Online Appendix

Stamping Out Stamp Duty: Housing Mismatch and Welfare

Yunho Cho, Shuyun May Li, and Lawrence Uren

A Data and empirical work

A.1 Housing transition rates

We compute housing transitions using the Household Income and Labour Dynamics Australia (HILDA) survey which is a longitudinal survey that is nationally representative. The survey started in 2001, and is conducted on an annual basis. A total of 7,682 households, consisting of 19,914 individuals, participated in Wave 1, and from Wave 11 onwards, an additional 2,153 households were added to the survey. As explained in the text, the survey contains information on home ownership 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 household i moved into their current dwelling. The variable $own_{i,t}$ is an indicator equal to one if household i lived in their own house in year t.

Sample selection. Our sample consists of households aged between 21 and 84. Information on housing tenure is important for our analysis. We drop households with missing information on such a variable. Households who report the value of their housing as 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.

A.2 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 include 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; 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; seeking change of lifestyle;
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 mismatch and size/quality categories. Our main concern is that the reasons for moving can be correlated with each other. For example, houses in an area with better neighbourhood may be of higher quality and more expensive. We classify the reasons into "mistmatch" and "size/quality categories" when we are objectively certain about the classification. For the mismatch 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 mismatch and size/quality reasons, to be conservative, we only count the response for the size/quality category.

To verify that our classification is well suited for calibration of the housing preference shock, in Table 2 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 mismatch reason would have moved longer distance, moved into a house with a smaller increase in housing value, and experienced smaller changes to their income. Encouragingly, Table 2 shows that homeowners who moved into a new owner-occupied house due to the mismatch reasons typically moved longer distances. The median distance moved for households in the mismatch category are 33 km for the "seeking change of lifestyle" reason and 105 km 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 km. Also, homeowners who moved due to the mismatch reason experienced smaller increase in their housing value and income relative to households who moved to live in better and larger houses. Finally, households in the mismatch 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 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 are 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:

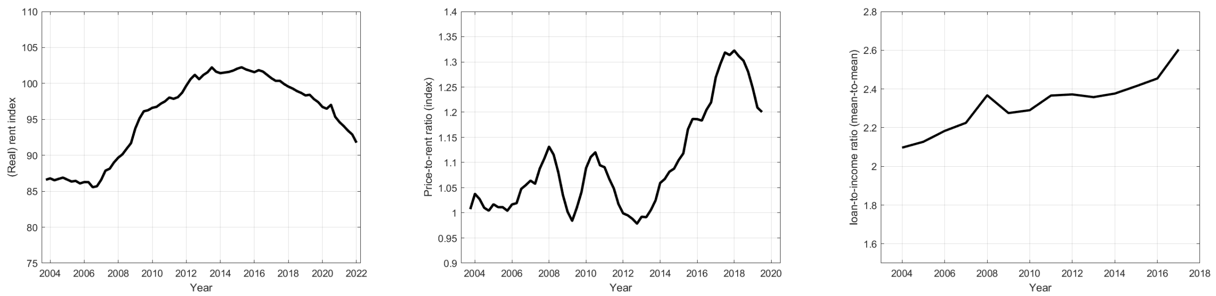
1. Estimate a logit regression for the sample that contains O2O movers who moved due to the mismatch and size/quality reasons. The dependent variable is a binary variable which assigns one if a household moved due to the size/quality reason. For control variables, we include age, education, distance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

2. Compute the predicted probabilities of moving for a size/quality reason for each household not already classified. 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 account for 27.3% of all O2O transitions in the data. The remaining 72.7% of O2O transitions are due to the desire to upgrade or downgrade their housing quality or size.

