}(x) = \max_{c,\tilde{h},s} u(c,\tilde{h}) + \beta \left[\kappa_a \mathbb{E}_{(z',\lambda')|(z,\lambda)} V(x') + (1-\kappa_a)\nu(b)\right] \tag{11}$$

subject to

$$\begin{aligned} &c + s + \delta p h_{-1} + T(Y) + \zeta \mathbb{1}_{\{h_{-1}>\tilde{h}\}} \\ &\qquad\qquad = y_a(z) + p^r(h_{-1} - \tilde{h}) + (1 + r + m\mathbb{1}_{\{s_{-1}<0\}}) s_{-1}, \\ &b = s + p h_{-1}, \\ &s \geq -(1-\theta) p h_{-1}, \end{aligned}$$

where $x' \equiv (a+1, z', s, h_{-1}, \lambda')$, and $Y = y_a(z) + r s_{-1}\mathbb{1}_{\{s_{-1}>0\}} + NRI(h_{-1}, \tilde{h}, s)$. This differs from a renter's problem in that a stayer can borrow subject to a collateral constraint and may choose to become a landlord and earn rental income. In addition, their bequest includes both financial and housing assets, and they face a housing preference shock such that λ evolves to λ' in next period.

A homeowner who decides to move house solves the following problem:

$$V^{\text{mover}}(x) = \max_{c,\tilde{h},s,h} u(c,\tilde{h}) + \beta \left[\kappa_a \mathbb{E}_{z'|z} V(x') + (1-\kappa_a)\nu(b)\right] \tag{12}$$

subject to

$$
\begin{aligned}
& c + s + ph + TC(h_{-1}, h) + \delta p h_{-1} + T(Y) + \zeta \mathbb{1}_{\{h > \tilde{h}\}} \\
& \qquad = y_a(z) + p h_{-1} + p^r (h - \tilde{h}) + (1 + r + m \mathbb{1}_{\{s_{-1} < 0\}}) s_{-1}, \\
& b = s + ph, \\
& s \geq -(1 - \theta) ph,
\end{aligned}
$$

where $x' \equiv (a + 1, z', s, h, 1 + \xi)$, and $Y = y_a(z) + r s_{-1} \mathbb{1}_{\{s_{-1} > 0\}} + NRI(h, \tilde{h}, s)$. This differs from a stayer's problem in that a mover has an additional decision of what size house to purchase, faces transaction costs from selling and buying housing, and starts next period with a high housing preference state.

3.2 Government

The government collects income tax, stamp duty, and the assets of deceased households and uses this revenue for its own consumption that does not affect households' decisions. We incorporate a progressive income tax system to replicate the Australian tax system. The total tax paid by a household, as a function of her total taxable income, is given by:

$$
T(Y) = \begin{cases}
0 & \text{if } Y \leq \bar{Y}_1 \\
\tau_1 (Y - \bar{Y}_1) & \text{if } \bar{Y}_1 < Y \leq \bar{Y}_2 \\
T_1 + \tau_2 (Y - \bar{Y}_2) & \text{if } \bar{Y}_2 < Y \leq \bar{Y}_3 \\
\vdots & \\
T_{Q-1} + \tau_Q (Y - \bar{Y}_Q) & \text{if } Y > \bar{Y}_Q.
\end{cases}
$$

Here, τ_q for $q \in \{1, \cdots, Q\}$ are the marginal income tax rates. $\bar{Y}_q$ and T_q represent the income thresholds at which marginal tax rates change and the tax paid at different income thresholds.

3.3 Construction Sector

A foreign-owned construction firm is introduced to endogenize housing supply. This firm fulfils two roles. First, it collects homeowners' maintenance expenditure on housing to offset the depreciation of existing housing stock. Second, new houses are supplied using newly available land for development. As in Floetotto et al. (2016), we assume that the construction firm purchases land to produce new housing using the following production function:

$$
H^{\text{new}} = \psi_1 L^{\psi_2}
$$

where L is the quantity of land purchased from the government, ψ_1 is a scale parameter and $\psi_2 < 1$ describes the degree of decreasing returns in housing construction. We assume

that the government's supply of land is perfectly elastic and hence can normalise the price of land to one. Homes produced by the construction company can be sold at price p. Hence, the construction firm solves:

$$\max_{L} \left\{ p\psi_1 L^{\psi_2} - L \right\},$$

which implies an inflow of new housing,

$$H^{\text{new}} \equiv \psi_1 (L^*)^{\psi_2} = \psi_1 \left(\psi_1 \psi_2 p\right)^{\frac{\psi_2}{1-\psi_2}}.$$

The elasticity of the steady state housing supply with respect to price is $\varepsilon = \psi_2/(1-\psi_2)$. The transition equation for aggregate housing stock is

$$H = H_{-1}(1-\delta) + H^{\text{new}}. \tag{13}$$

There are two sources of income that we assume away. First, the construction sector earns profits due to a decreasing returns to scale production function. We assume these profits are distributed to the foreign sector. Second, the government earns revenue from the sale of land. We assume this revenue does not contribute to government budget constraint.

3.4 Stationary Equilibrium

In our stationary equilibrium, households maximise utility by making optimal consumption, saving, housing asset, and housing consumption choices. Market clearing conditions determine house and rental prices. The total stock of housing is determined by the profit maximising behaviour of the construction sector and the distribution of the state variables is constant over time. A formal definition of equilibrium is in Appendix B.

3.5 Distortions and Market Failures

Our model is designed to study the welfare implications of removing stamp duty and replacing it with either a property or consumption tax. Here, we highlight the key market failures in the model, and the margins along which individuals can respond to different taxes and how these responses may lead to distortions. We begin with a caveat: our framework is an OLG model and hence, the competitive equilibrium without taxation is not necessarily efficient. As a result it is, in general, difficult to know what are the welfare implications of taxes or other distortions on the economy.

Moving beyond this observation, a key market failure in our model is that credit markets are imperfect; households are subject to a borrowing constraint (see Equation (6)). We expect this constraint to reduce housing assets held by households below efficient levels. Stamp duty can exacerbate this market failure by raising the purchase price (inclusive of

transaction tax) that a buyer faces. Furthermore, our model features idiosyncratic income and housing preference risk that can not be perfectly insured due to incomplete markets. Given these market failures, the presence of stamp duty may exacerbate inefficiency as households who desire to move (because of changes in income or preferences) may be discouraged by the transaction tax. This suggests that eliminating stamp duty may lead to welfare gains.

In reality, reduced stamp duty revenue has to be recovered by raising alternative taxes, which can be distortionary as well. In our experiments, we replace stamp duty with either a consumption or a property tax. In both cases, these taxes alter decisions and can be distortionary. The consumption tax raises the price of non-durable consumption relative to the price of renting or purchasing a home. As a result, it will tend to increase housing relative to non-durable consumption. Similarly, the imposition of a property tax will tend to discourage the purchase of housing and hence reduce house prices, which in turn, reduces the equilibrium supply of housing. That is, our policy experiments replace distortionary stamp duty with alternative distortionary taxes.

We also note labour income follows an exogenous process in our model. Hence, labour supply cannot respond to changes in the tax system. If a labour supply margin did exist, an increase in any of the taxes (stamp duty, property or consumption taxes) would induce a wedge between the market wage and the marginal rate of substitution between (either housing or non-durable) consumption and leisure and result in a labour supply response. Consequently, any of these taxes could distort labour supply decisions although the size of the distortion would depend upon the specifics of the calibration.

4 Calibration

Some of the exogenous parameters are set by referring to existing external evidence. The remaining exogenous parameters are set by matching model moments to the corresponding data. Table 3 reports the calibrated parameter values and Table 4 reports the targeted moments in both data and the model.

4.1 Externally Calibrated Parameters

Demographic and Preferences. A period in our model corresponds to two years. Households enter the economy at age 21 and exit with certainty at age 84. Age-dependent survival probabilities, κ_a, are sourced from the ABS Life Tables 2014-2016. We follow much of the literature and set σ, the coefficient of relative risk aversion, to equal 2.

Table 3: Parameter values

Parameter	Interpretation	Value	Source
Demographics			
A	Max. length of life (excluding youth)	64 years	-
κ_a	Survival probabilities	Refer to text	ABS
Preferences			
σ	Coefficient of risk aversion	2	Literature
α	Share of non-durable consumption	0.70	Internal
β	Discount factor	0.940	Internal
ϑ	Bequest intensity	33	Internal
$\underline{b}$	Extent to which bequest is luxury	0.74	Internal
Endowments			
η_a	Deterministic part of income	Refer to text	HILDA
ρ	Persistence of income shocks	0.94	HILDA
σ_u	Std. dev. of income shocks	0.173	HILDA
Housing			
ϕ^b	Other buying cost	0.01	Fox and Tulip (2014)
ϕ^s	Transaction cost for sellers	0.02	Fox and Tulip (2014)
θ	Downpayment requirement	0.2	Chiuri and Jappelli (2003)
δ	Maintenance/depreciation cost	0.025	Harding et al. (2007)
h_{min}	Minimum housing size for owning	0.63	Internal
h^r_{min}	Minimum housing size for renting	0.16	Internal
ζ	Fixed cost of being a landlord	0.025	Internal
ε	Housing supply elasticity	2	Liu and Otto (2014)
ψ_1	Scale parameter in housing production	4.83	Internal
Housing pref. shock			
ξ	Size of the shock	0.05	Internal
π_{hh}	Persistence of the shock (high state)	0.960	Internal
π_{ll}	Persistence of the shock (low state)	0.990	Internal
Interest rates			
r	(Real) risk-free interest rate	0.014	RBA
m	(Real) mortgage premium	0.026	RBA
Taxation			
τ_{sd}	Stamp duty progressivity	0.009	Authors' calculations
ϕ_{sd}	Stamp duty level	1.083	Authors' calculations
$T(Y)$	Taxation thresholds and marginal rates	Refer to text	ATO

Notes: The model period is two years. Interest rates, depreciation rate, parameters describing the stochastic process for income, and transition probabilities for the housing preference shock are presented on an annual basis (i.e., $\pi_{hh} = 0.96$ and $\pi_{ll} = 0.98$ in the model). Monetary values are normalised by the two-year median household income.

