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Stamping Out Stamp Duty: Property or Consumption Taxes?

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Abstract

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Keywords

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JEL Classification

E21, H24, R13, R2

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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 household to move. 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 transition dynamics we find that existing households prefer replacing stamp duty with a consumption tax.

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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] Yet at the same time, these taxes are often viewed as inefficient (Henry, Harmer, Piggott, Ridout, and Smith (2009), Mirrlees and Adam (2010)) and highly distortionary (Best and Kleven (2017)). As a result, reforms that involve the reduction or removal of stamp duty are often debated. In this paper, we examine the welfare implications of removing stamp duty by studying the Australian housing market. We focus upon removing stamp duty in a revenue neutral manner, by replacing it with either a recurrent property tax or a consumption tax.[2]

We begin by documenting a set of empirical facts. First, we show that there has been a sharp increase in the transaction tax burden for home buyers over the last 15 years. This increase in transaction taxes has been driven primarily by a rise in house prices. Second, over this period the housing market has become less dynamic. This loss of dynamism is reflected in a lower rate of transactions and a decline in the rate at which households transition to a new owner-occupied home. We show that this decline in activity is primarily linked to increases in the size of stamp duty and the initial deposit required to purchase a home rather than an increase in mortgage repayments or demographic factors.

In light of this evidence, we develop a general equilibrium overlapping generations model with heterogeneous agents and incomplete markets to understand the impact of stamp duty on house prices, housing allocations and transitions, as well as welfare. The model economy consists of finitely-lived households who derive utility from a non-durable consumption good and housing services. Households face uninsurable idiosyncratic income shocks and age-dependent mortality shocks. Every period they choose non-durable consumption, saving into a risk-free asset, and a housing asset. A household can also choose to rent or purchase a home. 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 reform. The government collects taxes from labour income, rental income and housing transactions, and consumes its revenue. A housing construction sector adjusts the supply of new housing in response to changes in prices.

A key concern regarding stamp duty is that large transaction costs may reduce housing turnover and lead households to remain in homes that are mismatched to their needs

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

[2] In Australia, replacing stamp duty with land, property or consumption taxes has been extensively discussed (see Deloitte (2015) and Productivity Commission (2017)).

or preferences. To allow for this possibility in our model, utility from home ownership is subject to match-specific preference shocks. As a result, in our model there are two motives that drive households to purchase a new home. First, as in standard OLG models of the housing market, households may move to a new house to alter their consumption of housing services. This is essentially a permanent income motive adjusted to account for transaction costs and credit constraints. Second, as in the literature that focuses upon search models of the housing market, households may seek to move house not because they are dissatisfied with the size or quality of their home. Rather, their personal circumstances may have changed so they seek a home of similar quality potentially in a different location or with different features.

We calibrate the model to match some key features of the Australian housing market. The model generates plausible lifecycle profiles of the homeownership and landlord rates, and matches other important moments such as housing turnover and housing transition rates. To discipline the role of match-specific preference shocks which are a novel feature of our model, we make use of data on the *reasons for moving* as well as data on home value changes and the distance moved in the Household Income and Labour Dynamics Australia (HILDA) survey. After calibrating the model, we conduct two counterfactual policy experiments where we remove stamp duty in a revenue neutral manner by replacing it with 1) a recurrent property tax which, for brevity we will refer to as a property tax, and 2) a consumption tax.

Our main findings are as follows: First, removing stamp duty leads to substantial changes in housing allocations across different age groups. The average homeownership rate increases by 2 percentage points, but the changes in the homeownership rate across age groups are more striking. The homeownership rate for households under age 35 increases by 4 percentage points whilst that for households over age 65 remains broadly unchanged. This suggests that transaction taxes discourage a significant portion of young households from entering the housing market. A large shift in housing asset ownership across age groups also occurs. The share of total housing assets held by older age cohorts (age over 65) decreases by 20 percent while it increase by 15 percent for younger households (age under 35).

Second, removing stamp duty has a large effect on the housing turnover and transition rates. We find that removing stamp duty can raise the annual housing turnover rate by 50 percent, back to the level observed in the early 2000s. Housing transition rates, especially owner-to-owner and renter-to-owner transitions increase substantially in the counterfactual economies.[3] Moreover, we observe that the proportion of mismatched homeowners,

[3]There is a set of empirical papers that study the effects on house prices and household mobility including Dachis et al. (2011), Van Ommeren and Van Leuvensteijn (2005) and Davidoff and Leigh (2013). These papers find large effects of housing transaction taxes on housing turnover.

homeowners with the lower housing preference state, significantly declines suggesting that the policy reform could encourage households who experience the changes to their preferences to move house.

Our third result relates to steady state welfare. We consider *ex-ante* consumption equivalent variation as our welfare measure. Replacing stamp duty with a revenue neutral property tax would generate the same increase in welfare to newborn households as providing them with (on average) an extra 6 percent of non-durable consumption in their first period of life (a two-year period). When stamp duty is replaced with consumption tax, the welfare gain to newly born households is slightly lower but still substantial at 4.4 percent. These welfare gains arise from a combination of factors associated with moving to a more efficient tax system, changes in prices that arise in our general equilibrium setting, and a reduction in mismatch in the housing market.

Our welfare results differ from Kaas et al. (2020) who show, using a similar life-cycle model, that newborn households in Germany would experience a *welfare loss* when stamp duty is reduced. One important difference between our papers is the way in which the housing rental price is determined. In our model, the supply of rental housing depends upon housing investment by households. When stamp duty is removed, rents decrease in our model because it reduces rental demand contracts and rental supply expands as the purchase price of housing falls. In contrast, Kaas et al. (2020) assume a perfectly competitive set of risk-neutral real estate firms. As a result, in their model purchase and rental prices always move together. Removing stamp duty increases both the purchase price and the rental price of housing. Because households start their life-cycle as renters in both models, this leads to significantly different welfare outcomes. In addition, the presence of housing preference shock in our model increases the size of the steady state welfare gain.

We also examine transition dynamics and study the instantaneous welfare effects on heterogeneous households. The majority of households lose when stamp duty is replaced with a property tax. Almost 70 percent 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 lose when the economy transitions to a recurring property tax. In the consumption tax case, the tax burden is shared more evenly across all surviving households and we find a small welfare gain on average and the majority of households prefer a consumption tax to stamp duty.

These welfare results highlight a tension that exists when removing stamp duty. If we consider households that enter the economy in steady state, there is a preference for replacing stamp duty with property rather than consumption taxes. On the other hand, when examining welfare over the transition, existing households tend to prefer replacing stamp duty with consumption rather than property taxes. In contrast to newborns, ex-

isting households often own housing assets and benefit from increases in the house price and prefer tax revenue to be raised by a broad-based consumption tax rather than a property tax. This highlights a tradeoff that policy makers face when eliminating stamp duty that is not present in Dachis, Duranton, and Turner (2011) or Määttänen and Terviö (2017), who focus solely upon static environments. Citizens within a society have, on average, a preference to replace stamp duty with a consumption tax. However, future households would prefer to enter an economy with a property rather than a consumption tax.

Related literature. Our paper is related to three broad literature. First, we contribute to a large literature that studies the effects of taxation in the housing markets using quantitative life-cycle models, e.g. Gervais (2002), Sommer and Sullivan (2018), İmrohoroğlu et al. (2018), Kaas et al. (2020). Our paper differs from the existing studies by focusing upon stamp duty and introducing a housing preference shock that generates housing mismatch.

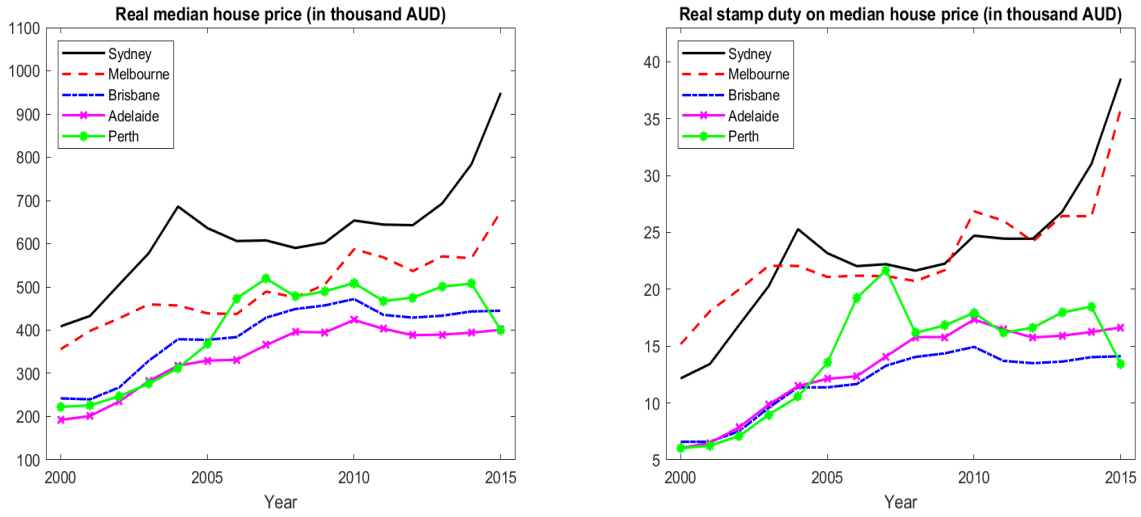
Second, our paper is closely related to a literature that examines the effects of property transaction taxes on house prices and welfare, e.g. O'Sullivan et al. (1995), Lundborg and Skedinger (1999) and Määttänen and Terviö (2017). Määttänen and Terviö (2017) study the heterogeneous welfare effects of housing transaction taxes using an assignment model. While our paper and Määttänen and Terviö (2017) share a similar objective, our approach allows us to focus on heterogeneity along both income and age. Our results reveal that considering the life-cycle property of housing demand is crucial for understanding the role of transaction taxes. In our counterfactual policy experiments, we emphasize that the housing demand by younger households increases while that of older households decreases. Such reallocation of housing assets across different age groups contributes to the welfare gain.

The paper is organized as follows: Section 2 provides empirical facts of the Australian housing market. Section 3 discusses the model. Section 4 describes the calibration strategy and some important quantitative properties of the calibrated model. Section 5 discusses the quantitative results, including the price and quantity effects of removing property transaction taxes and its impacts on welfare. Section 6 concludes.

2 Data and Evidence

Our data on household mobility comes from the HILDA survey which is an annual household panel survey that is representative of the Australian population. Data on house prices and stamp duty rates are from the Real Estate Institute Australia (REIA). We use this data to examine how stamp duty, housing turnover and housing transitions have changed over time. These empirics motivate our structural model that we use to examine

Figure 1: Real house prices (left) Real stamp duty (right) from 2000 to 2015



Source: Real Estate Institute of Australia. The median stamp duty payments are deflated using the Consumer Price Index released by the Australian Bureau of Statistics.

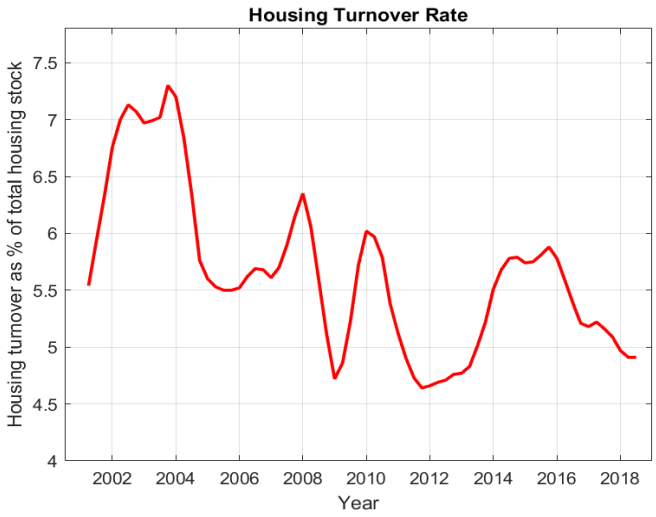
the welfare implications of removing transaction taxes in housing markets.

House prices and stamp duty. Data on the median house prices and stamp duty rates in capital cities of Australian states across 2001-2015 are provided by Crowley and Li (2016). They collect original data from various sources including the REIA. The state level stamp duty rates on the median house prices are calculated by applying the median house price of each capital city to the stamp duty rate schedule for the corresponding state. As such, we obtain the stamp duty rates and amount charged on the median house price of every capital city between 2001 and 2015.

The left panel of Figure 1 shows a large increase in house prices in all regions of Australia since 2000. The right-panel shows that the increase in house prices has led to a significant increase in stamp duty charged. For example, the amount of stamp duty paid by a household who purchases a median price house in Sydney increased by more than 200 percent from 2000 to 2015. The amount of stamp duty paid on a median priced home in Sydney in 2015 was AUD 41,000 which corresponds to almost 40 percent of annual household disposable income. Despite the level difference, other capital cities experienced similar increases in percentage terms. There have also been minor changes in the stamp duty rates over time but these have had little impact upon stamp duty payable.