A.3 Rent index, price-to-rent ratio, and loan-to-income ratios over time

Figure A–1: Rent index, price-to-rent ratio over time, and loan-to-income ratio over time



(a) Rent index (b) Price-to-rent ratio (c) Loan-to-income ratio

Source: Australian Bureau of Statistics (a); Australian Bureau of Statistics (b); HILDA

Table A–1: Logit regression result

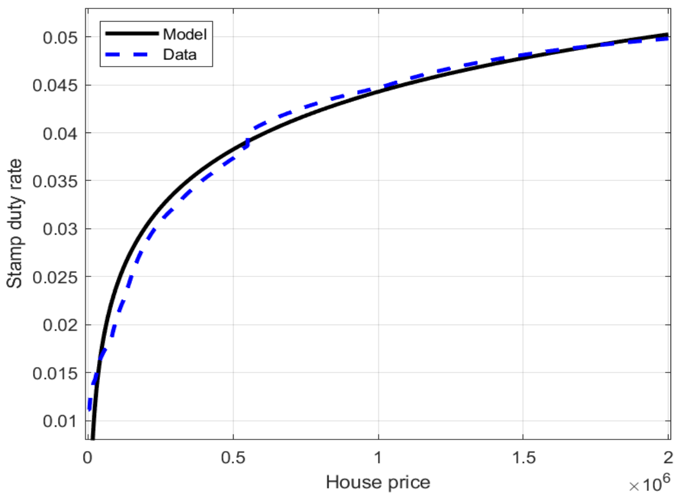
	Coefficient	**Std. error**
Demographics		
Age	-0.025	(0.007)
Distance moved	-0.002	(0.001)
Housing value	0.000	(0.000)
Living in big city	0.928	(0.188)
Education	-0.107	(0.108)
Marital status	-0.105	(0.215)
Number of kids	0.168	(0.100)
Reasons for moving dummies		
Start a new job	-2.172	(1.099)
Start own business	-0.503	(0.906)
Reallocate own business	-1.644	(0.878)
Look for work	-1.850	(1.342)
Health reasons	0.068	(0.437)
Nearer to workplace	-0.949	(0.495)
Close to place of study	-1.619	(0.931)
Better neighborhood	0.492	(0.289)
Close to amenities	-0.080	(0.457)
Get married	-0.392	(0.888)
Follow spouse or parents	1.350	(1.719)
Constant	2.218	(0.487)
Psuedo R^2	0.1964	
Number of observations	950	

Figure A–1 depicts the rent index, price-to-rent ratio, and loan-to-income ratios over time. The rent index in the left panel has been deflated using the headline Consumer Price Index, where we obtain both indices from the ABS. The price-to-rent ratio is calculated using the price and rent indices. The price index is also sourced from the ABS. For the loan-to-income ratio, we take a ratio of the average remaining mortgage balances for homeowners to their disposable income from HILDA.

A.4 Approximation of progressive stamp duty rates

To estimate the stamp duty function, we construct a national stamp duty schedule, as represented by the dashed line in Figure A–2. This is obtained as follows: we consider a vector of house prices, and for each house price, we calculate the effective stamp duty rates in each state based on each state's stamp duty schedule and weigh them by population shares to obtain the national stamp duty rate. We then use the vector of house prices and the corresponding stamp duties implied by the national stamp duty schedule to estimate parameters in the stamp duty function via least squares estimation. The fitted stamp duty schedule implied by the estimated stamp duty function is represented by the solid line in Figure A–2.

Figure A–2: Stamp duty rates: Model vs. Data



B Definition of a Stationary Equilibrium

Our state vector, $x \equiv (a, z, s_{-1}, h_{-1}, \lambda)$, describes age, earnings, financial assets, housing assets, and housing preference state of a household. Note, $a \in \mathcal{A} \equiv \{1, ..., A\}$, $z \in \mathcal{Z}$, $s \in \mathcal{S} \subset \mathbb{R}$, $h_{-1} \in \mathcal{H} \subset \mathbb{R}_+$ and $\lambda \in \Lambda \equiv \{1-\xi, 1, 1+\xi\}$. A stationary equilibrium consists of value functions $\{V(x), V^{\text{renter}}(x), V^{\text{stayer}}(x), V^{\text{mover}}(x)\}$, household decision rules