Income and Endowments. To calibrate the income process we use *household gross total income* less investment income (rental and savings income) from the HILDA survey. The deterministic life-cycle component is extracted using a sixth-order polynomial in age. The residual income, given in equation (4), is estimated by Cho et al. (2023). Values of $\rho = 0.94$ and $\sigma_u = 0.17$ are found to match the persistence and standard deviation of the residual income. These annual parameters are converted into 2-year values using a simulation method described in Cho et al. (2023). This continuous stochastic process is discretized with a seven-state Markov chain using the Rouwenhorst (1995) method. The median household income in the data over a two-year period is AUD 269,280 and this value is used to normalise all monetary variables. Using the Survey of Income and Housing (2014) (SIH 13-14 hereafter) we extract a distribution of both housing and financial wealth for households aged 21 and 22. We draw from this joint empirical distribution of housing and financial wealth to determine initial endowments of assets.

Housing. The annual depreciation rate, δ, is set to 2.5% following Harding et al. (2007). The transaction cost for a seller, ϕ^s, is set to 2% of the housing value, which is consistent with the average real estate agent fee and we set transaction costs for buyers other than stamp duty, ϕ^b, to equal 1% of the house value (Fox and Tulip, 2014).

Financial markets. We set the risk-free annual interest rate to 1.4% and the annual mortgage premium to 2.59%. This implies a model value of $r = 0.028$ and $m = 0.052$.[19] The downpayment requirement, θ, is set to 0.2, consistent with the practice of residential mortgage lending in Australia (Chiuri and Jappelli, 2003).

Taxation. The income tax thresholds, $\bar{Y}_q$, marginal tax rates, τ_q, and tax paid at each threshold, follow the individual income tax rates set by the Australian Tax Office (ATO) for the 2013-14 financial year.[20] Stamp duty rates are progressive and vary across states and territories. We construct a national stamp duty schedule by weighting the stamp duty schedule of each state and territory by population shares. We then estimate τ_{sd} and ϕ_{sd} using non-linear least squares. See Appendix A.4 for details and an illustration of the actual and fitted stamp duty schedules.

Housing supply elasticity. Estimates of the housing supply elasticity, ε, for Australia

[19] Our risk-free interest rate is consistent with the average interest rate on a 2-year Commonwealth government bond from March 2001 - December 2015. Our mortgage premium takes the real variable lending rates for owner-occupied home loans over the same period and subtracts the risk-free rate. Variable mortgage lending rates are sourced from the Reserve Bank of Australia.

[20] See https://www.ato.gov.au/Rates/Individual-income-tax-for-prior-years/ for details.

Table 4: Target moments for internal calibration

Parameters	Target Moments	Model	Data	Source
α	Median rent-to-income ratio	0.24	0.25	SIH 13-14
ϑ	Home ownership rate for 65+ (%)	78.4	84.0	SIH 13-14
$\underline{b}$	Total wealth p75/p25 for 65+	2.86	2.89	SIH 13-14
β	Median loan-to-value ratio	0.51	0.52	SIH 13-14
h_{min}	Home ownership rate for under 35 (%)	41.0	37.4	SIH 13-14
h^r_{min}	Rental expenditure of the bottom 5%	0.055	0.058	SIH 13-14
ζ	Landlord rate (%)	14.2	12.7	SIH 13-14
ψ_1	Median house value	1.90	1.78	SIH 13-14
ξ	Home ownership rate (%)	68.1	68.5	SIH 13-14
π_{hh}	O2O transition rate (%, annual)	2.5	2.5	HILDA
π_{ll}	R2O transition rate (%, annual)	5.0	5.2	HILDA
	% of O2O movers due to mismatch	27.5	27.3	HILDA

Notes: The model period is two years. Housing transition rates are presented on an annual basis. Monetary values are normalised by the two-year median household income.

at an aggregate level are unavailable. However, Liu and Otto (2014) estimate the housing supply elasticity for the Sydney housing market. They find an elasticity of housing supply of between 0.07 – 0.96 for houses and 0.16 – 4.34 for apartments. For our baseline calibration, we set $\varepsilon = 2$. We conduct a robustness check of steady state results with inelastic housing supply ($\varepsilon = 0$) and more elastic housing supply ($\varepsilon = 4$) in Appendix C.4.

4.2 Internally Calibrated Parameters

The remaining parameters are jointly calibrated by matching important moments observed in the data. Details of the computation procedure are provided in Appendix E. The internally calibrated parameters and the relevant target moments are reported in Table 4. Our approach follows standard practice of selecting target moments that are informative of parameters to be internally calibrated.

Preferences. Several preference parameters need to be calibrated. The parameter, α, governs the allocation of resources between non-durable consumption and housing services, so we include the rent-to-income ratio as a target moment. The bequest intensity ϑ is chosen to match the home ownership rate for households over age 65. The degree to which bequests are a luxury good are determined by $\underline{b}$. To determine this parameter we include the ratio of 75th percentile to 25th percentile of the total wealth distribution for older households (age 65+) as a target moment. The discount factor, β, is calibrated to match the median loan-to-value ratio, which is 51.7% in the SIH 13-14 survey. We obtain a value of 0.884 as the two-year discount factor or an implied one-year discount factor of 0.940. The implied discount rate is higher than the risk-free interest rate, an issue that we

will discuss in Section 4.3.

Housing. The smallest house size for purchase, h_{min}, is important in determining the home ownership rate of younger households. We therefore include the home ownership rate for households under age 35 as a target moment. The largest house size is set to be large enough so that it is rarely chosen in equilibrium. We discretize the housing state space into nine grid points. To calibrate the smallest rental size, h^r_{min}, we target the rental expenditure by households at the bottom 5th percentile of the rental expenditure distribution.[21] Renters may rent housing services similar in size as owners or smaller, so the rental grid includes the housing grid and another four grid points between h^r_{min} and h_{min}.

The fixed cost of being a landlord, ζ, is set to target the landlord rate in the economy, which is 12.7% according to SIH 13-14. The calibrated value of $\zeta = 0.025$ corresponds to about AUD 3,366 per year or equivalent to 12.8% of the median rental income in the model. The scale parameter in housing production function, ψ_1, determines the total housing stock and is calibrated to match the median house value normalised by (two-year) median household income.

The parameters governing the housing preference shock, including the size parameter ξ, and transition probabilities π_{hh} and π_{ll}, are important for our quantitative exercise. To calibrate these parameters, we target the following four moments: an average home ownership rate of 68.5%; an average annual O2O transition rate of 2.5% and R2O transition rate of 5.2% (see Table 1), and the fraction of O2O movers due to mismatch, which is 27.3% according to our classification strategy described in Section 2 and Appendix A.2. The calibrated parameter values are provided in Table 3, and the corresponding targeted moments are shown in Table 4. Our model does well in matching the data moments although we underestimate the home ownership rate for older households and overestimate it for younger households. Achieving an exact fit between the model and data is challenging due to the non-linear structure of the model and the complex relationship between model parameters and endogenous outcomes.

The housing preference shock plays an important role in explaining the housing turnover and transition rates in the model. In the absence of the housing preference shock, we have difficulty in fitting these aspects of the data. This is explained in more detail in Section 5.4.

Figure 4: Life-cycle profiles of home ownership (left) and landlord (right) rates