Housing mobility. We examine two measures of housing mobility that reflect the dynamism of the housing market. The first is the housing turnover rate. This is defined as

Figure 2: Housing turnover rate in Australia



Source: Australian Bureau of Statistics; Reserve Bank of Australia

the number of housing sales relative to the total number of dwellings. Figure 2, shows a decline in the housing turnover rate over the last 15 years. After peaking at 7.2 percent in 2004, there has been a persistent decline since then and the rate decreased to below 5 percent in 2018.

Our second measure of housing mobility are transition rates that describe the likelihood that a household of a particular type, i.e., owner or renter, will change residence. The HILDA survey contains information on whether households own or rent their property as well as the year they moved into their current address. We use this information, following Bachmann and Cooper (2014), 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. Similarly, the R2O and R2R transitions rates in a particular year are given by the total R2O and R2R transitions divided by the number of renters in the previous year.[4]

Table 1 reports the average annual transition rates over the sample period and the relative shares of each type of movers in total movers. In our data, 60 percent of all moves are renters moving into another rental house. The average rates at which homeowners and renters are moving into a new owner-occupied house, and hence typically subject to stamp duty, are 2.5 percent and 5.2 percent, respectively.

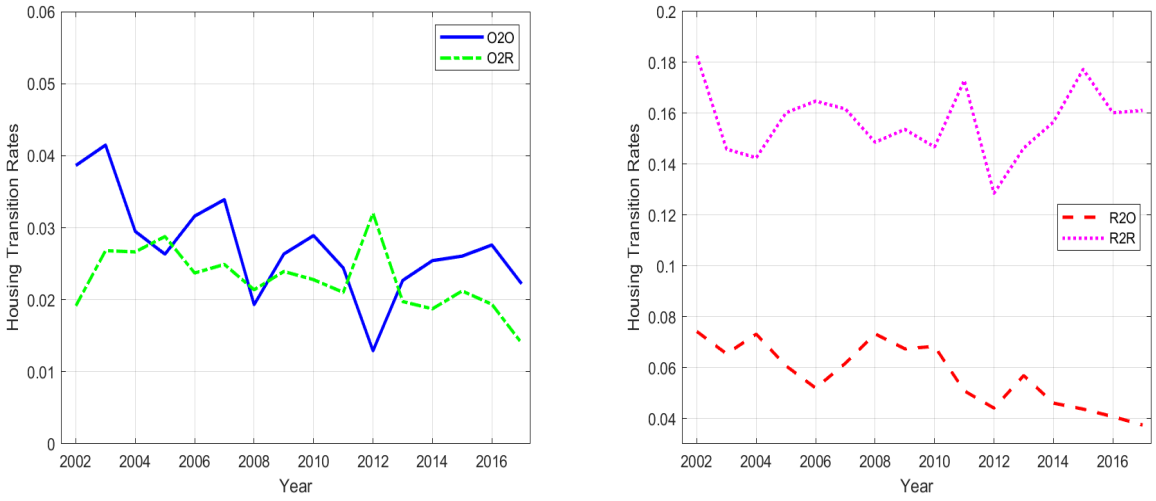
[4]We consider the period from 2001 to 2017 and households aged between 21 and 84. Further details about the HILDA survey and our sample selection procedure are provided in Appendix A.

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	10.3%	21.0%	8.7%	60.0%

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 movers out of total movers.

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



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

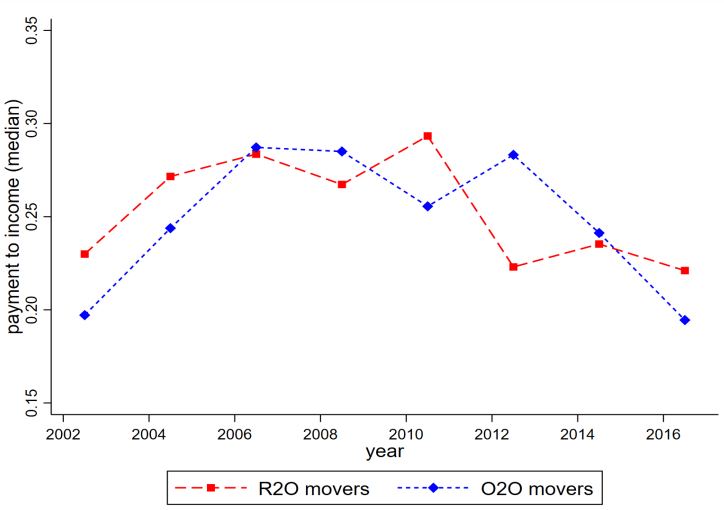
Figure 3 reports how housing transition rates have varied over the period 2002-2017. The left panel shows that both O2O (blue solid) and O2R (green dotted) transitions rates decreased gradually over the sample period. In particular, the O2O transition rate decreased more steeply from 4.1 percent in 2003 to 2.2 percent in 2017. The time paths of R2O and R2R transition rates are depicted in the right panel of Figure 3. While the level of R2R transition rate remained steady at around 15 percent, the R2O transition rate declined from 7.4 percent in 2002 to 3.7 percent in 2017.

We conclude that housing market has become less flexible with a decline in sales relative to the stock of housing and a decline in the rates at which households move to a new owner-occupied house. This decline in mobility occurs at the same time as a significant increase in house prices and stamp duty. Next, we provide evidence that this decline in mobility is not due to an increase in mortgage payments or demographic factor.

Figure 4 displays how mortgage payments relative to household income have changed over time for households that have recently moved into an owner-occupied home.[5] We

[5]Ideally, we would like to examine mortgage payments to income of households that have recently pur-

Figure 4: Mortgage payment to income ratio for households that have recently moved



Notes: R2O are households that have moved from rental to owner-occupied properties. O2O are households that have moved from owner-occupied to another owner-occupied home. Source: HILDA and authors' calculations.

divide our sample into two groups - R2O movers and O2O movers, where R2O movers are younger and more likely to be first-home buyers. For both groups, mortgage payment to income ratios increased from the early 2000s up until roughly 2010 and then declined in the post-2010 period. Although there has been a dramatic rise in house prices and hence stamp duty, the mortgage payments to income ratio actually decreased in the post-2010 period, reflecting the simultaneous decline in mortgage interest rates over the period. So, although Australian households have been borrowing larger amounts, the overall burden of mortgage repayments, at least as a share of income has remained relatively stable.

A second possible reason for the decline in mobility is perhaps due to demographic changes in the structure of the population such as population aging. To investigate this possibility, we examine the mobility decisions of households in a regression framework that takes into account a range of demographic factors. We consider the following specification:

$$M_{i,j,t} = \alpha + \beta SD_{j,t} + \gamma X_{i,j,t} + \nu_j + \lambda_t + \varepsilon_{i,j,t} \tag{1}$$

The dependent variable $M_{i,j,t}$ is an indicator equal to one if household i living in a metropolitan area of capital city j moved to a new owner-occupied house in year t and zero otherwise. $SD_{j,t}$ denotes the stamp duty rate (in percentage points) or amount (in AUD 10,000, inflation adjusted) on the median house price in capital city j in year t. $X_{i.j,t}$ denotes household-level controls which include the number of children, the number of family

chased a new home. Such information is unavailable so we examine the mortgage repayment to income ratio of households that have recently moved into an owner-occupied home.

Table 2: Marginal propensities to move to new owner-occupied housing

	(I)	(II)	(III)	(IV)
Stamp duty rate (in ppt)	-0.0049*		-0.0063**	
	(0.0025)		(0.0021)	
Stamp duty amount		-0.0084**		-0.0093**
(in AUD 10,000)		(0.0029)		(0.0027)
Year fixed effect	Yes	Yes	Yes	Yes
Region fixed effect	Yes	Yes	Yes	Yes
Age group interactions			Yes	Yes
Education interactions			Yes	Yes
Number of observations	42,252	42,252	42,230	42,230

**, * represent statistical significance at 5% and 10% respectively. Standard errors are clustered at the capital city level.

members, marital status and age of the household head. ν_j and λ_t are regional area and year fixed effects, respectively.

Table 2 reports the estimated coefficients of β in Eq. (1) under different specifications. The estimate in Column (I) implies that a one percentage point decrease in the stamp duty rate, which corresponds to a 25 percent reduction in the average stamp duty rate applied to the median house prices, is correlated with an increase of 0.5 percentage points. This corresponds to a 14 percent increase in the rate at which households move to a new owner-occupied home.[6] In Column (II), we report the results from the regression where the main independent variable is the stamp duty amount (in AUD 10,000) instead of the rate. The estimated marginal effect on household moving is 0.84 percentage points, suggesting that a decrease in stamp duty burden of AUD 1,000 is correlated with an increase in the moving rate to new owner-occupied housing of 0.084 percentage points or 2.4 percent.

Our estimates remain robust to inclusion of age and education categories interacted with $SD_{j,t}$. Columns (III) and (IV) show that the estimates remain significant although the negative effect of stamp duty becoming slightly larger when we include age and education interaction terms.[7] While we are unable to draw a causal inference, the results in Table 2 reveal that households' propensities to move (to owner-occupied dwelling) are negatively related to both the level and rate of property transaction taxes even after controlling for demographic factors.

[6]Our calculation from the HILDA survey suggests that on average approximately 3.5 percent of the households in the sample move into a new owner-occupied dwelling.

[7]The variable age is divided into three categories, young (under 35), middle (35-64), old (over 65). Likewise, education is also divided into three categories: i) high school dropouts, ii) high school graduates, and iii) college dropouts and graduates. The estimated coefficients on interaction terms suggest that older and higher education households have the highest propensity to move.

To summarise, we find that mobility in the Australian housing market has decreased. This has coincided with a large rise in house prices and stamp duty. Examining the impact of house prices on mortgage repayments to income, we find little evidence that these payments are responsible for the decline in mobility. In fact, these payments have declined in the 2010s. Furthermore, our regression results indicate that the negative correlation between mobility and stamp duty remains after controlling for demographic factors. That leads us to view the increase in required downpayment to purchase a house and the stamp duty fees as important factors responsible for the observed decrease in mobility. Unfortunately, we are unable to distinguish the effect of larger minimum mortgage downpayments from the effect of increased stamp duty since both are determined to a large extent by house prices. The impact on mobility should be similar since they both increase the amount of savings a household requires to purchase a home. A key difference is that mortgage downpayments are reflected in the value of the home, an asset that the household may sell at a later date, while stamp duty is a transaction cost that can not be recouped.

Housing preference shocks as a motivation for moving. In understanding housing markets, different models have focused upon different motivations for moving. OLG models of the housing market focus upon a permanent income motive with households selecting housing size on the basis of 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 become more likely to upsize their house, while if households face negative income shocks they may downsize. In this theory, O2O housing transitions are linked to changes in desired consumption of housing services, that in turn, are driven by changes in the lifetime resources that individuals may access. We describe these as *size-quality transitions* since households seek to alter their consumption of housing services by moving into either smaller or larger sized home or by moving to a home with better or worse quality.

A large parallel literature exists (e.g. Wheaton (1990), Lundborg and Skedinger (1999), and Ngai and Sheedy (2020)) in which the housing market is studied as a frictional search market. In these models, transactions in the housing market occur not because of underlying changes in the lifetime resources of households but rather due to changes in the preferences that households have 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, households preferences for characteristics may change over time and result in households becoming mismatched to their current home. As a result, households are willing to sell a property that they own and move to a property

of similar quality if their valuation of idiosyncratic characteristics of the property change over time. We describe these as *mismatch transitions* since households seek to alter their housing stock not to necessarily change the overall size or quality of their home but rather due to the fact that idiosyncratic features of the home are no longer appealing to them.

We view the possibility of mismatch as important to our model. One of the potential costs of stamp duty is that it creates a lock-in effect in which households that are mismatched to their current home would desire to move to an alternative property but are prevented from doing so due to the existence of transaction costs. Ignoring this mechanism could bias our estimates of the welfare effects of removing stamp duty. Hence, one of the key challenges in our study is to convincingly differentiate how important preference shocks are relative to changes in permanent income in driving transitions in the Australian housing market.

In our calibration (to be discussed in detail in Section 4), a key target moment we will try to match is the percentage of O2O transitions that arise due to shocks to preferences that create mismatch. We estimate this value using data from the HILDA survey. In particular, HILDA asks households that have moved in the last year for their reason for moving.[8] A full list of possible responses to this question are provided in Appendix B. In general, these self-proclaimed reasons for moving do not directly identify whether an O2O move is a size-quality transition or whether it is a mismatch transition. As an example, a household may state that a reason for moving is 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 transition should be classified as a *size-quality transition*. Alternatively, the new job may be far away from their current home. In that case, an individual may make an O2O transition to move to a home of similar quality that is closer to their new workplace so that they can reduce transportation costs. This would reflect a change in the valuation of idiosyncratic features of the house (in this case, the location) and should be classified as a *mismatch transition*.