$\{c(x), s(x), h(x), \tilde{h}(x)\}$, prices $\{p, p^r\}$, an aggregate housing stock $\overline{H}$, and a distribution on X, denoted as μ, such that:

1. Households optimise so that the value functions $\{V(x), V^{\text{renter}}(x), V^{\text{stayer}}(x), V^{\text{mover}}(x)\}$ and decision rules $\{c(x), s(x), h(x), \tilde{h}(x)\}$ solve household's problems (9)-(12) for the equilibrium $\{p, p^r\}$.

2. The aggregate housing stock evolves according to (13) with $H = H_{-1} = \overline{H}$.

3. The prices p and p^r adjust to ensure equilibrium in the purchase and rental market:

$$\int_X h(x) d\mu = \overline{H} \tag{B.1}$$

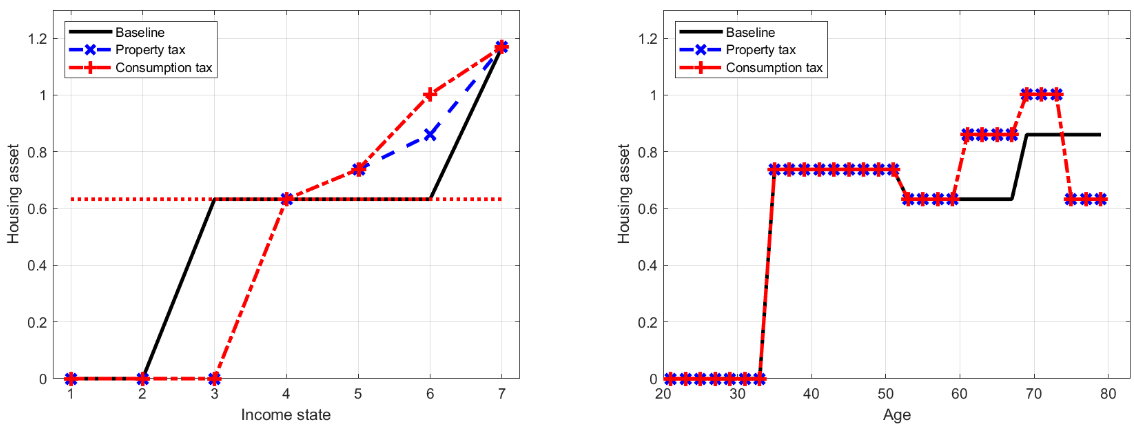
$$\int_X \left(\tilde{h}(x) - h(x)\right) d\mu = 0 \tag{B.2}$$