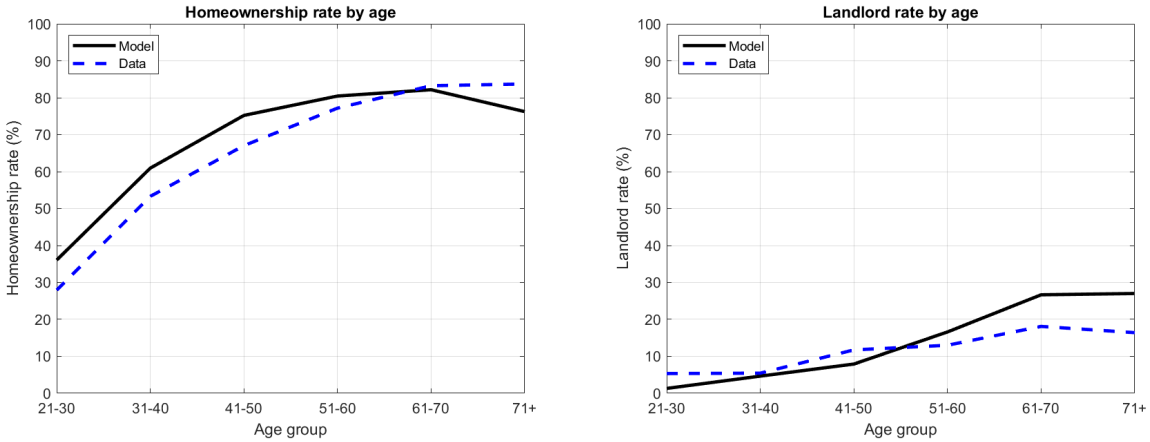


Figure 5: Home ownership (left) and landlord (right) rates by wealth quintile

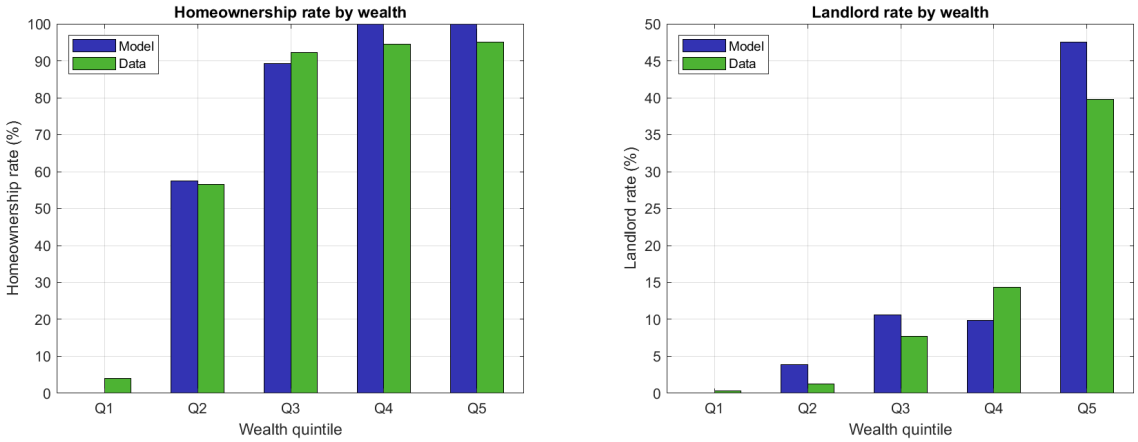
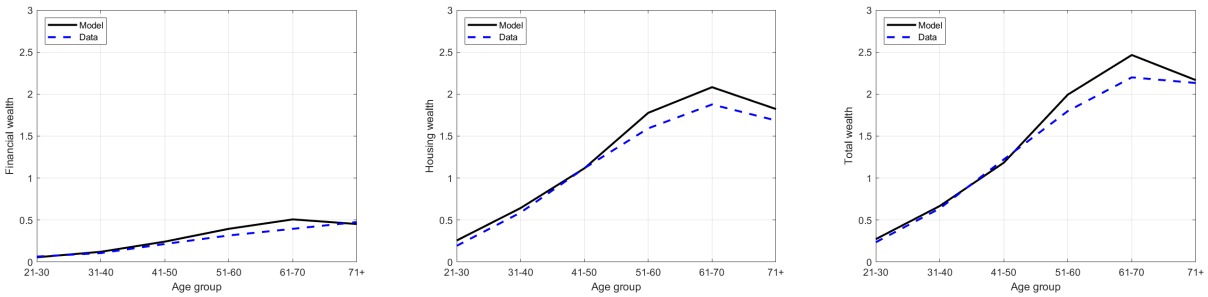


Figure 6: Life-cycle profiles of financial, housing, and total wealth



(a) Financial wealth (b) Housing wealth (c) Total wealth

Note: The figure depicts each age group's mean financial, housing, and total wealth. We define housing wealth as the value of primary and rental houses minus remaining mortgages held on those houses. Total wealth consists of the accounts held with financial institutions, shares, bonds, housing wealth, less credit card debt and other investment loans. Financial wealth is computed as total wealth less housing wealth.

4.3 Model Fit

As a validation of the calibration, we compare some important quantitative properties of the model that are not directly targeted with the data (SIH 13-14).

Home ownership and landlord rates. Figure 4 depicts the life-cycle profiles of home ownership and landlord rates. As shown in the left panel, the home ownership profile matches its data counterpart quite well although the ownership rates for young households are slightly overestimated while ownership rates for the oldest households are slightly underestimated. The home ownership rate increases with age and peaks at 81% for households between age 61 and 70. The model generates a landlord rate profile over the life cycle that shows a similar pattern as in the data. Figure 5 compares the the home ownership and landlord rates across wealth quintiles in the model to the data. The increasing patterns with wealth are broadly consistent with that observed in the data.

Wealth over the life cycle and the wealth distribution. In our model, the incentive to accumulate wealth over the lifecycle depends upon the discount factor, β, and the parameters that govern the bequest motive, ϑ and $\underline{b}$. In our calibration, the implied discount rate is high relative to the risk-free interest rate which, other things equal, would tend to shift households to consume when young and reduce wealth accumulation.[22] To demonstrate

[21] The calibrated values of h_{min} and h^r_{min}, together with the equilibrium house and rental prices in the baseline economy, imply that the market value of the smallest house and the minimum annual rental expense are AUD 438,850 and AUD 7,470, respectively.

[22] We are not unique in this respect. For example, Kaas et al. (2020), Graham (2020), and Boar, Gorea, and Midrigan (2022) present lifecycle models with housing and use annual discount factors of less than 0.95 and the risk-free interest rate less than 0.026 in their calibrations.

Table 5: Total wealth and LTV distributions

	Total wealth		**LTV ratio: borrower**	
	Data	Model	Data	Model
10th percentile	0.00	0.00	0.10	0.17
25th percentile	0.11	0.20	0.25	0.32
50th percentile	0.88	0.98	0.52	0.51
75th percentile	1.89	2.27	0.73	0.74
90th percentile	3.19	3.51	0.87	0.80

that our model captures the incentive to accumulate wealth over the life cycle, we present the average financial, housing, and total wealth as households age in Figure 6. Overall, the calibrated model does a good job in capturing trends over the life cycle in both financial and housing wealth, and total wealth as a result. These parameters are also important in determining the distribution of wealth and the loan-to-value ratios. In Table 5, we report selected percentiles from these distributions. While the model overestimates loan-to-value ratios at the lower tail and overestimates total wealth at the upper tail, it matches these distributions quite well, giving us confidence in the calibrated values of β, ϑ, and $\underline{b}$.

Response to changes in stamp duty. As a final check, we compare the impact of an increase in stamp duty rates on our model economy to causal estimates available in Han et al. (2022). They use a regression discontinuity design to study the impact of an increase in stamp duty in 2008 on the Toronto housing market. Theirs is the only paper we are aware of, with causal estimates of the impact of stamp duty on both the purchase and rental markets. They find that the 1.3 percentage points increase in effective stamp duty rate has the following effects: (i) house prices decline by 2.0%, (ii) there is a decline in the price-to-rent ratio of 3.9%, (iii) there is a decline in home sales of 2.7% (calculated based on their Table A.1), (iv) there is an increase in activity in the rental market and a decrease in activity in the purchase market, (v) an individual homeowner's moving hazard reduces by 13%, and (vi) the impact on rental price is statistically insignificant.[23]

In our baseline calibration, we find that a 1.3 percentage points increase in stamp duty rates leads to the following steady state effects:[24] (i) house price declines by 0.5%, (ii)

[23]These results are based on their baseline post-policy period of 2008-2012. They show that these results are robust to different period lengths. Although the estimated changes in house prices and price-to-rent ratio imply a rise in rents, the authors have communicated to us that there is a statistically insignificant impact on average rents when they study rental prices directly.

[24]We increase all marginal stamp duty rates in all Australian states by 1.3 percentage points and re-estimate the stamp duty function. We then re-solve the model and examine the effects of this increase in stamp duty rates, both in steady state and over the transition. We find that most of the changes on prices and housing transitions take place in the first two periods or 4 years, a duration comparable to the baseline post-policy period in Han et al. (2022). As a result, we only report the steady state effects.

the price-to-rent ratio decreases by 1.0%, (iii) there is a decline in the home sales as the housing turnover rate declines by 8.4%, (iv) there is an increase in the size of the rental market relative to the purchase market, as the share of rental out of total housing increases by 2.4%, (v) the O2O transition rate falls by 19.6% , and (vi) the rental price increases by 0.5%. Along many dimensions, particularly items (i) – (v), our results are qualitatively consistent with the causal effects identified by Han et al. (2022). It is not surprising that there are differences in the exact size of the effects. There are important differences in the two housing markets which may limit the comparability between our work and theirs. Also, we evaluate a 1.3 percentage points increase in stamp duty rate while the City of Toronto experienced an increase in stamp duty rate ranging from 0.5–2.0 percentage points depending on house price. Although the exact size of effects differ, our model provides effects of the correct order of magnitude.

Our model predicts a small increase in the rental price while the work of Han et al. (2022) is inconclusive regarding changes in rental prices; they estimate a statistically insignificant effect of an increase in stamp duty on rental prices. The mechanism in our model that leads to an increase in the rental price as stamp duty increases reflects the forces of demand and supply in the rental market. Consider a setting with fixed house and rental prices. An increase in stamp duty discourages households from purchasing homes and encourages demand for rental housing. The households that substitute from the purchase to the rental market have, on average, higher incomes than other renters and as a result have a relatively high demand for housing services.[25] The increase in the number and the changing composition of renters both serve to raise rental demand. On the supply side, rental housing supply is the difference between housing asset holdings and housing consumption and we find that homeowners with more housing assets tend to supply more rental housing. The increase in stamp duty reduces the proportion of homeowners in the economy and those that do become homeowners own, on average, less housing assets than in the baseline.[26] These changes in the quantity and composition of homeowners tend to reduce rental supply. With an increase in rental demand and fall in rental supply, there is a tendency for rental prices to increase when prices adjust.

Overall, we believe that our model provides a suitable laboratory to quantitatively examine the removal of property transaction taxes in the Australian housing market.

[25] If prices are fixed, there is a 2.9% increase in the average income of renters in the economy with higher stamp duty.

[26] With fixed prices, the home ownership rate falls from 68.1% to 67.9% and the average housing asset demand conditional upon ownership falls by about 4%.

5 Results

This section presents the quantitative impact of removing stamp duty. In doing so, we first compare the steady state outcomes of the baseline economy with two counterfactual economies: one in which stamp duty is replaced by a recurrent property tax and a second, in which stamp duty is replaced by a consumption tax.[27] Total tax revenue remains constant across experiments which requires an annual recurrent property tax rate of 0.20% (i.e., a property tax of 0.41% per model period) on the market value of housing assets or a consumption tax rate of 1.60% imposed on non-durable consumption.

5.1 Steady State Comparisons

The impact of our revenue-neutral policy change on key aggregate variables are displayed in Table 6 and Figure 7.

Prices and housing supply. In both of our counterfactual experiments, the removal of stamp duty makes owning a home more attractive and causes households to shift from the rental to the purchase market.[28] This increases the demand for housing in the purchase market. In the baseline economy with stamp duty, a wedge between the buyer and the seller price exists. A seller receives the price of 2.57 for a unit of housing but a buyer pays stamp duty on top of the house price. When stamp duty is eliminated, this wedge is removed. When a recurrent property tax replaces stamp duty, the steady state price a seller receives increases by 1.1%. With a consumption tax, the seller price increases by 1.9%. However, in both experiments the removal of stamp duty reduces the effective purchase price or buyer price (i.e. seller price plus stamp duty) and hence promotes home ownership.[29] Hereafter, we will continue to use house price to refer to seller price or pre-tax buyer price.