However, there are reasons for moving that can be classified in a way which is not controversial. In the HILDA survey, 55 percent of households engaged in an O2O transitions express their reason for moving as a desire “to get a larger/better place" or “to get a smaller/less expensive place". We view these reasons as being consistent with *size-quality transitions*. On the other hand, 21 percent of households state that the main reason for moving are “seeking change of lifestyle" or “to be closer to friends and/or family". We view these transitions, as being consistent with *mismatch transitions*.[9]

[8]The exact question asked is “If you have moved during the last 12 months, what were the main reasons for leaving your previous address?”.

[9]Some might argue that transitions motivated by a change in lifestyle could also reflect changes in employment and lifetime income and could possibly be classified as a size-quality transition. We don’t see

Table 3: Characteristics of households with different reasons 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	50.4	15.8
%Δ in house value (−, median)	-23.1	-21.7	-8.6	-24.4
% of hhs with +Δ in house value	56.8	58.7	88.8	25.7
%Δ in income (median)	3.3	3.2	7.2	3.7
Age (median)	54	59	39	62

Notes: This table reports, for different *reasons for moving* in columns, the 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.

Next, we note that the transitions motivated by the size-quality transitions are quantitatively different from transitions motivated by mismatch. This is reflected in Table 3. In particular, HILDA data record the distance that a household has moved, the percentage change in the self-reported value of the house, as well as changes in household income and household demographics such as age of the male head of household. Households that move where the stated reason is to move to a "larger/better place" (Column (3)) 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". Hence, different types of moves are associated with different characteristics. This suggests the following approach to classify the remaining transitions: we first estimate a discrete choice logit model that determines whether a transition is a *size-quality* or a *mismatch* transition using the reasons for moving that we view as uncontroversial. We then take this estimated discrete-choice logit model and apply it to the remaining 24 percent of O2O transitions that we are not confident in classifying. For each unclassified transition we apply the estimated discrete-choice model to calculate the probability that this transition is a *size-quality* transition. We aggregate over these probabilities to estimate the total proportion of transitions due to *size-quality* reasons. Overall, for O2O transitions, we estimate that 73 percent of moves are due to *size-quality* reasons and the remaining 27 percent are due to *mismatch*. Details of this procedure are provided in Appendix B.[10]

large contemporaneous changes in income when people move for this reason to support this view (Table 3).

[10]We have tried specifications where the fraction of mismatched O2O movers varies from 27 percent to 44 percent. We have also a specification without the preference shock (see Section 5.4). Our results remain qualitatively unchanged, in particular, removing stamp duty leads to large steady state welfare gains in all calibrations.

Taking stock. We briefly summarize our empirical findings as follows: First, house prices and hence stamp duty paid by home buyers have increased considerably over the past 15 years. Second, the degree of flexibility in the housing market has decreased over time. This is observed in a decline in housing transitions and an accompanying decrease in owner-to-owner and renter-to-owner transitions. The decrease in flexibility in the housing market does not seem to be primarily due to demographic changes. Finally, we use the reasons for moving and other characteristics associated with transitions to highlight the relative importance of *size-quality* versus *mismatch* transitions in Australian housing market. In light of this evidence, we examine the role of stamp duty on the housing market and welfare using a general equilibrium life-cycle model with housing decisions.

3 Model

Our model economy is similar to that of Cho, Li, and Uren (2019). The economy comprises of a large number of finitely lived households. Households receive utility from consuming a non-durable consumption good and from housing services. Housing services can be obtained by renting or purchasing durable housing stock. Households supply labour inelastically to the labour market and face idiosyncratic risk in their labour income. Households can partially insure themselves by saving. These savings can be in the form of a risk-free 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 that they receive from their existing home. The supply of housing is determined by a competitive construction sector that generates changes in the stock of housing in response to changes in house prices. Housing prices and the rental rate are determined endogenously through equating supply and demand.

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. Households face an age-dependent survival rate given by κ_a. The population size remains constant as new-born 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 expected lifetime utility of a household is given

by

$$\mathbb{E}_0 \left[\sum_{a=1}^{A} \beta^{a-1} \left[\kappa_a u(c_a, \tilde{h}_a) + (1 - \kappa_a) \nu(\mathrm{b}) \right] \right] \tag{2}$$

with $0 < \beta < 1$. The flow utility from the consumption of non-durables and housing services is:

$$u(c_a, \tilde{h}_a) = \frac{\left(c_a^{\alpha} (\lambda \tilde{h}_a)^{1-\alpha} \right)^{1-\sigma}}{1-\sigma} \tag{3}$$

where α measures the preference for non-durable consumption and σ is the risk aversion coefficient. The function ν in Eq. 2 measures the utility derived from leaving a bequest. Following De Nardi (2004) we assume:

$$\nu(\mathrm{b}) = \vartheta \frac{\mathrm{b}^{1-\sigma}}{1-\sigma} \tag{4}$$

where b is the size of the bequest, which equals the remaining assets of the deceased household, and ϑ measures the importance of bequest provision in utility.[11]

The parameter λ is a preference shifter that affects the utility that households receive from consuming housing services. This shock is introduced to reflect that owning a home often raises the utility received from housing services above that received from renting but that at times, some homeowners can become *mismatched* to their current homes which may reduce their utility associated with home ownership and provide an incentive for them to move houses.[12] Consequently, we set λ to 1 if a household is a renter, and let $\lambda \in \{1 + \xi, 1 - \xi\}$ be stochastic if the household owns a home. Here, $\xi > 0$ describes the benefit of living in a home that is well-matched and the penalty associated with living in a poorly-matched house. A household who has just purchased a home starts with a favourable match, $\lambda = 1 + \xi$. After that, if the household remains at this dwelling, λ follows a two-state Markov process with transition matrix

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

This moving shock is a novel aspect of our model closely related to shocks introduced by Floetotto et al. (2016) and İmrohoroğlu et al. (2018). In their models, households that receive a shock *must* move while in our framework, when faced with reduced utility from home ownership households make a rational decision to move or not. As a result, policies such as stamp duty may alter the equilibrium degree of mismatch in the housing market and helps us accurately measure the welfare gains of removing stamp duty.

[11] Having a bequest motive helps the model generate 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.

[12] Mismatch could occur due to changes in the location of their work, changes in their preference for hobbies, or changes related to age.

Income. We assume that households receive exogenous age-dependent periodic income given by

$$\log y_{i,a} = \eta_a + z_{i,a} \tag{5}$$

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

$$z_{i,a} = \rho z_{i,a-1} + u_{i,a} \qquad u_{i,a} \sim N(0, \sigma_u^2). \tag{6}$$

Housing demand. Households select whether to rent or own their homes. Homeowners may rent out a portion of their housing stock and become landlords. The quantity of housing owned by a household is given by h. If $h = 0$, the household is a renter and she selects 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 stock, $h - \tilde{h}$, may be rented out. The price of purchasing and renting a unit of housing are p and p_r, respectively, and determined endogenously within the model.

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

$$TC(h_{-1}, h) = \begin{cases} 0 & \text{if } \; h_{-1} = h \\ (\phi_1^b + \phi_2^b)ph + \phi^s p h_{-1} & \text{if } \; h_{-1} \neq h \end{cases}$$

Buyers incur both stamp duty that is charged at a rate of ϕ_1^b and other costs of purchasing a home, such as search costs, captured by ϕ_2^b. Likewise, sellers incur a constant fraction ϕ^s of the selling price of the house as real estate agent fees and other costs of selling. Note that homeowners who move house incur both selling and buying costs.

Homeowners also incur maintenance expenses to offset physical depreciation of housing. The maintenance cost is a constant fraction δ of the value of the house. In addition, landlords incur an additional fixed cost ζ which captures costs related to finding tenants and managing the rental property.

Financial assets. Households may trade a risk-free financial asset. They can save by purchasing this risk-free asset ($s > 0$) or borrow ($s < 0$). We assume the following borrowing constraint:

$$s \geq -(1 - \theta)ph, \qquad 0 < \theta < 1 \tag{7}$$

where θ is the minimum downpayment required to purchase a house. Savers receive an interest rate of r while borrowers face an interest rate of $r + m$, where m is a mortgage

premium. We treat Australia as a small open economy, so both r and m are exogenous.

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

$$Y = y_a(z) + rs_{-1}\mathbb{1}_{\{s_{-1}>0\}} + NRI \tag{8}$$

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 which takes a value of 1 if its argument is true and a value of zero otherwise. The last term, NRI, stands for net rental income (if the household is a landlord) which is defined as

$$NRI(h, \tilde{h}, s) \equiv \left[(p^r - p\delta)(h - \tilde{h}) + (r + m)s\left(\frac{h - \tilde{h}}{h}\right)\mathbb{1}_{\{s<0\}} - \zeta\right]\mathbb{1}_{\{h>\tilde{h}\}} \tag{9}$$

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.[13]

Household dynamic programming problem. At the beginning of a period a household first decides on their housing tenure status: That is, whether to (i) rent, (ii) stay in a current house, or (iii) move to a new house. Following their housing tenure status decision, a household selects 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), and also her age a, the current value of the income shock z, housing assets h_{-1}, 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

$$V(x) = \max\{V^{renter}(x), V^{stayer}(x), V^{mover}(x)\} \tag{10}$$

A renter's problem is as follows:

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

subject to

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

[13] 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 that a certain proportion of $\frac{h-\tilde{h}}{h}$ of total debt is deductible as an investment expense while the remaining proportion is associated with interest expenses on owner-occupied housing which is not deductible.

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

A homeowner who chooses to stay in her existing home sets $h = h_{-1}$. She solves the following problem:

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

subject to

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

where $x' \equiv (a+1, z', s, h_{-1}, \lambda')$, and $Y = y_a(z) + rs_{-1}\mathbb{1}_{\{s_{-1}>0\}} + NRI(h_{-1}, \tilde{h}, s)$. This differs from a renter's problem in that a stayer can borrow subject to a borrowing constraint, she can choose to become a landlord and earn net rental income, her bequest in the case of death includes both liquid assets and housing assets that she owns, and she faces a housing preference shock such that λ evolves to λ' in next period.

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

$$V^{\text{mover}}(x) = \max_{c,\tilde{h},s,h} u(c,\tilde{h}) + \beta \left[\kappa_a \mathbb{E}_{z'|z} V(x') + (1-\kappa_a)\nu(b)\right] \tag{13}$$

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 $Y = y_a(z) + rs_{-1}\mathbb{1}_{\{s_{-1}>0\}} + NRI(h, \tilde{h}, s)$. This differs from a stayer's problem in that a mover has an additional decision of what size house to purchase and faces transaction costs from selling existing home and purchasing a new home, and she 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:

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

where $\bar{Y}_q$ for $q \in \{1, 2, \cdots, Q\}$ are income thresholds at which marginal tax rates change, τ_q are the corresponding marginal tax rates, and T_q is the tax paid on a threshold income so that $T_q = T_{q-1} + \tau_q(\bar{Y}_{q+1} - \bar{Y}_q)$.

3.3 Construction Sector

We introduce a competitive construction firm to endogenize housing supply. This firm buys existing dwellings from households who sell housing assets, develops new dwellings, and sells existing and new dwellings at price p to households who choose to purchase housing assets. The construction firm also collects homeowners' maintenance expenditure on housing and uses part of the newly developed housing stock to offset the depreciation of existing housing stock. Because there is no capital gain, the competitive construction firm does not earn profits from buying, selling, and maintaining existing dwellings.