4. The distribution μ is stationary and consistent with shock processes and household decisionmaking.

C Additional quantitative results

C.1 Illustration of (S,s) decision rules

Figure C–3: (S,s) decision rules for housing asset

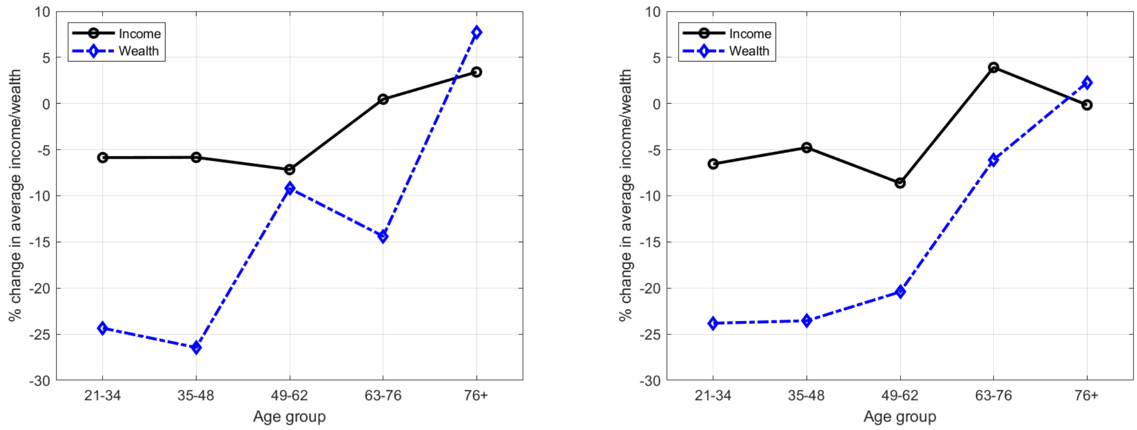


Notes: The left panel depicts the choice of housing asset h as a function of stochastic income states z, for given $(a, s_{-1}, h_{-1}, \lambda)$, where age $a = 4$, $\lambda = \lambda_H$, s_{-1} and h_{-1} are close to the median levels of financial and housing assets in the baseline steady state. The dotted red line represents the existing level of housing asset, h_{-1}. The other three lines represent choices of housing asset in our baseline and two counterfactual economies, respectively. The right panel depicts the simulated paths of housing asset in three economies for a household born with zero wealth and income state 3, provided that the household survives to age 84 and experiences identical income shocks in the three economies.

These diagrams illustrate the impact on housing choices of larger transaction costs due to stamp duty. In the left-panel, when stamp duty is present we see that if a household's current income is state 3 through to state 6, there is no change in their housing choice. In contrast, when stamp duty is replaced with a property or consumption tax, housing choice is only unchanged if the household is allocated to income state 4. If income is below this level, the household will downsize and if income exceeds this level they will upsize. Similarly, in the right panel we show a simulated path of housing choices under different tax systems for a household that experiences the same set of shocks. In the baseline case, the households makes three housing transactions over their life cycle. In the property and consumption tax cases the households makes five transactions.

C.2 Steady state comparisons: income and wealth of renters

Figure C–4: Percentage changes in income and wealth of renters by age



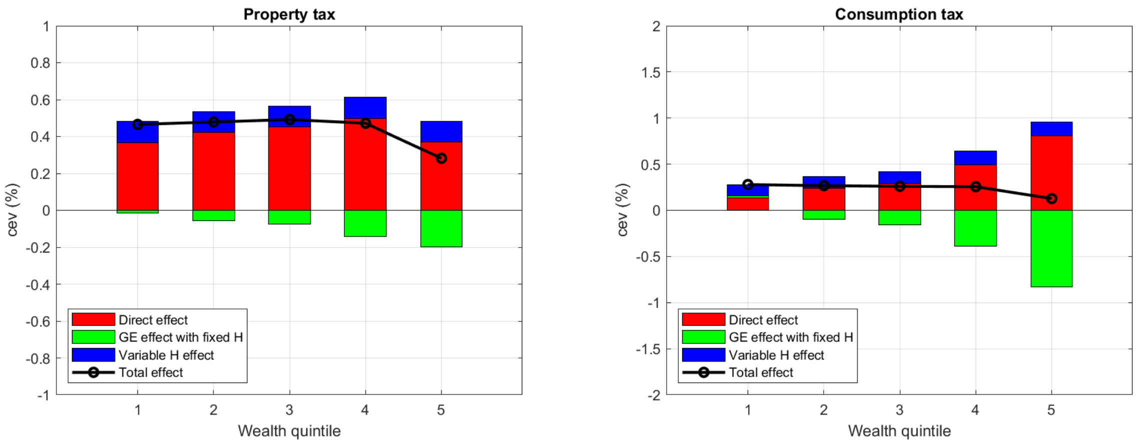
(a) Property tax (b) Consumption tax

Here, we compare the income and wealth of renters in the counterfactual economies to the baseline economy. Figure C–4 plots the percentage changes in average income and wealth of renters in each age group for the property tax case (panel (a)) and consumption tax case (panel (b)). We highlight two observations. First, the percentage changes are negative for most age groups, suggesting that on average renters in the counterfactual economies have lower income and wealth. This reflects a change in the composition of renters when stamp duty is removed. Second, the drop in income and wealth is the largest for renters under age 35, suggesting that the compositional change is the largest for younger renters. This is consistent with the result discussed in the main text that young households experience a larger increase in home ownership as stamp duty is removed.