Comparing across experiments, the increase in the house price is smaller in the property tax case. This is natural since a property tax still raises revenue from owning property and discourages participation in the purchase market. On the other hand, with a consumption tax, there is a substitution effect that shifts households away from non-durable

[27] In Australia, consumption taxes are collected at the federal level and the tax proceeds are then distributed to state governments. Stamp duty is collected by state governments. Property tax is collected at a local government level. We consider experiments in which total government tax revenue is kept unchanged. Presumably tax revenue can be transferred between different levels of government (as is currently done with consumption tax revenue).

[28] This is even true when stamp duty is replaced by a property tax. Stamp duty and property tax both raise a similar amount of revenue and as a result, will have a similar impact on the amortised user cost of housing if p is affected in the same way by both taxes

[29] The stamp duty fee on the lowest priced house in our baseline equilibrium is 3.7% of the seller price. Removing stamp duty and raising the seller price by 1.1% or 1.9% lowers the buyer price for all buyers.

consumption and towards housing consumption. As the selling price increases, there is an increase in the supply of housing of 2.3% and 3.8% in the property tax and consumption tax cases, respectively.

There are also changes in the rental market. As in Section 4.3, changes in the composition of renters and homeowners in these counterfactual experiments are important. When stamp duty is removed, households substitute from renting towards ownership. As more households purchase homes, there is a reduction in households looking for rental housing. The most likely to switch from renting to owning are the wealthy or those with high income. This implies that in our counterfactual economies renters have, on average, lower income and less wealth and hence less demand for rental housing.[30] At the same time, we find there is an increase in the supply of homes to the rental market if house and rental prices do not adjust.[31] The absence of stamp duty makes households more likely to purchase housing and also more willing to purchase larger homes. These changes lead to an increase in rental supply if house and rental prices are kept unchanged. The net effect of changes in rental demand and supply is a fall in rental prices; the removal of stamp duty reduces rental prices by 1.6% and 4.7% in the property and consumption tax cases, respectively. Together with the increases in house prices, the price-to-rent ratios increase in both cases.

Home ownership and housing assets. As discussed above, removing stamp duty lowers the effective purchase price of housing for home buyers and hence shifts housing demand towards ownership. Renters at the margin of becoming homeowners in the baseline economy transition towards ownership as the policy reform makes it cheaper for them to do so. As a result, the home ownership rate increases by 1.6 and 2.0 percentage points while the share of rental housing in total housing stock decreases by 1.5 and 1.9 percentage points in property and consumption tax cases, respectively, as shown in Table 6.

Panels (a) and (b) in Figure 7 present the life-cycle profiles of the home ownership rate and housing assets. The removal of stamp duty raises the home ownership rate for households under age 35 or over age 76 while barely changing the ownership rate for households in other age groups. In particular, the home ownership rate for households under age 35 increases by 2.5 and 3.2 percentage points in property and consumption tax cases, respectively. Furthermore, the average housing asset held by households under age 35 increases by 10.5% in both property and consumption tax cases. The removal of stamp duty

[30] The average income and wealth of renters fall by 4.3% and 12.0% respectively in the property tax case, and by 4.6% and 12.3% in the consumption tax case. The fall in average income and wealth is particularly significant for younger renters, as shown in Figure C–4 in Appendix C.2, consistent with a significant increase in the home ownership rate of young households to be discussed below.

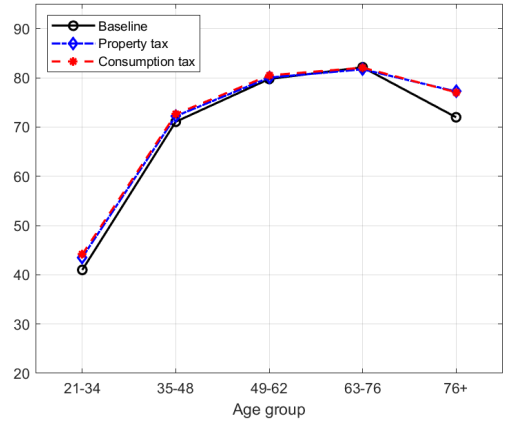
[31] This is confirmed by the large increase in the share of rental housing for the partial equilibrium case in Table 7 below.

Table 6: Steady state comparisons

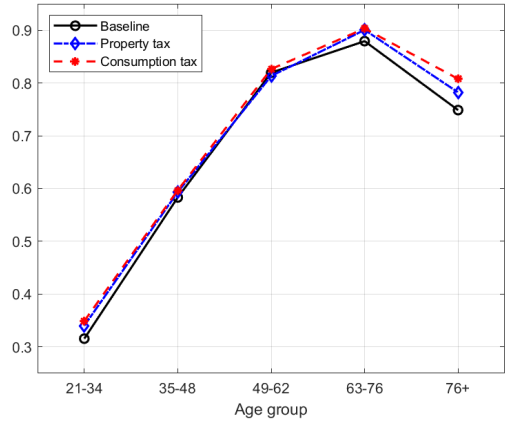
	Baseline	**Counterfactual**	
		Property tax	Consumption tax
House price	2.57	2.60	2.62
Rent	0.36	0.35	0.34
Price-to-rent ratio	7.22	7.42	7.72
Home ownership rate (%)	68.1	69.7	70.1
Share of rental housing (%)	16.6	15.1	14.7
Total housing stock	1.00	1.03	1.04
Avg. housing consumption by owners	1.00	1.02	1.03
Avg. housing consumption by renters	1.00	0.99	1.02
Avg. non-durable consumption	1.00	0.99	0.98
Transition rates (%)			
O2O	2.5	4.7	4.7
R2O	5.0	6.1	6.5
O2R	1.0	1.4	1.4
R2R	14.8	15.3	14.3
Housing turnover rate (%)	4.6	7.0	7.2
Mismatched homeowners (%)	13.4	4.6	4.8

Notes: Total housing stock, average housing consumption by owners and renters, and average non-durable consumption are normalized to their baseline steady state levels. Transition rates and housing turnover rate are converted into annual values.

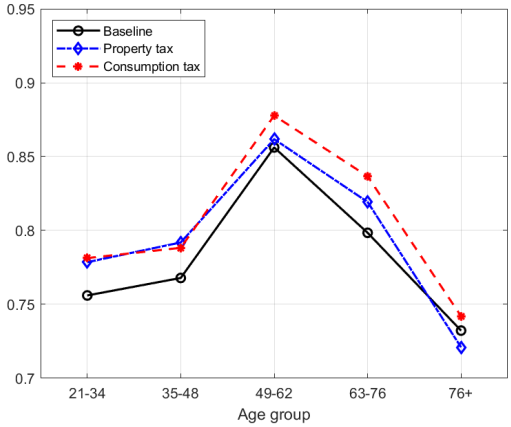
Figure 7: Steady state comparison: life-cycle profiles



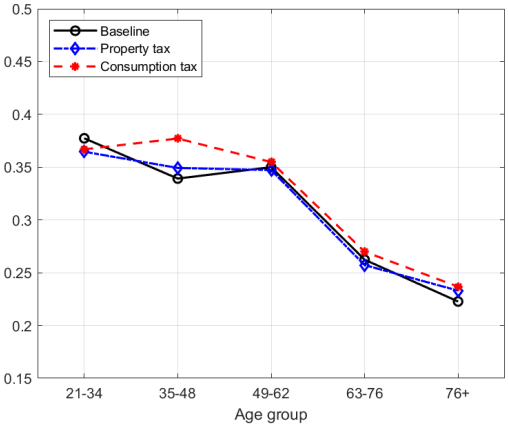
(a) Home ownership rate (%)



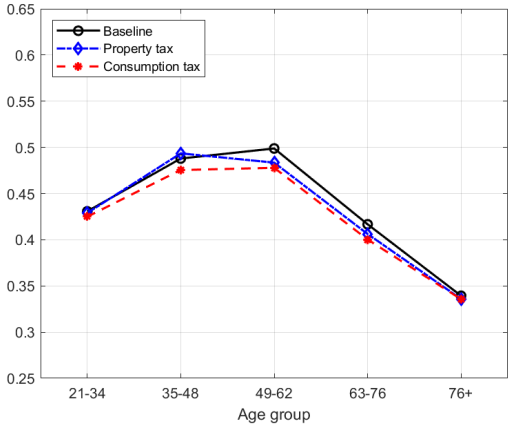
(b) Housing asset



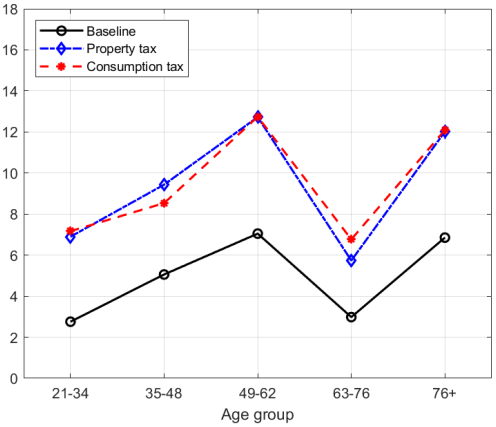
(c) Housing consumption: homeowners



(d) Housing consumption: renters



(e) Non-durable consumption



(f) O2O transition rate (two year, %)

lowers the cost of purchasing and downpayment requirements and hence helps younger, more credit-constrained households to become homeowners. Therefore, removing stamp duty could partially mitigate the decline in home ownership among the young (see Figure 2). The home ownership rate and average housing assets held by households aged over 76 also increase significantly in both cases, suggesting that the removal of stamp duty allows older households to move into smaller owner-occupied houses instead of renting.