Following Floetotto, Kirker, and Stroebel (2016), we assume that the production technology to create new housing stock is given by

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

where L is the amount of land issued by the government every period. The firm purchases the land at a competitive market price which is normalized to 1, and sells the newly produced housing stock at price p. The parameter ψ_2 is a scale parameter that is less than 1. The construction firm therefore solves the following static problem:

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

which gives the following new housing stock,

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

Note that the elasticity of housing supply is given by $\varepsilon = \psi_2/(1 - \psi_2)$. The transition equation for aggregate housing stock is given by

$$H = H_{-1}(1 - \delta) + H^{\text{new}}. \tag{14}$$

3.4 Stationary Equilibrium

Recall, the state vector of a household is defined as $x \equiv (a, z, s_{-1}, h_{-1}, \lambda)$, which reflects the household's age, earnings, financial assets, housing assets, and housing preference state. Here $a \in \mathcal{A} \equiv \{1, ..., A\}$, $z \in \mathcal{Z} \equiv \{z_1, ..., z_J\}$, $s \in \mathcal{S} \subset \mathbb{R}$, $h_{-1} \in \mathcal{H} \subset \mathbb{R}_+$ and $\lambda \in \Lambda \equiv \{1-\xi, 1, 1+\xi\}$. The individual state space is given by $X \equiv \mathcal{A} \times \mathcal{Z} \times \mathcal{S} \times \mathcal{H} \times \Lambda$. A stationary equilibrium consists of value functions $V^{\text{renter}}(x), V^{\text{stayer}}(x), V^{\text{mover}}(x)$ household decision rules $\{c(x), s(x), h(x), \tilde{h}(x)\}$, housing price p and rent p^r, an aggregate housing stock $\overline{H}$, and a stationary distribution on X, μ, such that:

1. Taking p and p^r as given, households optimize by solving (10)-(13) with value functions $\{V^{\text{renter}}(x), V^{\text{stayer}}(x), V^{\text{mover}}(x)\}$ and decision rules $\{c(x), s(x), h(x), \tilde{h}(x)\}$.

2. The aggregate housing stock satisfies (14) with $H = H_{-1} = \overline{H}$.

3. The housing and rental markets clear:

$$\int_X h(x) d\mu = \overline{H} \tag{15}$$

$$\int_X \left(\tilde{h}(x) - h(x)\right) d\mu = 0 \tag{16}$$

4. The distribution μ is stationary and consistent with household behavior.

4 Calibration

We calibrate the model in two stages. In the first stage, we select the values of certain parameters without solving the model. In the second stage, we calibrate the remaining parameters by matching the model moments in the baseline steady state to their data counterparts as closely as possible. We summarize parameters that are externally determined in Table 4. The parameters calibrated internally are summarized in Table 5 while the respective data and model moments are reported in Table 6.

4.1 Externally calibrated parameters

Demographic and Preferences. The model period is set to 2 years. Households enter the model at age 21 and exit at age 84. The number of cohort is therefore 32. The age-dependent survival probabilities, κ_a, are obtained from the ABS Life Tables 2014-2016.

Income. We follow Cho, Li, and Uren (2019) in setting the idiosyncratic income process parameters $\rho = 0.94$ and $\sigma_u^2 = 0.17$ to match the annual persistence and standard deviation of residual earnings in the HILDA survey. The income measure used in this calibration is *household total gross income*. These annual parameters are converted into the 2-year

Table 4: Externally calibrated parameters

	Parameter	Value	Source
r	(Real) risk-free interest rate	0.028	RBA
m	(Real) mortgage premium	0.052	RBA
σ	Coefficient of risk aversion	2	Literature
ϕ_1^b	Stamp duty	0.04	Avg. stamp duty
ϕ_2^b	Other buying cost	0.01	Refer to text
ϕ^s	Trans. costs for sellers	0.02	Ave. agent fee
θ	downpayment requirement	0.2	See text
δ	maintenance/depreciation cost	0.04	SIH 2013-14
η_a	deterministic part of income		HILDA
ρ	Persistence of income shocks	0.940 (annual)	HILDA
σ_u	Std. dev. of income shocks	0.173 (annual)	HILDA
κ_a	Survival probabilities		ABS life table
$T(Y)$	Taxation thresholds and marginal rates	Refer to text	ATO
ε	Housing supply elasticity	2	Refer to text

values using a simulation method described in Cho et al. (2019). The income process is then discretized with seven states using the Rouwenhorst (1995) method. The deterministic component, η_a, is extracted using a sixth order polynomial in age. This component captures the life-cycle profile of earnings that is increasing and then decreasing over the life cycle. The median income in the data over a 2-year period is AUD 269,280 and we use this value to normalize all variables in monetary units.

Housing. For parameters governing housing transaction and maintenance costs, we set the stamp duty rate, ϕ_1^b, to 4 percent of the housing value, which is the population weighted average stamp duty rate across the seven capital cities in Australia from 2011 to 2015. The additional transaction cost for buyers, ϕ_2^b, is set to 1 percent. The annual depreciation rate is set to 0.02, which translates to a model value of 0.04. The downpayment requirement θ is set to 0.2, consistent with the practice of residential mortgage lending in Australia.

We discretize the size of housing that households may purchase into $K = 12$ discrete sizes, $h \in \{0, h(1), ..., h(12)\}$. Following Gervais (2002) and Floetotto, Kirker, and Stroebel (2016), we introduce a minimum housing size for owner-occupiers, $h_{min} = h(1)$, which is internally calibrated to be described below. The largest house size is about five times the minimum house size and it is rarely chosen by households. We allow renters to consume housing services less than this minimum housing size to reflect shared accommodation. As in Kaplan, Mitman, and Violante (2020), we also put a cap on the maximum housing size that can be consumed by renters, which is smaller than the maximum housing size available to homeowners (see Appendix D for more details).[14] Increasing the number of

[14]For robustness, we have tried allowing renters to consume the same sizes of housing as homeowners.

housing sizes does not have a significant impact upon the steady state housing transition rates.

Interest rates. The interest rate of the risk-free asset is calibrated to the average yield of the 2-year Commonwealth government bond from March 2001 to December 2015, deflated by annual CPI inflation. This gives a real risk-free rate of 1.41 percent, equivalent to a model value of $r = 0.028$. The annual mortgage premium is calculated by subtracting the risk-free rate from the real variable lending rates for owner-occupied home loans across the same period. The annual average is 2.59 percent which translates to a model value of $m = 0.052$.

Taxation. The income tax function captures the progressivity of the Australian individual income tax rates. The parameters to be calibrated are income thresholds for each tax bracket $\bar{Y}_q$, the marginal tax rates τ_q, and the tax payment thresholds for each bracket, T_q. These are obtained from the Australian Taxation Office using the individual income tax rates for the 2013-14 financial year.

Housing supply elasticity. Estimates of housing supply elasticity are not readily available for the national housing market. Liu and Otto (2014) estimate that the supply elasticity of houses in the Sydney metropolitan area is between 0.07 and 0.96 while that of apartments is between 0.16 and 4.34. As far as we are aware, these are the only measures available for Australia. In our baseline model, we set $\varepsilon = 2$. This value is slightly above their average estimate since we believe the Sydney housing market is more supply constrained by geography and regulation than other regions in Australia.

4.2 Internally calibrated parameters

The remaining parameters are calibrated internally by jointly matching important moments observed in the data. These internally calibrated parameters and the relevant moments are reported in Tables 5 and 6, respectively.

The minimum size for owner-occupied housing h_{min} is an important parameter governing the home ownership rate for younger households. We therefore match the home ownership rate for households under age 35 to calibrate h_{min}. Similarly, the bequest intensity ϑ is chosen to match the home ownership rate for households over age 65.

The fixed cost of being a landlord, ζ, is set to target the average landlord rate in the economy, which is 17.8 percent according to the Survey of Income and Housing (SIH)

Very few renters consume the larger sizes of housing and the quantitative predictions of the model remain unchanged.

Table 5: Internally calibrated parameters

	Parameter	Value
ξ	Size of housing preference shock	0.08
h_{min}	Minimum housing size for owning	0.62
ϑ	Bequest intensity	15
ζ	Fixed cost of being a landlord	0.014
β	Discount factor	0.880
α	Share of non-durable consumption	0.768
π_{hh}	Persistence of housing preference shock (high state)	0.96
π_{ll}	Persistence of housing preference shock (low state)	0.99
ψ_1	Scale parameter in housing production	4.26

Table 6: Target moments

Target Moments	Model	Data	Source
Avg. homeownership rate	68.2%	68.5%	SIH 13-14
Avg. H.O. rate under 35	41.0%	37.4%	SIH 13-14
Avg. homeownership rate for 65+	78.1%	84.0%	SIH 13-14
Avg. landlord rate	18.0%	17.8%	SIH 13-14
% of mortgaged homeowners	46.4%	49.0%	SIH 13-14
Median rent-to-income ratio	0.21	0.24	SIH 13-14
Avg. O2O transition rate (annual)	2.3%	2.5%	HILDA
Avg. R2O transition rate (annual)	4.9%	5.2%	HILDA
% of O2O movers due to mismatch	30.5%	27.3%	HILDA
Median housing wealth	1.63	1.58	SIH 13-14

2013-14 . The calibrated value of ζ is 0.014 which corresponds to a cost of around AUD 1,900 per year. The parameter that captures the share of non-durable consumption, α, governs the allocation of resources between non-durable consumption and housing services in the model, so we choose the rent-to-income ratio as the target moment. This gives a value of 0.768 for α and a median rent-to-income ratio of 0.21 that is slightly lower than in the data. The discount factor, β, is calibrated to match the fraction of mortgaged homeowners, which is 49 percent in the SIH survey. We obtain a value of 0.880 as the two-year discount factor with the fraction of mortgaged homeowners being 46.4 percent. The scale parameter in housing production function, ψ_1, largely determines the total size of housing stock and it is calibrated to match the median housing wealth to income ratio.

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. We calibrate these three parameters to match the following four moments: an average home ownership rate of 68.5 percent; an average annual O2O transition rate of 2.5 percent and R2O transition rate of 5.2 percent, which are obtained from the HILDA survey as

described in Section 2; and the fraction of O2O movers due to mismatch, which is 27.3 percent according to our classification strategy described in Section 2 and Appendix B. The calibrated values are $\xi = 0.08$, $\pi_{hh} = 0.96$ and $\pi_{ll} = 0.99$, and the three targeted moments are all closely matched, as shown in Table 6. Note that the low housing preference state is more persistent than the high state, suggesting that a homeowner with a low housing preference state is unlikely to exit this state unless she moves to a new dwelling. This gives additional motive for homeowners to move house.

4.3 Model fit

As a validation of the calibration, we present some important quantitative properties of the baseline steady state which are not targeted in the calibration.

Home ownership and landlord rates. Figure 5 depicts the life-cycle profiles of home ownership (left panel) and landlord rates (right panel). The model-produced home ownership and landlord rates are displayed in the black solid line while their data counterparts (SIH 2013-14) are displayed in the blue dotted line. As shown in the left panel, the home ownership profile matches well the life-cycle properties observed in the data although it slightly underestimates the ownership rates for the last few age cohorts. As in the data, the home ownership rate continuously rises from the initial age and reaches the average of 82 percent for households between the ages 61 and 68. The model also generates a landlord rate profile over the life cycle that is similar to the data, increasing from the average of 2 percent for age cohorts between 21 and 28 to 31 percent for cohorts in the age range from 69 to 76. Figure 6 shows the home ownership and landlord rates across wealth quintiles. The increasing patterns with wealth are broadly consistent with that observed in the SIH.

Housing transition rates. Table 6 reports that the model generates an annual O2O transition rate of 2.3 percent and R2O transition rate of 4.9 percent. Both moments closely match their data counterparts. The model implies a R2R transition rate of 12.1 percent and a housing turnover rate of 4.8 percent per annum. These are also in line with the empirical evidence in Section 2 (see Figure 2 and Table 1). Having realistic values for these transition rates in the baseline economy is important since we want to quantify the effects of removing property transaction taxes on housing allocation and welfare through influencing housing transitions among households. 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. See 5.4 for more details where we re-calibrate the model in the absence of the housing preference shock.