C.3 Steady state welfare decomposition by initial wealth

Figure C–5 shows the welfare decomposition for newborn households in differing initial wealth quintiles. Here, initial wealth refers to the combined financial and housing wealth endowment. It is constructed in a manner similar to Figure 8. The average welfare changes from removing stamp duty are positive for all initial wealth quintiles. The welfare gains are relatively flat across wealth quintiles, though it is smallest for households with the highest initial wealth. The direct effect accounts for most of the welfare gains in the property tax case, while the general equilibrium effect also plays an important role in the consumption tax case especially for households with higher initial wealth. The general equilibrium effect arising from a variable housing supply is relatively small.

Figure C–5: Welfare changes by wealth group: *cev* for newborn households across wealth quintile



C.4 Steady state results with alternative housing supply elasticities

Our quantitative analysis in the main body of the paper is based on a housing supply elasticity of $\varepsilon = 2$. For robustness, we examine the steady state results with $\varepsilon = 0$ (fixed housing supply) and $\varepsilon = 4$ (highly elastic supply). We report the results in Table C–2.

There are three main observations. First, the price a seller receives increases by more when housing supply is less elastic while rental price is not sensitive to housing supply elasticity. With more elastic housing supply, equilibrium housing stock increases by a greater amount. Second, the substantial changes in household mobility indicators including the housing turnover rate, the O2O and R2O transition rates, and the fraction of mismatched homeowners are largely insensitive to the choice of ε. Finally, there is a small steady state welfare gain in all cases, with a larger ex-ante *cev* in the property tax case across all elasticity values.

Table C–2: Steady state comparison: alternative housing supply elasticities

	Baseline	Property tax			Consumption tax		
		$\varepsilon = 0$	$\varepsilon = 2$	$\varepsilon = 4$	$\varepsilon = 0$	$\varepsilon = 2$	$\varepsilon = 4$
Prop./Consump. tax rate (%)		0.207	0.204	0.212	1.58	1.60	1.65
Price	2.575	2.613	2.604	2.597	2.642	2.623	2.615
Rent	0.356	0.351	0.351	0.351	0.341	0.340	0.339
Price-to-rent ratio	7.225	7.437	7.424	7.409	7.748	7.717	7.714
Home ownership rate (%)	68.1	68.9	69.7	68.2	68.4	70.1	69.9
Share of rental housing (%)	16.6	14.8	15.1	15.7	14.6	14.7	15.8
Housing stock (normalized)	1	1	1.026	1.038	1	1.041	1.068
O2O transition rate (%)	2.5	4.7	4.7	4.8	4.7	4.7	4.6
R2O transition rate (%)	5.0	6.5	6.3	5.8	6.2	6.5	6.5
Housing turnover rate (%)	4.6	7.2	7.6	7.1	7.3	7.2	7.0
Mismatched homeowners(%)	13.4	4.8	4.6	4.4	5.3	4.8	4.9
Ex-ante *cev* (%)	-	0.34	0.45	0.44	0.08	0.24	0.27

C.5 Direct and general equilibrium effects on welfare over the transition

Table C–3: Welfare changes over the transition with fixed prices or fixed housing supply (property tax case)