Consumption and housing consumption. Panels (c) and (d) in Figure 7 show how housing consumption changes over the life cycle for homeowners and renters. Homeowners' average housing consumption is higher for all age groups in the counterfactual economies, except for households aged over 76 in the property tax case. The increases range from 0.7% to 3.0% and from 1.3% to 4.8% in the property and consumption tax cases, respectively. For renters, the average housing consumption over the life cycle in the property tax case is similar to the baseline economy. In the consumption tax case, there is a large increase in rental demand among households in the 35–48 age range. Panel (e) shows that the average consumption of non-durable goods falls slightly relative to the baseline economy in both experiments. The increase in housing consumption, for both owners and renters, and the decrease in non-durable consumption are larger in the consumption tax experiment as households substitute away from non-durable consumption and increase housing consumption by a greater amount.

Housing transitions. Removing stamp duty boosts mobility in the housing market. The bottom panels of Table 6 report the impact of removing stamp duty on transition rates, the housing turnover rate, and the fraction of mismatched households. In both counterfactual economies, the housing turnover rate increases by more than 50%, from an annual baseline value of 4.6% to around 7.0. Housing transitions that involve the purchase or sale of a home also increase; the O2O transition rate almost doubles and the R2O transition rate increases by roughly 22% in the counterfactual economies. Moreover, the policy change substantially reduces mismatch in the housing market; the fraction of mismatched homeowners, i.e. in a low housing preference state, falls from 13.4% to about 4.6%. Panel (f) in Figure 7 depicts the life-cycle profiles of O2O transition rate for homeowners, which exhibit a similar pattern in the baseline and counterfactual economies. However, in the absence of stamp duty, the O2O transition rates are substantially higher across all age groups.

This is expected as stamp duty is a transaction cost associated with buying a house. As discussed in Section 3.1, housing decisions follow a (S, s) rule as in Grossman and Laroque (1990); households are reluctant to change their homes in response to shocks in

Table 7: Steady state comparisons: Decomposition for the property tax case

	Baseline	**Property tax**		
		Partial eqlm.	**GE with fixed** H	**GE wth var.** H
	(1)	(2)	(3)	(4)
House price	2.57	2.57	2.61	2.60
Rent	0.36	0.36	0.35	0.35
Price-to-rent ratio	7.22	7.22	7.42	7.42
Home ownership rate (%)	68.1	74.2	69.2	69.7
Share of rental housing (%)	16.6	42.8	14.8	15.1
Total housing stock	1.00	1.00	1.00	1.03
Avg. housing consump. by owners	1.00	1.00	1.02	1.02
Avg. housing consump. by renters	1.00	0.95	0.99	0.99
Avg. non-durable consump.	1.00	1.00	0.99	0.99
O2O transition rate	2.5	4.4	4.7	4.7
R2O transition rate	5.0	7.2	6.4	6.7
Housing turnover	4.6	5.8	7.3	7.0
Mismatched homeowners	13.4	7.5	5.0	4.6

Notes: This table reports selected steady state moments for the property tax experiment in three different cases along with our baseline steady state. In column (1) we display the baseline results. In column (2) we present results for the partial equilibrium experiment in which the tax system changes but prices are fixed. In column (3) we present results for an economy in which the tax system changes and prices adjust but housing supply is fixed. In column (4) we present results with prices and housing stock adjusting. This is our main property tax counterfactual displayed in Table 6.

the presence of uncertainty and transaction costs. The removal of stamp duty reduces transaction costs and makes households more willing to change homes and reduces mismatch. A more detailed discussion on this point is provided in Appendix C.1, where we illustrate the (S,s) decision rule for housing and demonstrate how the removal of stamp duty reduces inertia in housing purchase choices by comparing the decision rules and the simulated paths of housing asset in the counterfactual and baseline economies.

A Decomposition: Direct vs General Equilibrium Effects. To gain further insight into the effect of stamp duty on key endogenous variables we consider a decomposition into three separate effects. First, there is a *direct effect*. This is a partial equilibrium effect that measures how endogenous variables change in response to changes in the tax system while holding prices and rents constant. Second, there is a *general equilibrium (GE) effect with fixed housing supply* associated with a change in house and rental prices while holding the aggregate supply of housing fixed. Third, there is a *GE effect with variable housing* associated with additional changes in prices and rents accompanied by a change in housing supply. To identify these effects, we solve three different versions of the counterfactual economy: (i) an economy with the counterfactual tax system but with no change in prices or rents, which is a partial equilibrium experiment in which markets do not clear, (ii) an

economy with the counterfactual tax system and no change in housing supply but prices and rents adjust to clear markets, and (iii) our main counterfactual economy in which the tax system changes and both prices, rents, and housing supply adjust to clear the market. Table 7 presents the results for the property tax case.[32]

The direct effect is revealed by comparing the outcome in our partial equilibrium experiment to the baseline economy. In this case, prices are unchanged by design. The removal of stamp duty and its replacement with a property tax leads to large increases in housing turnover and transition rates. The percentage of mismatched homeowners also falls but not as much as in the main counterfactual experiment. Also note that there is a much larger increase in the home ownership rate and share of rental housing as many households buy properties and are willing to lease out housing assets. Although we do not report the aggregate quantities, there is an excess demand in the purchase market and excess supply in the rental market in this partial equilibrium experiment.

The general equilibrium effect with fixed housing is revealed by comparing the outcome of the general equilibrium with fixed housing to that of the partial equilibrium economy. The difference from the partial equilibrium experiment is that we allow house and rental prices to adjust to bring about equilibrium. This requires an increase in the house price, a decrease in the rental price, and an implied increase in the price-to-rent ratio to equate demand and supply in both rental and purchase markets. The price changes also tend to further raise housing turnover and lower the percentage of mismatched homeowners. Finally, we consider the effect of variable housing supply by comparing the outcomes of an experiment with fixed housing supply to one with variable housing supply. In making this comparison we note that there are relatively minor changes in price, rents, and other variables between these two cases. This suggests that allowing for variable housing supply has little impact on key endogenous variables in our model.

5.2 Steady State Welfare

As mentioned in Section 3.5, there are several market failures and distortions within the economy. Here, we highlight how changes in welfare are related to improvements in resource allocation, credit constraints, and changes in prices. We evaluate changes in steady state welfare using the notion of ex-ante consumption equivalent variation (*cev*), extended to consider housing services and bequest, as defined in Cho et al. (2023). More precisely, for a newborn household in the baseline economy with initial income state z and initial assets (s_0, h_0), we calculate the percentage change in their non-durable consumption, housing services and potential bequests in every period of life that is required to equate their expected discounted utility in the baseline economy to that in the counterfactual economy.

[32]The implications of results for the consumption tax case are broadly similar.

We then average across the stationary distribution of (z, h_0, s_0) to obtain the average *cev*. A positive value indicates households would prefer to be born in an economy without stamp duty.

Using average *cev* as our welfare measure, we find removing stamp duty improves welfare of newly born households by 0.45% or 0.24% when it is replaced with revenue-neutral property tax or consumption tax, respectively. Newborn households prefer property taxes over consumption taxes and consumption taxes over stamp duty.

Sources of Welfare Gain. The welfare gain from removing stamp duty arises due to several reasons. First, removing stamp duty makes it easier for households to move into houses that better suit their needs. This leads to a substantial reduction in the fraction of mismatched homeowners, as shown in Table 6. Mismatch is costly from the perspective of an individual household. We calculate the cost of mismatch as the percentage change in their non-durable consumption, housing services and potential bequest a household would require over their lifetime to be just as well off as moving from a mismatched to a matched home with no other change in state. This *cev* measure of the cost of mismatch equals 1.3% on average across mismatched households in our baseline economy and 1.0% in both counterfactual economies. Welfare gains arise from the removal of stamp duty as it reduces both the amount and the costs of mismatch.

Second, as stamp duty is an upfront payment for purchasing a home, the removal of it can relax the borrowing constraint faced by households. To examine this effect, we consider a less tight borrowing constraint by reducing the downpayment requirement from $\theta = 0.2$ to $\theta = 0.16$, and re-calculate welfare changes. We find a *cev* of 0.32% and 0.01% for the property tax and consumption tax experiments, respectively. These welfare gains are smaller than in our original experiments, illustrating that the welfare benefits of removing stamp duty are larger in economies with tighter borrowing constraints.

The welfare gains suggest that replacing stamp duty with a property or consumption tax leads to a more efficient allocation of resources. Next, we illustrate this point by studying the intratemporal allocation of non-durable consumption and housing consumption across experiments.

Misallocation and Stamp Duty. In the absence of transaction costs, taxes, and credit constraints, a household would select non-durable consumption and housing consumption to satisfy the following intratemporal first-order condition:

$$\frac{\partial u(c_a, \tilde{h}_a)}{\partial c_a} = \frac{\partial u(c_a, \tilde{h}_a)/\partial \tilde{h}_a}{p^r}$$

Table 8: Steady state misallocation: Distribution of the misallocation wedge

	Mean			Standard deviation		
Tenure group	Baseline	Prop. tax	Consump. tax	Baseline	Prop. tax	Consump. tax
Renters	0.04	0.04	0.02	0.14	0.15	0.15
Homeowners	0.37	0.31	0.27	0.41	0.36	0.35
Owner-occupier	0.39	0.34	0.30	0.45	0.39	0.37
Landlords	0.29	0.22	0.16	0.22	0.22	0.22
Mismatched	0.39	0.32	0.28	0.43	0.36	0.35
Not mismatched	0.26	0.21	0.18	0.32	0.29	0.29

Notes: This table reports the mean and standard deviation of the misallocation wedge, φ, for households of different types in our different steady states.

for renters or

$$\frac{\partial u(c_a, \tilde{h}_a)}{\partial c_a} = \frac{\partial u(c_a, \tilde{h}_a)/\partial \tilde{h}_a}{p^*}$$

for owners, where p^* is an appropriately defined user cost of housing.[33] In the presence of transaction costs, taxes, and credit constraints, these conditions will not hold exactly.[34] We measure the degree to which households deviate from this frictionless ideal by defining the parameter φ in the following manner:

$$\frac{\partial u(c_a, \tilde{h}_a)}{\partial c_a}(1+\varphi) = \frac{\partial u(c_a, \tilde{h}_a)/\partial \tilde{h}_a}{p^r}$$

for renters or

$$\frac{\partial u(c_a, \tilde{h}_a)}{\partial c_a}(1+\varphi) = \frac{\partial u(c_a, \tilde{h}_a)/\partial \tilde{h}_a}{p^*}$$

for owners. A positive value of φ implies that the marginal utility of housing adjusted for the housing price (rental or user cost) is high relative to the marginal utility of non-durable consumption and that housing is underconsumed relative to non-durables. The converse applies if φ is negative. In this sense φ is a measure of an intratemporal consumption *misallocation wedge*.