Figure 5: Lifecycle profiles of homeownership (left) and landlord (right) rates

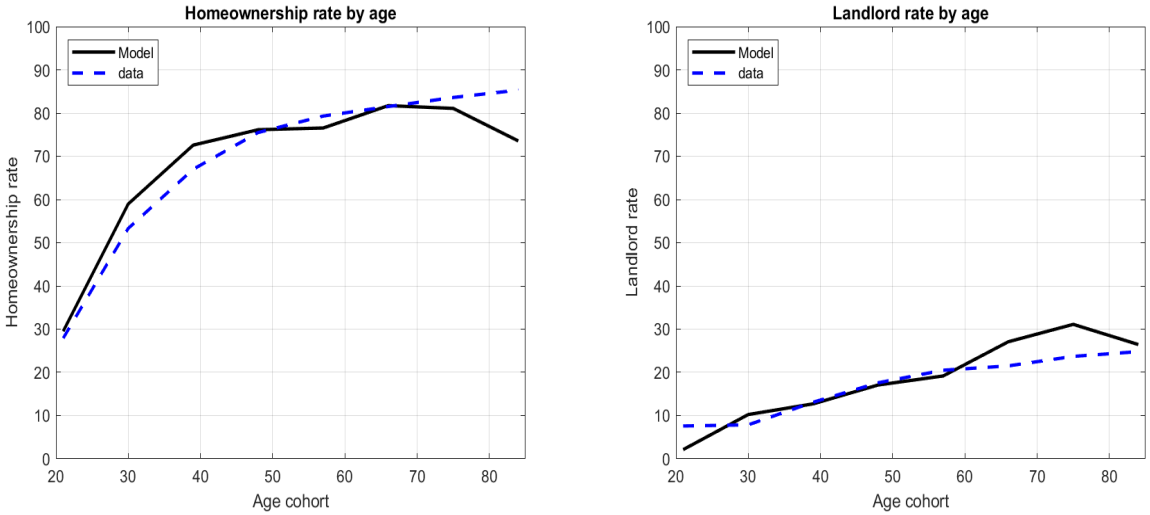


Figure 6: Homeownership (left) and landlord (right) rates by wealth quintile

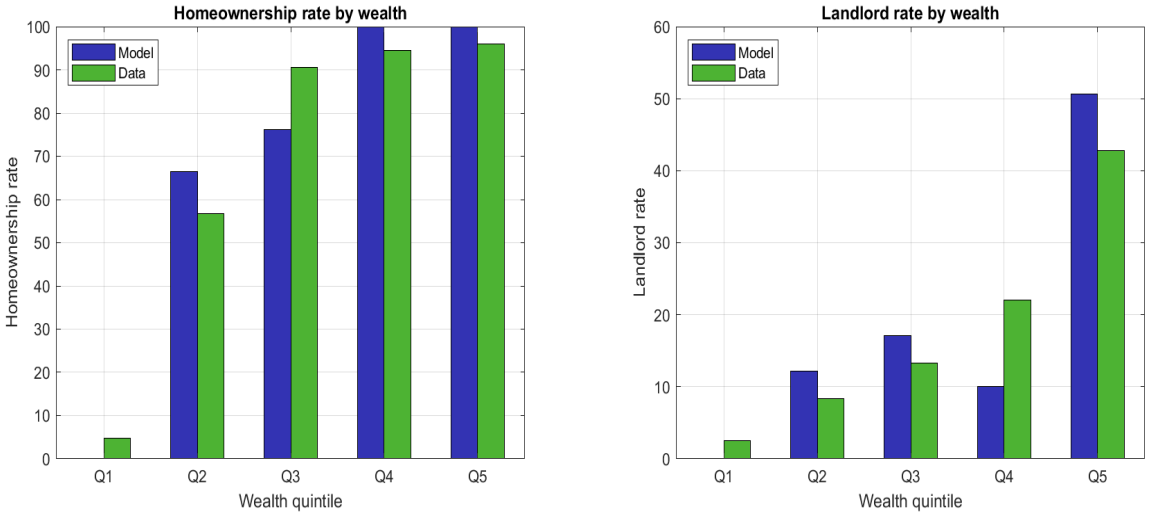


Table 7: Wealth distributions

	Net worth		**LTV ratio: borrower**	
	Data	Model	Data	Model
10th percentile	0.003	0.099	0.095	0.177
25th percentile	0.111	0.326	0.243	0.265
50th percentile	0.876	1.092	0.499	0.560
75th percentile	1.888	2.170	0.726	0.759
90th percentile	3.187	3.253	0.856	0.800

Response to a decrease in stamp duty rate. Our regression in Section 2 suggests that the transition rate to owner-occupied housing increases by 0.5 percentage points in response to a one percentage point reduction in the stamp duty rate. To see whether the model yields a similar marginal effect, we solve the model with a stamp duty rate one percentage point lower than its baseline value. That is, we keep parameter values unchanged from those reported in Tables 4 and 5 but reducing the value of ϕ_1^b from 4 percent to 3 percent, and re-solve for the new steady state. We find that the sum of O2O and R2O movers as a proportion of total households increases from 3.3 percent to 3.6 percent per annum. The 0.3 percentage points increase is comparable to the 0.5 percentage point marginal effect found in the empirical regression.

Wealth distribution. In Table 7, we report the distribution of households' net wealth and loan-to-value ratios in the baseline steady state, where net wealth is defined as the sum of net risk-free asset and housing asset. While the model overestimates the net wealth and loan-to-value ratios along the left tail, it matches the median values and upper percentiles relatively well.

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

5 Results

This section presents the quantitative impacts of removing stamp duty. In doing so, we first compare the steady state outcomes of the baseline economy with those of two counterfactual economies. In the first counterfactual we remove stamp duty and replace it with a property tax. In the second, we replace stamp duty with a consumption tax. Our counterfactual economies raise the same total tax revenue as our baseline economy with stamp duty. Revenue neutrality requires a recurrent property tax rate of 0.17 percent imposed

Table 8: Steady state comparisons: prices and quantities

	Baseline	**Counterfactual**	
		property tax	consumption tax
Price	2.631	2.654	2.676
Rent	0.324	0.316	0.307
Price-to-rent ratio	8.124	8.400	8.704
Housing stock (normalised)	1	1.025	1.040
Homeownership rate	0.682	0.705	0.715
Landlord rate	0.180	0.203	0.196

on the market value of housing assets owned or a consumption tax rate of 1.06 percent imposed on the consumption of non-durable goods.

5.1 Steady state comparisons

Prices and quantities. The steady state comparisons are presented in Tables 8 to 10. The first four rows of Table 8 compare the prices and quantities in the baseline and counterfactual steady states. In our baseline economy with stamp duty a seller receives the price of 2.631 for a unit of housing but a buyer pays an additional four percent in stamp duty. When stamp duty is replaced by a recurrent property tax, the steady state price a seller receives increases by 0.9 percent while the price paid by a purchasing household decreases by 3 percent. When a consumption tax replaces stamp duty, the selling price increases by 1.7 percent while the price paid by a buyer falls by 2.2 percent. The removal of a large transaction cost reduces the housing price paid by purchasing households and hence promotes home ownership. With a fixed population there is a decline in the number of renters and a reduction in equilibrium rents. The rental price decreases by 2.5 and 5.3 percent in the property and consumption tax cases, respectively. As the selling price increases, there is an increase in the supply of housing of 2.5 percent and 4.0 percent in the property tax and consumption tax cases, respectively. In moving to a consumption rather than a property tax, households substitute towards owner-occupied housing by a greater amount and this leads to a higher home ownership rate, housing price, and lower rents.

Home ownership and landlord rates. The last two rows of Table 8 report home ownership and landlord rates across simulations. The stamp duty imposes a transaction tax on home buyers which cannot be financed by borrowing. Hence the removal of stamp duty reduces the cost that a buyer pays for a home and promotes home ownership. Renters at the margin of becoming homeowners in the baseline steady state substitute towards home ownership as the policy reform makes it cheaper for them to do so. The home ownership rate increases by 2 and 3 percentage points in the property and consumption tax cases,

Table 9: Steady state comparisons: housing demand across age groups

Age group	Baseline	Counterfactual	
		property tax	consumption tax
	Homeownership rates (%)		
Young (under 35)	41.0	44.8	45.9
Middle (35-64)	75.6	79.2	80.2
Old (over 65)	78.1	77.3	78.0
	Housing asset demand		
Young (under 35)	0.11	0.14	0.14
Middle (35-64)	0.52	0.56	0.57
Old (over 65)	0.37	0.33	0.34

Notes: The top panel compares the homeownership rate for the young (under 35), middle (35-64) and old (over 65) between the baseline and the two counterfactual economies. The bottom panel show the demand for housing asset relative to the *baseline* total housing demand for each age group.

respectively. The removal of stamp duty also encourages investment in housing; the landlord rate increases by about 2 percentage points in the counterfactual economies.

Housing demand across age groups. Table 9 summarizes the differences in housing demand across different age groups across simulations. We classify households into three age groups: young (under 35), middle (36-64), and old (over 65). The top panel reports the home ownership rate by age. As noted earlier, there is slightly more substitution towards home ownership when stamp duty is replaced with a consumption tax. Also note that changes in the home ownership rate from the removal of stamp duty tend to vary by age. The home ownership rates of the young and middle age groups increase significantly while rates of the old remain relatively constant. This confirms that removing stamp duty helps younger, more credit-constrained households become homeowners by reducing the cost of purchasing and the size of required downpayments.

The bottom panel of Table 9 compares the demand for housing assets for each age group, normalised by the total housing assets in the baseline steady state. It reflects the change in the intensive margin of housing demand across different steady states. Similar to the patterns observed for the home ownership rate, households in the young and middle age groups increase their demand for housing while older households reduce their demand. It is worth noting that the demand for housing assets by older households decreases although their ownership rate remains roughly constant.

Housing transitions. Removing stamp duty significantly increases mobility in the housing market. Table 10 reports the effects of removing stamp duty on the housing turnover rate, housing transition rates of each type, and the fraction of mismatched households. In

Table 10: Steady state comparisons: housing turnover and transition rates (annual)

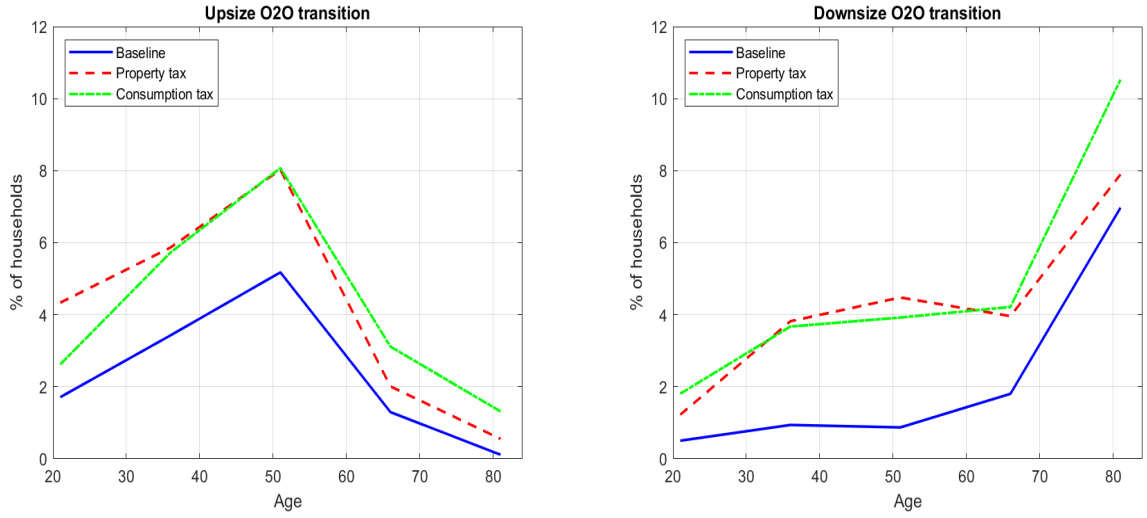
	Baseline (%)	**Counterfactual (%)**	
		property tax	consumption tax
Housing turnover rate	4.8	7.5	7.7
Transition rates			
O2O	2.3	4.4	4.5
R2O	4.9	6.8	7.0
O2R	1.0	1.7	1.4
R2R	12.1	10.2	10.5
Mismatched homeowners	11.0	2.7	2.4

the counterfactual economies, the annual housing turnover rate increases to around 7.5 percent from a baseline value of 4.8 percent, suggesting that the number of households buying a new house increases by more than 50 percent. The impacts on housing transitions rates are also significant. In particular, the O2O transition rate almost doubles and the R2O transition rate increases by roughly 40 percent in the counterfactual economies. Moreover, the policy change substantially reduces the number of homeowners who are mismatched (i.e., in a low housing preference state) from 11 percent to 2.7 percent so that removing stamp duty significantly reduces mismatch in the housing market.

Table 10 shows that the elimination of stamp duty leads to a substantial increase in the overall O2O transition rate. We can examine further how removing stamp duty affects different types of transitions along the life cycle. We define an upsize transition as one in which a household moves to a larger house and a downsize transition as one in which a household moves to a smaller house. Figure 7 displays the transition rates for both upsizing and downsizing O2O transitions in the baseline and counterfactual economies. Here, we define a transition rate as the number of O2O movers in a particular age group relative to the total number of households in that age group. A number of interesting observations arise. First, there are distinct life-cycle patterns that are common to all simulations. The upsize transition rate has an inverse-U shaped pattern with respect to age, while the downsize transition rate tends to increase with age, for O2O movers. Second, unsurprisingly, removing stamp duty consistently raises the transition rates for all age groups and for both types of transitions. Third, when comparing between the consumption and property tax counterfactual, we find that the consumption tax tends to raise mobility among older households while the property tax tends to raise mobility among younger households seeking to upsize.