We calculate the wedge, φ, for every household in each steady state. Table 8 presents summary statistics describing the distribution of the wedges for different population segments in each economy. We make a few observations. First, for homeowners in our baseline economy there is a positive wedge on average. This suggests that owners are underconsuming housing due to transaction costs, taxes, and credit constraints relative

[33] In this exercise we set $p^* = p(r+\delta)$ as the user cost of housing.

[34] The use of a discrete state space for housing is another reason for why such a wedge exists. We don't expect this approximation to bias our measured wedge in any particular direction or to bias the implied changes in the wedge across experiments.

to a frictionless economy. Second, when stamp duty is removed and replaced with either a consumption or property tax, the average sizes of the misallocation wedges are significantly smaller. This is consistent with the observation in panels (c)-(e) of Figure 7 that housing consumption increases relative to non-durable consumption. Finally, the dispersion of the misallocation wedge, as measured by the standard deviation, tends to decline when stamp duty is eliminated. If the cost of the misallocation wedge is convex, as we would expect, then a reduction in dispersion should also lead to welfare gains.

Direct vs General Equilibrium Effects. To gain further insight we conduct a similar decomposition as in Section 5.1. This decomposes welfare changes into a *direct effect*, *general equilibrium effect with fixed housing*, and a *general equilibrium effect with variable housing*.

Table 9 presents this decomposition for our different policy experiments. The first column captures the change in steady-state welfare due to changes in the tax system but keeping the rental and house prices fixed. The second column captures the overall change in steady-state welfare from changes in the tax system *and* allowing rental and house prices to respond but with fixed housing supply. When moving from the first to the second column, any change in welfare arises due to the endogenous response of prices with housing supply fixed. The third column displays the overall change in steady-state welfare from changes in the tax system *and* allowing rental and house prices to respond with a variable housing supply. This column represents the total welfare effect discussed earlier under our preferred specification. When moving from the second to the third column, any change in welfare arises due to the fact that housing supply responds and moderates the overall change in prices.

The direct effect is responsible for the majority of the welfare gains under both policy counterfactuals. When prices respond to changes in tax but housing supply is fixed, the steady state welfare gains are smaller. In the property tax case, the reduction in steady state welfare gains is about a quarter (0.34% compared to 0.46%). In the consumption tax case, which features larger price changes, the welfare gain is reduced by three quarters (0.1% compared to 0.44%). Allowing a housing supply response moderates the negative effect of price adjustment on welfare in both policy experiments. The magnitude of this general equilibrium effect with variable housing supply is modest relative to the direct effect and the the general equilibrium effect with fixed housing.

Figure 8 shows our decomposition of the welfare effects of the policy change for newborn households with different initial levels of income. The *direct effect* reflects welfare changes due to changes in the tax system holding prices constant. The *GE effect with fixed housing stock* measures an additional change in welfare caused by a change in house and rental prices under the new tax system. For each income group, this is calculated as the

Table 9: Welfare effects on newborn households

	Partial equilibrium (1)	**GE with fixed H** (2)	**GE with variable H (main)** (3)
Property tax	0.46%	0.34%	0.45%
Consumption tax	0.44%	0.10%	0.24%

Notes: This table reports the average *cev* for newborns from replacing stamp duty with a property tax or consumption tax in three different cases: (1) Partial equilibrium: tax changes but prices are fixed; (2) GE with fixed H: tax changes and prices adjust, but housing supply is fixed; (3) GE with variable H, which is our main counterfactual experiment: tax changes, prices adjust, and housing supply responds.

average welfare change for newborns in this group in our GE economy with fixed housing minus the corresponding welfare change in our direct effect experiment. Finally, there is an additional GE effect with a variable housing stock. For each income group, this is calculated as the average welfare change for newborns in this group in our GE economy with variable housing minus the corresponding welfare change in our GE economy with fixed housing.

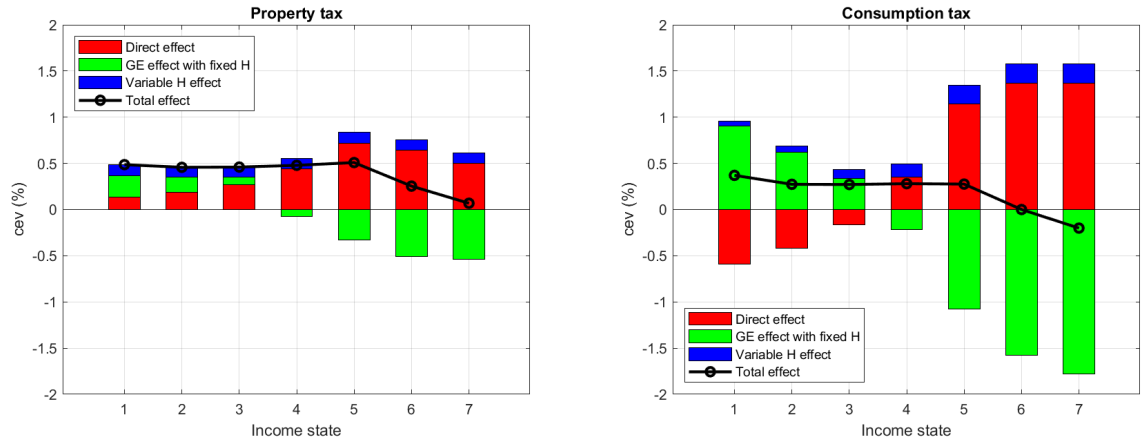
The direct effect of replacing stamp duty with a property tax is positive for all income groups but is smallest for the lowest income newborns. The direct effect of replacing stamp duty with a consumption tax leads to decreases in welfare for the lowest income households but large welfare gains for the highest income newborns. This reflects at least in part, that housing is most likely to be purchased by high income individuals while consumption taxes are regressive with high tax burdens on low income individuals.

In both experiments with fixed housing supply, the house price increases and the rental price decreases. Hence, it is unsurprising that the GE effect with fixed housing supply is qualitatively similar across experiments. This effect benefits low-income households and hurts high-income households. The magnitude of effects are larger in the consumption tax case, which is again unsurprising, since it features larger price movements. The effect of variable housing supply is small across income levels in both experiments.

The relationship between overall welfare changes (given by the black lines in Figure 8) and income states is less clear as it mixes a direct effect that is mostly increasing in income and a GE effect that is decreasing in income. Overall, most households entering the economy benefit from the removal of stamp duty and average welfare gains tend to be larger for those with lower income. Newborns with the highest income suffer a welfare loss when stamp duty is replaced by a consumption tax. Comparing across cases, average welfare gains are larger in the property tax case at all income levels, so that replacing stamp duty with a property tax is the preferred policy change.

Along with income, newborn households also vary in their initial wealth. Appendix C.3 provides the welfare decomposition for newborn households in differing initial wealth quintiles. We find that welfare gains are relatively similar across initial wealth quintiles.

Figure 8: Welfare changes by income group: *cev* for newborn households across income states



Note: Income states are ordered from lowest to highest income.

In Appendix C.4 we evaluate the quantitative impact of removing stamp duty with inelastic housing supply ($\varepsilon = 0$) and with more elastic supply ($\varepsilon = 4$). As mentioned in Section 4, there is some uncertainty regarding the elasticity of housing supply. The fact that the general equilibrium effect from variable housing supply is relatively small suggests that uncertainty regarding the elasticity of housing supply will not have a large effect on key endogenous variables or welfare. Our results in Appendix C.4 confirm this point.

Comparison with Kaas et al. (2020). Our welfare results differ from Kaas et al. (2020), who find that households in Germany would experience a welfare *loss* if stamp duty is reduced and labour income taxes adjust to retain revenue neutrality. They highlight that the general equilibrium effect on prices (rental and house prices) is responsible for this welfare loss. An important difference is that competitive real estate firms supply rental housing and satisfy a zero-profit condition in their model. As a result, the relationship between the house and rental prices is almost unchanged when tax policy is adjusted, so in their model, the removal of stamp duty leads to a simultaneous increase in house prices and rents.[35] Households enter the economy as renters. Hence, the increase in rents combined with an increase in income tax reduces welfare in their model.

In contrast, household investment determines rental supply in our model. As removing stamp duty lowers the effective purchase price of housing, it causes households to substitute towards ownership (for consumption and investment purposes) and away from rental services. In general equilibrium, prices respond with an increase in the house price

[35]Explicitly, Kaas et al. (2020) impose the following relationship between house and rental prices for real-estate firms: $(r + \delta)p = p^r - c_m$ where c_m is the cost of managing rental homes. This is a user cost of capital equation except that real-estate firms do not have to pay stamp duty. If stamp duty costs were included in the zero profit condition of real-estate firms, then the removal of stamp duty could also reduce rental prices in their model.

and a decline in the rental price as discussed in Section 5.1. The fall in rental price is important as it lowers the cost of housing for young households and allows them to increase consumption when credit constraints are most severe. Our assumption that housing investment is determined by the household and not the business sector is consistent with the fact that households rather than institutional investors dominate the supply of rental properties in the Australian housing market. Kearns, Major, and Norman (2021) report that households and the non-profit sector own 95% of dwellings in Australia, with only 5% owned by institutional investors. One reason for this feature, as discussed by Newell et al. (2015), is that the tax system provides advantages to household investors that are unavailable to institutional investors.[36]

To illustrate the role of rental prices, we conduct the following experiment: stamp duty is replaced by a property or consumption tax and house prices are set to the equilibrium level in the relevant counterfactual economy. However, the rental price is set such that the price-to-rent ratio is unchanged by the tax reform. As a result, rents and prices move together as in Kaas et al. (2020). Such an experiment yields an average *cev* of 0.09% in the property tax case and -0.16% in the consumption tax case. These welfare gains are smaller than in our counterfactual experiments in which rents fall. Notably, in the consumption tax case, the removal of stamp duty leads to a slight welfare loss which is in line with their result. Although our models vary in other dimensions,[37] we view the differences in rental supply as important for understanding the differences in the welfare results.