Taxation. Figure 8 shows how the tax burden varies by age as stamp duty is removed. The left hand panel shows the percentage change in the average tax to income ratio of

Figure 7: Steady state comparison: upsize and downsize O2O transitions by age



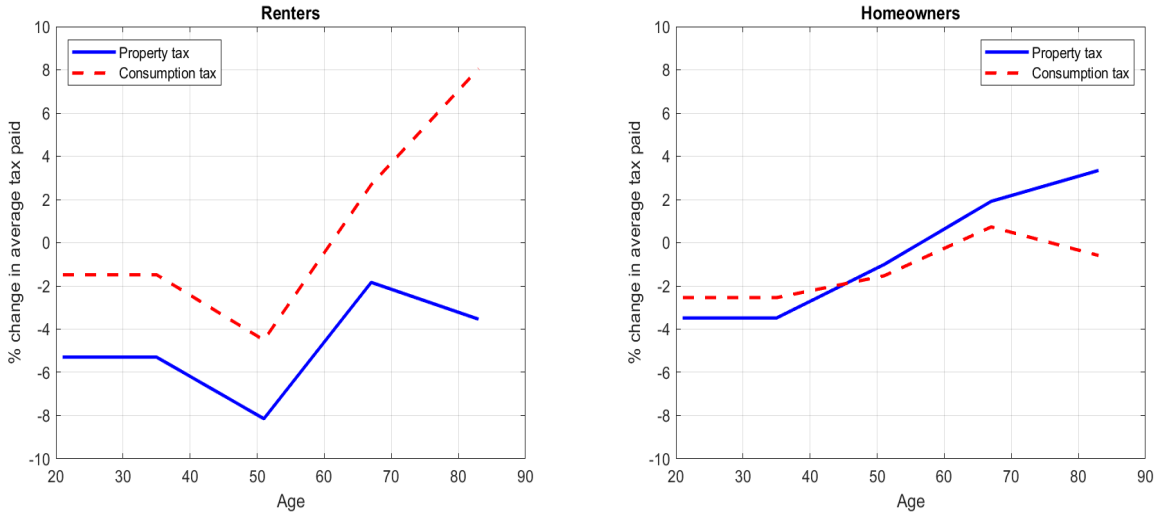
renters of a given age as we move to a consumption or a property tax. The right hand panel shows the corresponding outcome for homeowners. Note that this diagram captures the direct effect of changes in the tax system but also captures indirect effects associated with composition changes. In particular, the removal of stamp duty encourages more households to become homeowners and these households have slightly lower levels of labour income. If the economy replaces stamp duty with a property tax, the tax burden of renters declines across all age groups. For homeowners, there is a decline in tax burden of young homeowners but an increase in tax burden among older homeowners. In contrast, if the economy replaces stamp duty with a consumption tax, the tax burden of young renters and homeowners tends to decline while the tax burden of older renters tends to rise.

5.2 Steady state welfare

We follow the literature and evaluate steady state welfare using the notion of ex-ante consumption equivalent variation, *cev*. More precisely, for a newborn household with initial income draw z, we calculate the percentage change in her first period non-durable consumption in the baseline economy that would equate her expected discounted utility with that in the counterfactual economy. We then average across the stationary distribution of z to obtain the ex-ante *cev* measure. A positive *cev* indicates households would prefer to be born in an economy without stamp duty. That is, the policy reform increases steady state welfare.

Column (1) in Table 11 reports that removing stamp duty increases the average *cev* for newly born households by 6 and 4.6 percent when it is replaced with revenue neutral

Figure 8: Percent change in average tax burden by age due to the removal of stamp duty



property tax and consumption tax, respectively.[15] The size of welfare gain is smaller in the consumption tax case. One reason for this result is that although the steady state revenue is equated across experiments, the burden of taxation varies with age. In the consumption tax counterfactual, households pay a slightly larger amount of tax when young and less when old relative to the property tax case. This implies a relatively large present value of tax paid by newborns in the consumption tax when compared to the property tax case.

We decompose the welfare gain into two different sources. First, there is a *direct effect* that measures how much welfare would change as a result of a change in the tax system but with prices remaining at their initial levels. These results are presented in Column (2) of Table 11. The direct effect generates a welfare gain of 4.7 percent in the property tax case and 4.2 percent in the consumption tax case.

The second effect is the *general equilibrium* effect. Changes in the tax system alter the equilibrium house price and rent. We ask how much would welfare change if prices adjusted to their new levels but the tax system remains unchanged. The magnitude of this effect is reported in Column (3) of Table 11 and show a welfare increase of 2.2 percent and 5.5 percent in the property and consumption tax cases, respectively. Since our model is non-linear, the sum of the direct and the general equilibrium effect will not equal the total effect (Column (1) of Table 11). This is most apparent when examining the consumption tax case. It appears that the direct effect is responsible for the majority of the welfare gains when replacing stamp duty with a property tax. On the other hand, when replacing stamp duty with a consumption tax, it seems the general equilibrium effect provides a

[15] Cho, Morley, and Singh (2019) report that the average annual non-durable consumption of Australian households from the HILDA survey is AUD 28,007 (in 2012 AUD). Our back-of-the-envelope calculation thus suggests that the welfare gains over the life cycle are around AUD 3,248 and AUD 2,464 in monetary unit for property tax and consumption tax cases, respectively.

Table 11: Welfare effects on newborn households

	Main (1)	**Direct effect** (2)	**General eqm. effect** (3)
Property tax	0.060	0.047	0.022
Consumption tax	0.045	0.042	0.055

Notes: The table reports ex-ante *cev* for the following three cases: (1) our main experiment in which we change the tax system and prices and rents are determined in general equilibrium; (2) Direct effect: economy in which we change the tax system but retain initial prices and rents; and (3) General equilibrium effect: economy in which tax system is unchanged but we impose counterfactual prices and rents.

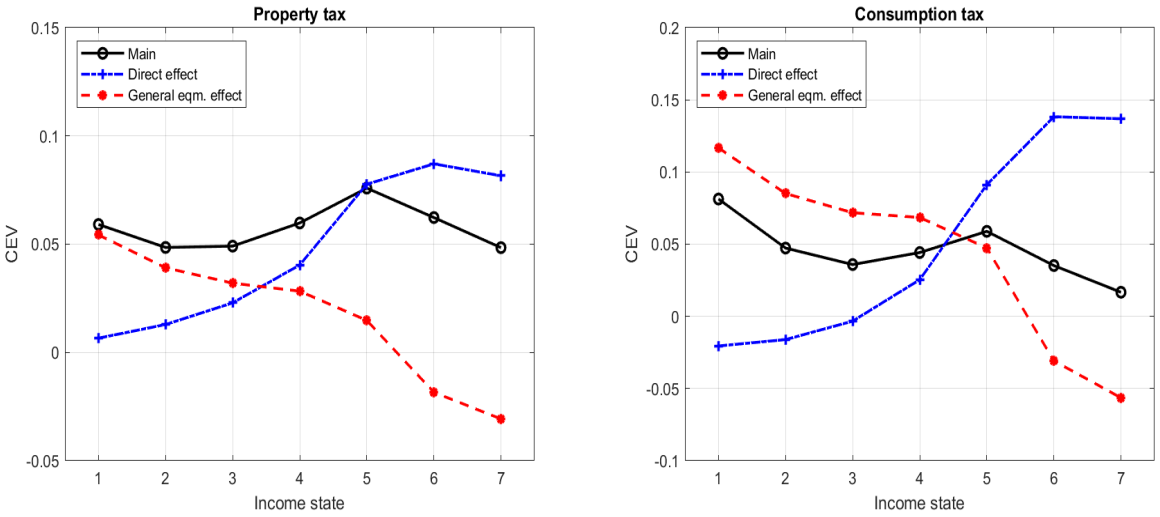
larger source of welfare gains.

Figure 9 shows the *cev* for newborn households as a function of their initial income state for the different policy experiments. The magnitude of the general equilibrium effect for different income levels is depicted by the red lines. When replacing stamp duty with either a property tax or a consumption tax the qualitative effect on prices is similar; prices increase and rents decrease when stamp duty is removed. Hence, it is unsurprising that the qualitative impact on welfare across income groups is similar. Households on lower income levels tend to gain the most from lower rental prices as they are more likely to remain in rental housing for longer. Households on the highest income levels tend to lose as house prices increase and they are more likely to purchase a house. Second, the magnitude of the general equilibrium effect is larger in the consumption tax case. This is consistent with the price changes being more dramatic when replacing stamp duty with a consumption tax than with a property tax.

The direct welfare impact of removing stamp duty while holding prices fixed in our simulations is given by the blue lines in Figure 9. Again, the qualitative features of removing stamp duty are similar regardless of whether it is replaced with a property or with a consumption tax. Broadly speaking, the direct effect of removing stamp duty benefits high income households the most while low income households gain the least or even lose in the consumption tax case, as high income households are more likely to become home owners and pay the stamp duty. When comparing the direct effect of the property tax relative to the consumption tax case we find that high income households prefer the consumption tax case while low income households prefer the property tax. This reflects that high income households bear a greater burden of the property tax while the share of tax paid by low income households is relatively higher in the consumption tax scenario.

The overall effect of replacing stamp duty in our simulations is given by the black lines in Figure 9. Here the relationship between welfare changes and income states is less clear as it mixes a general equilibrium effect that is decreasing in income and a direct effect that is increasing in income. Overall, most households entering the economy prefer replacing

Figure 9: Ex-ante *cev* for new born households across income states



Notes: The black lines represent our main counterfactual experiments in which we change the tax system and prices and rents are determined in general equilibrium. The blue lines plot the results from an experiment in which we change the tax system but retain initial prices and rents. The red lines plot the results from an experiment in which the tax system is unchanged but we impose counterfactual prices and rents.

stamp duty with a property tax. The exception are those households that enter the economy with the lowest income levels and are least likely to transition to home ownership.

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. An important difference is that in their model the majority of rental housing is supplied by competitive real-estate firms that satisfy a zero-profit condition. As a result, house prices and rents move in the same direction and the price-to-rent ratio is almost unchanged when tax policy is adjusted. Prices and rents both increase when stamp duty is reduced. Households enter the economy as renters. Hence, the increase in rent combined with an increase in income tax reduces welfare in their model.

In contrast, in our model, the equilibrium rent is determined by the demand and supply of rental properties where the supply of rental properties is determined by the amount of housing investment optimally chosen by households. As removing stamp duty favours home ownership, it reduces the rental demand and raises the demand for owner-occupied and investment housing, leading to an increase in equilibrium housing price and a fall in equilibrium rent, as shown in Table 8. This setup is consistent with the fact that in Australian housing market the provision of rental properties is dominated by households rather than institutional investors (Berry and Hall (2005)). The fall in rent plays an important role in generating the large welfare gains from replacing stamp duty with property or consumption taxes.

To illustrate this point, we examine an economy in which stamp duty is replaced by a

property or consumption tax. House prices are set to the equilibrium level in the relevant counterfactual economy. However, we set the rent at a level such that the price-to-rent ratio in the baseline economy is preserved so that rents and prices move together as in Kaas et al. (2020). Such an experiment gives an average *cev* of 2.5 percent in the property tax case and -0.1 percent in the consumption tax case. These welfare gains are much smaller than those obtained in our counterfactual experiments in which rents fall. Notably, in the consumption tax case, the removal of stamp duty leads to a small welfare loss, which is in line with their result.[16] Although our models vary in other dimensions, we view the differences in assumptions regarding entry into the rental market as critical for driving differences in welfare results.

5.3 Transition dynamics

Thus far, our analysis has focused upon welfare changes across different steady states. In this section we examine transitional dynamics. In doing so, we assume that the replacement of stamp duty by a property or consumption tax is unanticipated but that once the change is announced that households have perfect foresight regarding the behaviour of housing prices and rents in the transition to the new steady state.

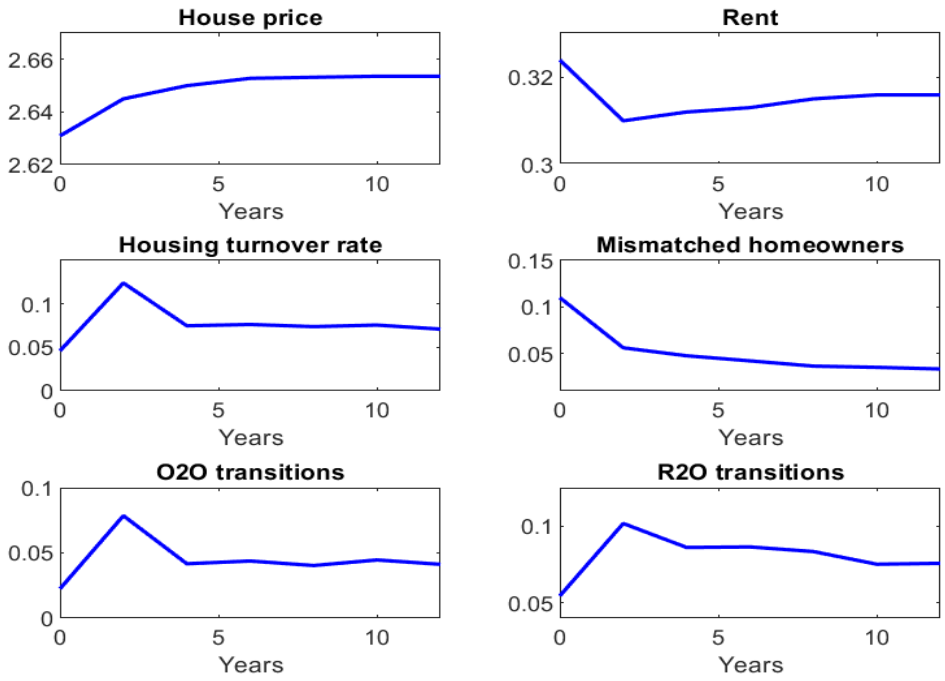
5.3.1 Evolution of aggregates along the transition

The transitional dynamics in the two counterfactual experiments cases are broadly similar, and therefore for brevity, we only present the property tax case. Figure 10 depicts the path of aggregate variables after the unexpected replacement of stamp duty with a property tax of 0.17 percent per annum. Note that the transition to the new steady state takes about 10-12 years (i.e., 5-6 periods). However, most of the effects take place in the first 4 years. The house price increases by 0.53 percent immediately after the reform, which is around 62 percent of the total increase in the house price, and then smoothly converges to the new steady state. The initial drop in rental price is large. In fact, the decline in rent overshoots by 4 percent in the first period then increases gradually to the new steady state level, which is 2.5 percent below the baseline steady state level.