5.3 Transition Dynamics

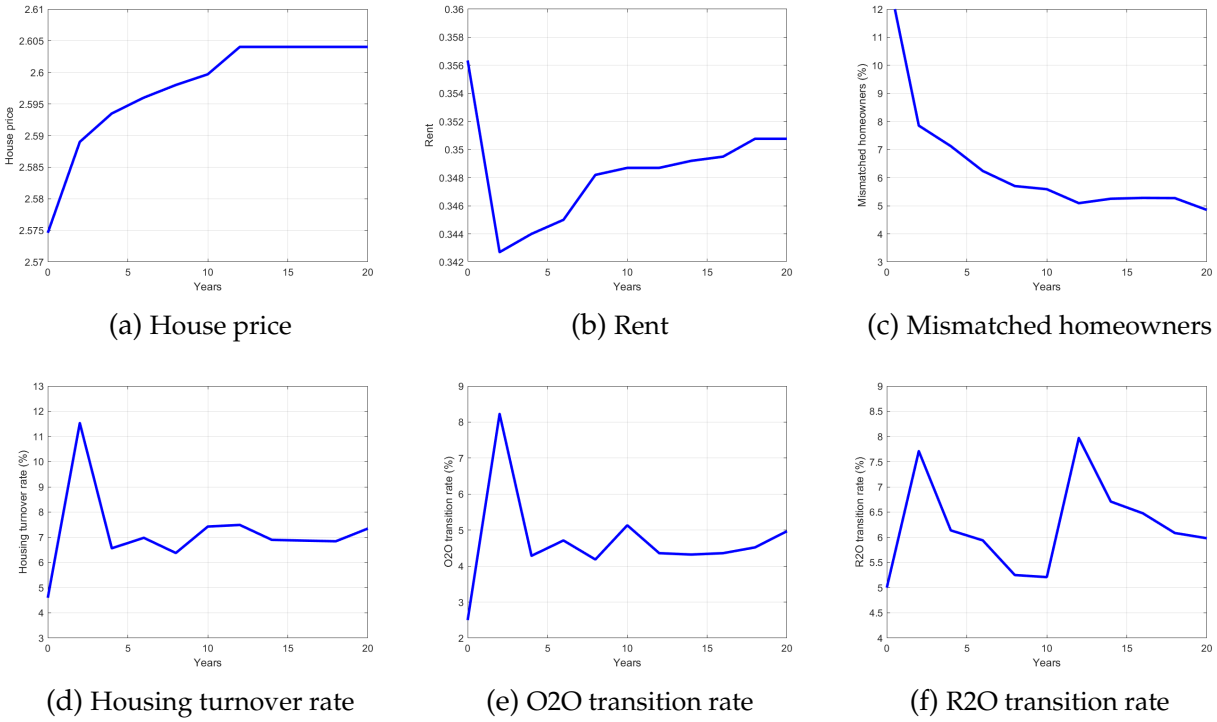
Thus far, we have focused on steady state changes. In this section, we examine transition dynamics (see Appendix E for the computation procedure). In doing so, we assume that changes in the tax system are unanticipated but once the change occurs, households have perfect foresight regarding prices and rents over the transition.

Evolution of Aggregates along the Transition. The transitional dynamics in the two counterfactual experiments are broadly similar; for brevity, we present only the property tax case. Figure 9 depicts the transition paths of variables after stamp duty is replaced with a property tax. Note that the transition to the new steady state takes about 18-20 years, i.e., 9-10 periods. However, most of the adjustment takes place in the first 4 years. The house price increases by 0.56% immediately after the reform, which is around 50% of the total increase in the house price, and then smoothly converges to the new steady state.

[36] In Australia, household investors may deduct rental losses from taxable labour income and are usually entitled to a 50% discount on capital gain tax when selling investment properties. These concessions are unavailable to institutional investors.

[37] For example, we include housing mismatch while their work includes a role for social housing.

Figure 9: Transitional dynamics when stamp duty replaced by property tax



(a) House price (b) Rent (c) Mismatched homeowners

(d) Housing turnover rate (e) O2O transition rate (f) R2O transition rate

The initial decline in the rental price is large and overshoots the long run decline before gradually increasing to the new steady state level.

The removal of stamp duty leads to a large increase in housing market activity as shown in panels d), e), and f) of Figure 9. The housing turnover rate, and the O2O and R2O transition rates more than double immediately after the reform. This burst in housing transactions is accompanied by a large drop in the proportion of mismatched homeowners, as shown in panel (c), as many choose to relocate when stamp duty is removed. In subsequent periods, the housing turnover rate and the O2O transition rate decline, but remain above the original steady state levels. The R2O transition rate exhibits more fluctuations but also remains above the original steady state level. The proportion of mismatched homeowners continues to decline toward the lower new steady state level.

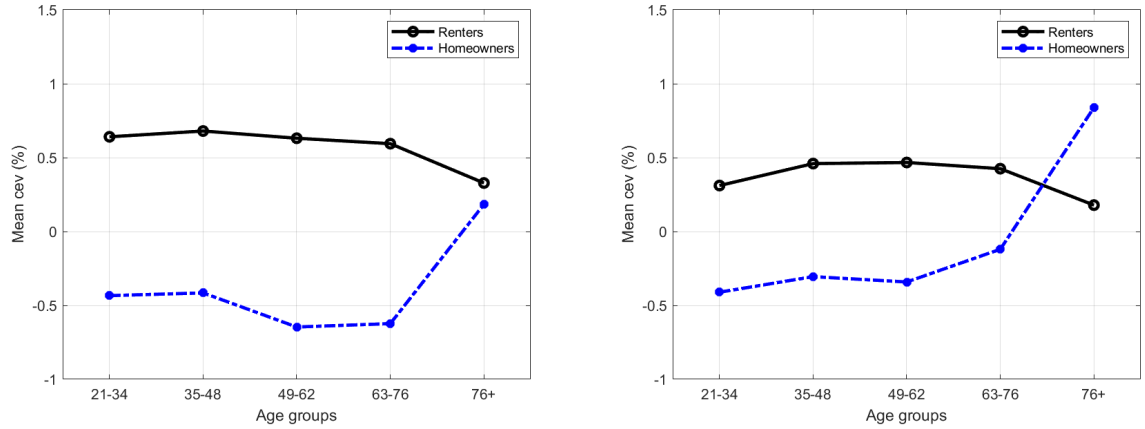
Welfare along the Transition. The welfare changes along the transition across heterogeneous households and in aggregate are displayed in Table 10. We measure welfare for each household i in the baseline steady state simulation using the ex-ante cev_i, as before. Replacing stamp duty with a property tax leads to small aggregate welfare losses as measured by the mean cev_i. Furthermore, only 45.9% of existing households experience an improvement in welfare. In contrast, when stamp duty is replaced by a consumption tax, the economy experiences a median welfare gain of 0.13% and 56.4% of existing house-

Table 10: Welfare changes over the transition: by initial housing status

	Property tax			Consumption tax		
Housing status	mean (%)	median (%)	$P(cev_i > 0)$	mean (%)	median (%)	$P(cev_i > 0)$
Renters	0.65	0.67	1	0.37	0.34	0.997
Homeowners	-0.44	-0.46	0.206	-0.08	-0.20	0.361
Owner-occupiers	-0.37	-0.45	0.187	-0.12	-0.22	0.325
Landlords	-0.71	-0.61	0.278	0.11	0.00	0.501
Mismatched	-0.07	-0.02	0.490	0.45	0.33	0.757
Not mismatched	-0.51	-0.49	0.151	-0.18	-0.28	0.285
Overall	-0.09	-0.15	0.459	0.07	0.13	0.564

Notes: This table reports the mean and median values of computed cev_i's and the proportion of households with a positive cev_i.

Figure 10: Welfare changes by initial age and housing tenure status



(a) Property tax

(b) Consumption tax

holds gain from the policy change. To understand these differences we examine outcomes across heterogeneous households.

Table 10 shows how the welfare effects vary across housing tenure status. Renters experience large welfare gains in both experiments but prefer replacing stamp duty with a property tax. Unsurprisingly, renters gain from the removal of stamp duty as rents and the purchase price of houses inclusive of stamp duty decline. The removal of stamp duty also makes it easier for renters to transition to home ownership as the effective down-payments are reduced. Owner-occupiers and landlords, on average, suffer large welfare losses in the property tax experiment and smaller welfare losses or small welfare gains in the consumption tax experiment. Homeowners can be disaggregated into those that are mismatched and those that are not. Unsurprisingly, mismatched homeowners lose less or gain more from the removal of stamp duty than those that are well-matched to their housing asset.

Figure 10 shows how welfare effects differ by age for existing homeowners and renters.

Table 11: Welfare changes over the transition: by initial consumption, housing consumption, and total wealth

	Consumption		**Housing consumption**		**Total wealth**	
	mean (%)	$P(cev_i > 0)$	mean (%)	$P(cev_i > 0)$	mean (%)	$P(cev_i > 0)$
			Property tax			
Bottom [0,25)	0.30	0.744	0.65	1	0.67	1
Middle [25,75]	-0.07	0.442	-0.31	0.262	-0.27	0.296
Top (75,100]	-0.54	0.205	-0.66	0.130	-0.53	0.226
			Consumption tax			
Bottom [0,25)	0.34	0.855	0.37	0.998	0.37	0.996
Middle [25,75]	0.09	0.563	0.03	0.425	-0.05	0.414
Top (75,100]	-0.26	0.271	-0.26	0.259	-0.08	0.417

Notes: This table reports the mean values of computed cev_i's and the proportion of households with a positive cev_i.