The removal of stamp duty leads to a large increase in housing market activity as shown in the middle and bottom panels of Figure 10. The housing turnover rate, and the O2O and R2O transition rates all increase by more than double from their baseline steady state levels immediately after the reform. In subsequent periods they decline, but remain at levels significantly above the original steady state. This burst in housing market activity

[16]The consumption tax case is more comparable to the exercise in Kaas et al. (2020) in the sense that both consumption tax and income tax are borne by all households.

Figure 10: Transitional dynamics of the economy when replaced with property tax



is accompanied by a large drop in the proportion of mismatched homeowners, as many take the opportunity to relocate when stamp duty is removed.

5.3.2 Welfare analysis along the transition

We now quantify welfare gains and losses along the transition path across surviving households who are heterogeneous in terms of housing asset h, financial asset s, age a, labour earnings z, and mismatch status, λ. We measure welfare for each household i using an ex-post consumption equivalent variation, cev_i, defined as the percentage change in her non-durable consumption for the baseline economy in the period of the proposed policy reform that would equate her expected discounted utility in the baseline economy to that under the reformed economy.

Replacing stamp duty with a property tax leads to a median welfare loss of 0.5 percent. Moreover, just under half (49 percent) of households experience an improvement in lifetime welfare. In contrast, when stamp duty is replaced by a consumption tax, the economy experiences an overall welfare gain of 3.5 percent and 63 percent of households are better off when the reform is implemented. To understand these welfare differences across alternative tax reforms, we examine welfare outcomes across heterogeneous households.

Table 12 shows how the welfare effects vary across housing tenure status. In particular, renters (without housing assets) experience large welfare gains. Landlords and owner-

Table 12: Welfare over transition: by initial housing status

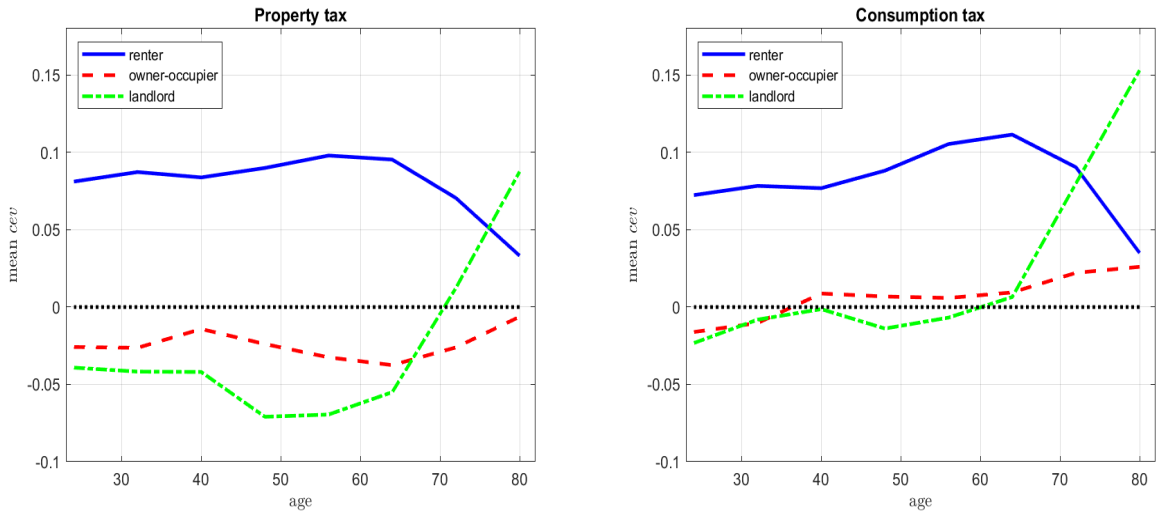
	Property tax			Consumption tax		
Tenure group	mean	median	$P(cev_i) > 0$	mean	median	$P(cev_i) > 0$
Renters	0.082	0.081	1	0.080	0.076	0.999
Homeowners	-0.024	-0.035	0.251	0.015	-0.006	0.460
Owner-occupiers	-0.025	-0.036	0.212	0.007	-0.010	0.421
Landlords	-0.022	-0.029	0.361	0.036	0.020	0.570
Mismatched	0.006	-0.004	0.478	0.057	0.044	0.721
Not mismatched	-0.029	-0.036	0.215	0.008	-0.011	0.419
Overall	0.010	-0.005	0.489	0.035	0.035	0.631

occupiers, on average, suffer welfare losses in the property tax experiment and experience small welfare gains in the consumption tax experiment. Unsurprisingly, renters gain from the removal of stamp duty as rents and the purchase price of houses inclusive of stamp duty (effective purchase price of houses) decline. The removal of stamp duty also makes it easier for renters to transition to home ownership as the effective downpayments are reduced. Households that own housing assets typically prefer a consumption to a property tax for two reasons. First, the housing price increase is larger in the consumption than property tax case and this benefits those who own housing assets. Second, the tax burden for homeowners is smaller in the consumption tax case, as the overall tax burden is shared more evenly across the whole population. Finally, we note that the welfare losses or gains for homeowners can be disaggregated into homeowners 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 11 shows how age and housing tenure status interact. When stamp duty is removed, the young and middle-aged renters tend to gain more than older renters who benefit from the reduced tax for a shorter period of time. Older landlords tend to gain from the removal of stamp duty regardless of whether a property or a consumption tax replaces it. These households have large housing assets and benefit from an increase in housing price and have a short life expectancy which implies a limited increase in tax burden. On the other hand, younger landlords tend to be worse off, particularly when stamp duty is replaced with a consumption tax. Although they may gain from a rise in housing price, their expected increase in tax burden is also larger. When examining households that are owner-occupiers, their welfare changes are relatively small although they prefer replacing stamp duty with a consumption tax rather than a property tax.

Table 13 reports how the welfare results for our property tax and consumption tax

Figure 11: Welfare by initial age and housing tenure status: property tax (left); consumption tax (right)



experiments vary by initial consumption, housing consumption, and net wealth. In general, the reforms favour poorer households with lower net wealth and those who tend to consume less of both housing and non-housing consumption. These households are more likely to be renters and tax reform 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.

We conclude that the difference in welfare implications between the property and consumption tax are due to the following reasons. Replacing stamp duty with a property tax leads to welfare gains for renters but welfare losses for the majority of homeowners. The property tax case features a greater tax burden and smaller house price increases for homeowners, which explains why they are worse off in this case. On the other hand, replacing stamp duty with a consumption tax generates welfare gains for a wider range of the population. Renters still gain from the lower prices and removal of stamp duty. Homeowners also have the potential to gain since house prices increase by more and the rise in their tax burden is less than in the property tax case.

5.4 Role of housing preference shock

The housing preference shock is a key element of our model that helps match housing transitions and the proportion of mismatched homeowners. This section discusses the importance of housing preference shocks on welfare. To do so, we re-calibrate a model without housing preference shocks. In the absence of the housing preference shock, λ only

Table 13: Welfare over transition: by initial consumption, housing consumption and net worth

	Consumption		Housing consumption		Net worth	
	mean	$P(cev_i) > 0$	mean	$P(cev_i) > 0$	mean	$P(cev_i) > 0$
			Property tax			
Bottom [0,25)	0.007	0.721	0.043	0.999	0.016	0.805
Middle [25,75]	-0.023	0.376	-0.041	0.246	-0.037	0.264
Top (75,100]	-0.050	0.173	-0.055	0.130	-0.042	0.208
			Consumption tax			
Bottom [0,25)	0.027	0.888	0.026	0.996	0.017	0.855
Middle [25,75]	0.008	0.547	0.004	0.459	-0.005	0.429
Top (75,100]	-0.023	0.253	-0.016	0.296	0.008	0.440

takes a single value and all other features of the model are maintained. The calibration follows a similar procedure as the baseline calibration in Section 4 except that the target moments do not include the O2O and R2O transition rates and the proportion of missed matched homeowners. See Appendix C for details.

We then conduct the same counterfactual policy experiments as in Section 5.1. The first column of Table 14 reports a selected set of results for the baseline steady state without a housing preference shock. These differ slightly from the results reported 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 outcomes for property tax and consumption tax steady states, respectively.

We highlight three main findings. First, the effects of replacing stamp duty with a property tax or consumption tax on house price, rent and home ownership are similar to our original calibration both qualitatively and quantitatively. Second, the housing turnover and O2O transition rates are significantly lower than in the baseline economy with the housing preference shock. As discussed earlier, these rates are difficult to match to the data without a housing preference shock. Third, the steady state welfare gain is smaller relative to the welfare gain in the version with the housing preference shock. Ex-ante welfare gains are 4.4 percent and 3.9 percent in the property and consumption tax experiments without preference shocks, respectively. This compares to welfare gains of 6.0 percent and 4.5 percent when considering preference shocks. We conclude that if we ignore preference shocks, we would underestimate the welfare gains from tax reform by somewhere between 15-25 percent.

Table 14: Steday state outcomes without housing preference shock

	Baseline	**Counterfactual**	
		property tax	consumption tax
House price	2.639	2.658	2.684
Rent	0.322	0.315	0.305
Price-to-rent ratio	8.188	8.429	8.789
Frac. of homeowners	0.693	0.704	0.719
Frac. of landlords	0.171	0.181	0.181
Homeownership under 35	0.390	0.442	0.467
Homeownership 36-65	0.768	0.770	0.807
Homeownership over 65	0.786	0.782	0.773
Housing asset held under 35	0.098	0.112	0.130
Housing asset held 36-65	0.532	0.532	0.554
Housing asset held over 65	0.370	0.356	0.316
Housing turnover rate	0.040	0.062	0.064
O2O transition rate	0.016	0.033	0.033
R2O transition rate	0.050	0.063	0.070
Ex-ante *cev*	–	4.4%	3.9%

Notes: The table presents the steady state moments and welfare for a model economy without housing preference shocks. The baseline economy has been re-calibrated and re-simulated to find the new equilibrium house price and rent. The housing turnover rate, O2O and R2O transition rates are annual figures.

6 Conclusion

We have examined the effects of removing housing transaction taxes in a general equilibrium overlapping generations model with heterogeneous agents. Replacing stamp duty with revenue neutral property and consumption taxes increases house prices, decreases rents, and increases the home ownership rate. Eliminating stamp duty also leads to a substantial reallocation of housing assets across different age groups. As stamp duty is removed, younger households are more likely to own homes and increase the size of the homes that they purchase. Older households on the other hand reduce their housing demand as the policy reform allows them to move to smaller houses more easily.

Our steady state results support a common view that stamp duty is an inefficient form of taxation. There are significant 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 price changes (rental and purchase prices), changes in the burden of taxation over the life cycle, and a reduction in mismatch in the housing market. However, when we examine the transition dynamics we find that existing households prefer replacing stamp duty with a *consumption tax* but would rather retain stamp duty than replace it with a property tax. This contrasts with the preferences of newborn households. This reflects that existing households typically own

a significant amount of housing assets and benefit more from a consumption tax which leads to larger housing price increases and a lower tax burden for homeowners than the consumption tax.

Our model abstracts from elements that may be important in reality. For example, some argue that 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 taxes. 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 economic downturns. This effect is beyond the scope of our model that lacks aggregate uncertainty. Finally, our model is not rich enough to allow us to consider taxation of land separately from taxing the value of improvements to the 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 if it reduces the incentive to improve land.

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Appendix for Online Publication

A Household Income and Labour Dynamics Australia

We compute housing transitions from the Household Income and Labour Dynamics Australia (HILDA) survey. The HILDA survey is a longitudinal survey that contains a nationally representative sample of Australian households. Since the release of its first wave in 2001, the survey is conducted every year, and to this date, Wave 17 is completed and available to researchers. A total of 7,682 households, consisting of 19,914 individuals participated in Wave 1, and from Wave 11 onwards, additional 2,153 households have been added to the survey. As explained in the text, the survey contains information on homeownership status and the year they moved into their current address. We construct the four types of household moves as follows:

$$O2O_{i,t} = \begin{cases} 1 & \text{if } \; m_i = t \;\; \& \;\; own_{i,t} = 1 \;\; \& \;\; own_{i,t-1} = 1 \\ 0 & \text{otherwise} \end{cases}$$

$$R2O_{i,t} = \begin{cases} 1 & \text{if } \; m_i = t \;\; \& \;\; own_{i,t} = 1 \;\; \& \;\; own_{i,t-1} = 0 \\ 0 & \text{otherwise} \end{cases}$$

$$O2R_{i,t} = \begin{cases} 1 & \text{if } \; m_i = t \;\; \& \;\; own_{i,t} = 0 \;\; \& \;\; own_{i,t-1} = 1 \\ 0 & \text{otherwise} \end{cases}$$

$$R2R_{i,t} = \begin{cases} 1 & \text{if } \; m_i = t \;\; \& \;\; own_{i,t} = 0 \;\; \& \;\; own_{i,t-1} = 0 \\ 0 & \text{otherwise} \end{cases}$$

where t is year and m_i is the year in which the household i moved into her current dwelling. The variable $own_{i,t}$ is an indicator which assigns one if household i lived in her own house in year t.

Sample selection. Our initial raw sample contains every household and its members pooled from Wave 1 to Wave 17. The total number of observations of the initial raw dataset equals 709,733. We keep individuals who are the eligible member of current household. To be consistent with the model's age restriction, we drop those households who are younger than 21 and older than 84. Since our analysis only requires one member from each household, we drop child under 15, dependent student, non-dependent child, other family members who are not related to a couple or involved in a parent-child relationship. Information on housing tenure is important for our analysis. We thus drop those households with missing information on such a variable. Households who reported the value of their housing less than AUD 10,000 or whose value has been top-coded are also dropped. In total, our sample consists of 10,491 households with 67,871 observations.

B Calibration of housing preference shock

The HILDA survey asks respondent the following question:*"If you have moved during the last 12 months, what were the main reasons for leaving your previous address?"*. The answers to this question from the survey respondents include the reasons related to many different aspects including work, health, preferences, family, size/quality of house. The list of reasons is provided below:

> to start a new job; decided to relocate own business; seeking change of lifestyle;
> work transfer; to start own business; decided to relocate own business;
> health reasons; to be nearer place of work; to be close to place of study
> to be closer to friends and/or family
> to get married/moved in with partner; marital/relationship breakdown;
> to follow a spouse or parent/whole family
> to get a place of my own/our own; to live in a better neighbourhood;
> to be closer to amenities/services
> to get a larger/better place; to get a smaller/less expensive place;

For our calibration of the housing preference shock, we focus on owner-to-owner moves and isolate the reasons for moving listed above into preference and size/quality categories. Our main concern is that the reasons for moving can be correlated each other. For example, houses in an area with better neighbourhood are likely to have a better quality and more expensive. In the meantime, it can be a household's preference to move to an area with better neighbourhood. We classify the reasons into preference and size/quality categories when we are objectively certain about the classification. For the preference category, we include *'seeking change of lifestyle'* and *'to be closer to friends and/or family'*. For the size/quality category, we consider *'to get a larger/better place'* and *'to get a smaller/less expensive place'*. The survey respondents are allowed to provide multiple reasons. When we see the multiple answers that involve both preference and size/quality reasons, we only count the response for the size/quality category.

To validate that our classification is well suited for calibration of the housing preference shock, in Table 3 from Section 2, we reported the median distance moved, the median percentage change of housing value, percentage of households with positive change in house value, the median percentage change in disposable income, and the median age. Our conjecture is that households who moved due to the preference reason would have moved longer distance, moved into a house with a smaller increase to the housing value, and experienced smaller changes to their income. Encouragingly, Table 3 shows that homeowners who moved into a new owner-occupied house due to the preference reasons typically moved longer distance. The median distance moved for households in the preference category are 33 kilometers for the seeking change of lifestyle reason and 105 kilometers for

the to be closer to friends and family reason. In contrast, the median distance moved for the two reasons in the size/quality category are only 4 and 6 kilometers. Also, homeowners who moved due to the preference reason experienced smaller increase in their housing value as well as income relative to households who moved to live in better and larger houses. Finally, households in the preference category tend to be older than those who moved to live in better and larger houses but they are slightly younger those who moved to get smaller or less expensive houses.

A key moment which we calculate using information on reasons for moving is the percentage of O2O movers due to mismatch. Mismatched homeowners in our model is defined as homeowners in the low housing preference state. In the data, the percentage of O2O movers due to mismatch is obtained the following procedure:

1. Run a logit regression for the sample that contains O2O movers who moved due to the preference and size/quality reasons. The dependent variable is a binary variable which assigns one if a household moved due to the size/quality reason. For control variables, we include age, education, distance moved, housing value, marital status, the number of kids, and the reasons for moving other than the four reasons included in the preference and size/quality categories.

2. Compute predicted probabilities for each household. We obtain the sum of these predicted probabilities and divide the sum by the total number of observation to get the fraction of households who moved due to the size/quality reason.

As reported in the main text, O2O moves due to mismatch in housing preferences in the data accounts for 27.3% of the total O2O transitions and the remaining 72.7% are due to the desire to upgrade or downgrade their housing quality or size.

Table B–1: Logit regression result

	Coefficient	**Std. error**
Demographics		
Age	-0.025	(0.007)
Distance moved	-0.003	(0.001)
Housing value	0.000	(0.000)
Living in big city	0.929	(0.188)
Marital status	-0.107	(0.215)
Number of kids	0.170	(0.100)
Reasons for moving dummies		
Start a new job	-2.172	(1.099)
Start own business	-0.500	(0.907)
Reallocate own business	-1.644	(0.878)
Look for work	-1.852	(1.343)
Health reasons	0.067	(0.437)
Nearer to workplace	-0.948	(0.495)
Close to place of study	-1.618	(0.931)
Better neighborhood	0.494	(0.289)
Close to amenities	-0.079	(0.457)
Get married	-0.391	(0.888)
Follow spouse or parents	1.352	(1.719)
Constant	2.221	(0.487)
Psuedo R^2	0.1959	
Number of observations	949	

C Calibration of model without housing preference shock

This section describes the calibration of the model without the housing preference shock. Tables B–2 and B–3 contain information on internally calibrated parameters and target moments, respectively. A selected set of non-targeted moments are reported in Table 14 in the main text. The calibration suggests that while the housing preference shock has a strong influence on the housing transition rates, it does not have a significant impact on other moments.

Table B–2: Internally calibrated parameters: Model without housing preference shock

	Parameter	**Value**
λ	Utility premium for homeowners	1.08
h_{min}	Minimum housing size for owning	0.62
ϑ	Bequest intensity	15
ζ	Fixed cost of being a landlord	0.014
β	Discount factor	0.880
α	Share of non-durable consumption	0.768
ψ_1	Scale parameter in housing production	4.26

Table B–3: Target moments: Model without housing preference shock

Target Moments	**Model**	**Data**	**Source**
Avg. homeownership rate	68.5%	69.3%	SIH 13-14
Avg. H.O. rate under 35	39.0%	37.4%	SIH 13-14
Avg. homeownership rate for 65+	78.6%	84.0%	SIH 13-14
Avg. landlord rate	17.1%	17.8%	SIH 13-14
% of mortgaged homeowners	46.0%	49.0%	SIH 13-14
Median rent-to-income ratio	0.21	0.24	SIH 13-14
Median housing wealth	1.64	1.58	SIH 13-14

D Computational details

For computation of steady state and transitional dynamics, we closely follow computational techniques used in Cho, Li, and Uren (2019). In this section of Appendix we provide details on how we find the stationary equilibrium as well as our algorithm for transitional dynamics.

State and control variables. The state of a household in every period is determined by five state vectors including savings s_{-1}, housing asset h_{-1} obtained in previous period, the realisations of income shock z and housing preference shock λ, and age a in current period. The control variables include savings s, housing asset h, housing services $\tilde{h}$, and non-durable consumption c. We discretize the housing asset into 12 discrete sizes, $h \in \{0, h_{\min}, ..., h(12)\}$. The housing grids are set such that they are finer at smaller house sizes. Note that there is a minimum size of housing asset which is calibrated internally as explained in the main text. While the housing services grid for homeowners is the same as the housing asset grid, housing services grid for renters are given by $h^{\text{rent}} \in \{h^{\text{rent}}(1), h^{\text{rent}}(2), h^{\text{rent}}(3), h(1), ..., h(6)\}$, with $h^{\text{rent}}(1) = h(1)/3$, $h^{\text{rent}}(2) = h(1)/2$ and $h^{\text{rent}}(3) = 3h(1)/4$. The smaller sizes are added to allow renters to consume housing services of a size smaller than the minimum housing size available for owner-occupied housing. The risk-free asset is discretized into 99 grids. Households are allowed to choose the maximum possible borrowing for each housing size, $s = -(1-\theta)ph$. Between a pair of these maximum borrowing points, we allow for four equally spaced grids so that it gives more flexibility in choosing the size of mortgages. For positive values of s, we employ a power grid where the maximum value of the risk-free asset is capped at \$500,000.

Computation of stationary equilibrium. The stationary equilibrium is computed using constant prices and rents. We start first by guessing these two equilibrium objects. Given price and rent, we compute the optimal policy and value functions for the last period $A = 32$. Once the optimal policy and value functions for the final period is obtained, we solve the household problem for all other periods using backward induction. Once we obtain policy functions, we simulate the economy with 10,000 households until a stationary distribution of households over the state space is achieved. Each households starts their life-cycle with zero savings and housing assets. In the beginning of each period, households draw income shocks and housing preference shocks, make rent/stay/move decisions, and choose consumption, housing services, housing stock and saving/borrowing. At the end of each period, households receive an age-dependent death shock. We assume that each age-dependent death shock follows a binomial distribution. Households

exit the economy with certainty after 32 periods. If a household survives, he continues to make choices and we simulate the optimal behaviour of these households forward using the policy functions. If a household dies, he is replaced by a newly born household who starts his life-cycle from the following period. The stationary distribution is obtained when the age distribution, average savings, average income and average housing asset across 10,000 households are all stabilized. Finally, we iterate the whole process until the market clearing price and rent that clears housing and rental markets are found.

Computation of transition dynamics. Define a vector $w_t = [p_t, p_t^r]$. Recall that μ_t captures the ergodic distribution in the stationary equilibrium at time t. The baseline economy is when $t = 0$ and the steady state in the counterfactual economy corresponds to $t = T$. Solving for the transition dynamics requires us to find the transition paths of the equilibrium house price and rent for each t. We employ an algorithm from Cho et al. (2019) which is summarised as below:

Algorithm:

1. Choose the length of the transition phase, T. Choosing a large number increases the computational burden. We choose $T = 12$, i.e., the transition to the new steady state finishes within 24 years.

2. Guess a sequence of housing prices and rents $\{p_t, p_t^r\}$ for $t = 1, ..., T-1$. Note that $\{p_T, p_T^r\}$ are set to the housing price and rent in the steady state of the counterfactual economy.

3. Given the guessed sequence of $\{p_t, p_t^r\}$, solve backward for the value function V_t (taking as given V_{t+1}), starting from $T-1$. Note that V_T is the steady state value function for the counterfactual economy, which is known.

4. Given the value functions $V_t, t = 1, 2, \ldots, T$, find the market clearing housing prices and rents for each period $t = 1, 2, \ldots, T-1$. The computation for finding the market clearing prices in period t follows the procedure described earlier for computing the equilibrium prices in a stationary equilibrium but the simulation only involves simulating households one period forward from the distribution in $t-1$ (μ_0 is the stationary distribution in the baseline economy). This gives a sequence of market clearing prices $\{\hat{p}_t, \hat{p}_t^r\}$ and corresponding distribution $\hat{\mu}_t$ for each period $t = 1, ..., T-1$.

5. Compare $\{\hat{p}_t, \hat{p}_t^r\}$ and $\{p_t, p_t^r\}$. If they differ, go back to Step 2 to update the guessed price sequence and repeat Step 3 and 4, until convergence in prices is achieved.

6. Calculate the distribution in period T, $\hat{\mu}_T$, and compare it with the stationary distribution in the counterfactual economy. Increase T if the two distributions differ.