When stamp duty is removed, renters of all ages benefit in both experiments because of lower rents as well as an improved prospect of transitioning to ownership. On the other hand, with the exception of 76+ age group, homeowners across all age groups are worse off on average, particularly when stamp duty is replaced with a property tax. Although they may gain from a rise in house prices, their expected increase in tax burden is also larger. Homeowners in the 76+ group gain from the removal of stamp duty particularly in the consumption tax case. These households benefit from an increase in house price but have a short life expectancy which implies a limited increase in tax burden.

Table 11 reports how the welfare results vary by initial consumption, housing consumption, and total wealth. In general, the reforms favor poorer households with lower total wealth and those who tend to consume less of both housing and non-durable consumption. These households are more likely to be renters and benefit more from the tax reform that lowers effective purchase prices and reduces the size of the downpayment needed to become a homeowner. Among households that are wealthier or among those that consume relatively large amounts, there is a preference for the consumption tax over the property tax. Again, this reflects a larger increase in house prices and the fact that the burden of raising tax revenue is shared more evenly.

It is perhaps surprising that existing households lose, on average, when stamp duty is replaced by a property tax. To gain a deeper understanding of the welfare effects in this case, we decompose welfare changes into a direct effect and a general equilibrium effect along the transition. The results, provided in Appendix C.5, are broadly consistent with what we find in the steady state analysis. The direct effect from the policy change is responsible for most of the welfare gains or losses for existing households while housing supply and price changes play a minor role.

To further understand the welfare effects of the policy change we look at the changes in

tax burden more closely for the property tax case in Appendix C.6. Although the steady state level of tax revenue is maintained, due to the OLG nature of our model, there are changes in the burden of taxation over the transition that depends upon age and housing tenure status. As shown in Figure C–6, a shift from stamp duty to property tax raises the present value of housing-related taxes on homeowners and reduces it on renters, and the increase in tax burden is more significant for young and middle-aged homeowners than for older homeowners. These changes in tax burden are qualitatively consistent with the welfare effects shown in panel (a) of Figure 10. To allow for a quantitative comparison between welfare effects and changes in tax burden, we follow Kindermann and Krueger (2022) to calculate an alternative measure of welfare change for each household - wealth compensating variation (*wcv*). It is the wealth transfer required to compensate a household when stamp duty is replaced with a property tax. Figure C–6 shows that the *wcv*s exhibit a similar pattern across different age groups of owners and renters as the changes in the present value of housing taxes. Furthermore, they are highly comparable in magnitude. These results suggest that changes in the burden of housing-related taxes play an important role in determining our welfare results. For a more detailed discussion, please refer to Appendix C.6.

Credit constraints also contribute to shaping the welfare changes. The removal of stamp duty tends to loosen credit constraints for both homeowners and renters. Without stamp duty, renters face a lower purchase price of housing and require a smaller deposit to purchase a home, which contributes to the welfare gain they experience. Homeowners must pay a property tax every period which reduces their disposable income. However, the value of their property increases which tends to ease their borrowing constraints. As a result, although homeowners tend to lose from the policy change, we find that homeowners who are credit-constrained tend to lose less, on average, than homeowners who are not credit-constrained.[38]

Our welfare analysis highlights a tension that exists if policymakers seek to remove stamp duty and raise funds via an alternative tax system. Although new households entering the economy would prefer a property tax (as shown in our steady state results), existing households would on average, prefer a consumption tax over a property tax. From a political economy perspective, this raises the possibility that what is preferred from a long run perspective may not be feasible to implement in a democratic society.

Table 12: Steady state outcomes without housing preference shock

	Baseline	**Counterfactual**	
		Property tax	Consumption tax
House price	2.59	2.61	2.63
Rent	0.36	0.35	0.34
Price-to-rent ratio	7.24	7.40	7.75
Home ownership rate (%)	67.1	67.7	68.6
Housing turnover rate (%)	4.2	6.3	6.4
O2O transition rate (%)	1.9	3.6	3.7
R2O transition rate (%)	4.8	6.2	6.3
Ex-ante *cev* (%)	–	0.34	0.18

Notes: This table presents some steady state moments and welfare changes for a model without housing preference shocks. The housing turnover rate, O2O and R2O transition rates are annual figures. Monetary figures are nomalised by two-year median household income.

5.4 Role of Housing Preference Shock

This section discusses the role of housing preference shocks, which are a novel element of our model. We show that these shocks help the model to match housing transitions. To do so, we re-calibrate a model without housing preference shocks. In this world, $\lambda = 1$ for renters and $\lambda = 1 + \xi$ for owners.[39] Other features of the model are unchanged. The calibration follows a similar procedure as the baseline calibration in Section 4. See Tables D–4 and D–5 in Appendix D for details on the new calibration. Compared to the steady state moments reported in Table 6, the absence of the housing preference shock leads to 24.4% and 8.4% reductions in the O2O transition rate and housing turnover rate, respectively. As discussed earlier, these rates are difficult for the model to match in the absence of the housing preference shock. Table D–6 in Appendix D details how the steady state responds to changes in the model parameters. We find that the values of the O2O transition rate are consistently lower than the data value.[40]

We conduct the same counterfactual policy experiments as in Section 5. The first column of Table 12 reports a selected set of results for the baseline steady state without the housing preference shock. These differ from the results in Section 5.1 as the model has been recalibrated in the absence of the housing preference shock. The second and third columns report the steady state outcomes for the property tax and consumption tax economies, respectively. We highlight three main findings from this exercise. First, the ef-

[38]Credit-constrained homeowners are those homeowners who borrow at their loan-to-value limit. We find that the average *cev* for credit-constrained owners is -0.25% while it is -0.46% for unconstrained owners.

[39] In this specification owner-occupied housing provides a utility premium over rental housing and homeowners will not become mismatched.

[40]Furthermore, the O2O transition rate is largely insensitive to changes in other parameters except for the discount factor where a higher discount factor yields a higher O2O transition rate. We note however that the discount factor is more important for determining the borrowing and savings behaviour, and increasing its value leads us to underestimate the median LTV ratio by a large amount.

fects of replacing stamp duty with a property or consumption tax on household mobility remain large. As discussed, the model without preference shocks has much lower O2O transition and housing turnover rates. However, the removal of stamp duty increases these rates by a similar percentage as in our baseline calibration. Second, the effects of removing stamp duty on house price, rent and home ownership are similar to our original calibration both qualitatively and quantitatively. Third, the steady state welfare gains are smaller in the model when preference shocks are absent. Welfare gains are 0.34 and 0.18 in the property and consumption tax experiments without preference shocks, respectively. This compares to gains of 0.45 and 0.25 when housing preference shocks are present. As such, if preference shocks are ignored, the welfare gains from tax reform are underestimated.

6 Conclusion

We have examined the quantitative effects of removing housing transaction taxes in a general equilibrium OLG model with heterogeneous agents. Replacing stamp duty with a revenue-neutral property or consumption tax leads to moderate increases in house prices and decreases in rents. Despite a small increase in the overall home ownership, there is a significant increase in the home ownership rate and average housing asset holdings of the young. The removal of stamp duty raises household mobility substantially, as reflected in the large increases in housing turnover and O2O transition rates. As a result, the degree of housing mismatch among homeowners is substantially reduced.

Our steady state results support a common view that stamp duty is inefficient. There are welfare gains for newborn households when stamp duty is replaced by either a consumption or a property tax with the *property tax* being the preferred option. These gains arise due to a combination of the reduction in housing mismatch, the easing of downpayment requirements on purchasing homes, and an improved intratemporal allocation of resources. These welfare changes can be decomposed into direct effects related to changes in the tax system and general equilibrium effects that arise due to changes in prices.

Stamp duty may play a useful role in some settings. If expectations of future house prices are irrational then housing markets may feature episodes of excessive speculation and volatility. This volatility could lead to an inefficient allocation of resources and financial instability. Stamp duty may act as a Tobin Tax that reduces speculation and hence moderates fluctuations and prevents excessive volatility in the housing market. The effectiveness of stamp duty in moderating volatility in the housing market has been questioned by Fu, Qian, and Yeung (2016). They study the role of increased transaction taxes on housing in Singapore and find evidence that the imposition of a property transaction

tax *raised* price volatility and rationalised this finding by appealing to the differential effects of stamp duty on informed and uninformed speculators. It would be interesting to incorporate speculation in housing market and study the potential role of stamp duty in curbing speculation and reducing housing market volatility.

Our model abstracts from elements that may be important when evaluating the effects of removing stamp duty. For instance, stamp duty may hinder the efficient operation of the labour market if individuals are unwilling to accept jobs in other locations due to the presence of housing transaction costs (see Halket and Vasudev (2014)). Furthermore, in Australia, stamp duty remains an important source of government revenue for state governments. However, the revenue raised from stamp duty is more volatile than revenue that would be raised via ongoing consumption or property taxes. This volatility could hinder the ability of government to increase expenditure during downturns. This effect is beyond the scope of our model that lacks aggregate uncertainty. Our model is also not rich enough to allow us to consider taxation of land separately from taxing the value of improvements to land. This distinction may be important. Taxing the value of land is often viewed as non-distortionary due to its inelastic nature while taxing the value of improvements to land may be distortionary as it reduces the incentive to improve land.

Finally, there are other issues beyond welfare, such as equity, that may be important for policymakers if they transition away from stamp duty: current homeowners have paid stamp duty in the past. If stamp duty is abolished and replaced with property tax, then additional tax revenue will be raised from these homeowners. This *double-taxation* is partly mitigated by the increase in house prices when stamp duty is removed, as it allows homeowners to recoup some of the taxes they have paid. However, the increase in house prices is well below the expenditure on stamp duty suggesting that they will bear a greater tax burden than individuals who have similar income but did not purchase homes. Some State governments in Australia have tried to address this issue, either by having a gradual transition from stamp duty to property tax or by allowing new purchasers to opt in to pay a property tax rather than stamp duty.

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