	Fix p and p^r		Fix H for 1 period		Fix H for 3 periods		Fix H permanently	
Housing status	mean (%)	$P(cev_i > 0)$	mean (%)	$P(cev_i > 0)$	mean (%)	$P(cev_i > 0)$	mean (%)	$P(cev_i > 0)$
Renters	0.44	0.955	0.51	0.999	0.51	0.999	0.47	0.999
Homeowners	-0.35	0.236	-0.42	0.213	-0.43	0.212	-0.42	0.235
Owner-occupiers	-0.28	0.228	-0.38	0.190	-0.40	0.188	-0.40	0.204
Landlords	-0.62	0.268	-0.58	0.302	-0.57	0.304	-0.47	0.354
Mismatched	-0.02	0.529	-0.02	0.509	-0.02	0.506	0.04	0.539
Not mismatched	-0.41	0.180	-0.50	0.157	-0.51	0.156	-0.50	0.176
Overall	-0.09	0.465	-0.12	0.464	-0.13	0.463	-0.13	0.478

We conduct several experiments to examine the direct and general equilibrium effects on welfare along the transition for the case of replacing stamp duty with a property tax. To explore the direct effect of replacing stamp duty with a property tax, we fix house and rental prices, p and p^r, at their baseline steady state levels and simulate existing households forward for 11 periods.[41] As prices are fixed, purchase and rental markets do not clear in every period, with excess demand in the purchase market and excess supply in the rental market. The welfare effects on existing households are presented in the first two columns of the table above. A comparison with the results in Table 10 for the property tax experiment suggests that with fixed prices renters gain less and homeowners lose less on average. Such differences reflect the general equilibrium effect coming from endogenous

[41] The choice of 11 periods is because the transition from the baseline steady state to the property tax counterfactual steady state takes 11 periods. As prices are fixed, the policy functions needed for simulation are unchanged from period to period.

changes in prices over the transition as shown in Figure 9. A smaller welfare gain for renters is driven by the fixed rental price as compared with the lower equilibrium rental prices, while a smaller welfare loss for owners results from being able to upsize or downsize at the lower fixed house price. Nevertheless, the results suggest that the direct effect accounts for the majority of the welfare changes for existing households. In particular, the overall average welfare change is similar as in the property tax experiment.

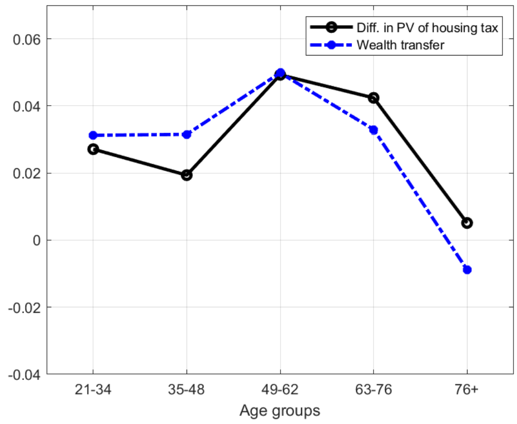
To examine the role of housing supply, we fix housing supply for one period or three periods after the policy reform, then allow housing supply to respond afterwards. In each experiment, the economy eventually converges to the steady state of the counterfactual economy. In another experiment, we permanently fix housing supply and the economy converges to the steady state of the counterfactual economy with fixed housing supply. For each of the three experiments, we re-solve the transition dynamics and re-calculate the welfare effects on existing households by initial housing status. We find that due to temporarily fixed housing supply, the initial increase in house price is larger while the initial drop in rental price is more moderate, compared with the price dynamics in Figure 9. As a result, the welfare gain of renters is slightly smaller and the welfare loss of landlords is also slightly smaller, compared with the results in Table 10. Overall, the results in both experiments are similar to those reported in Table 10, with the average welfare loss slightly larger than in the variable housing supply case. In the experiment with permanently fixed housing supply, a similar pattern is observed, but the drops in the average welfare gain of renters and average welfare loss of landlords and more significant. Consistent with what we find in the steady state analysis, these results suggest the elasticity of housing supply plays only a minor role in determining the welfare effect of the policy change.

C.6 Changes in tax burden and welfare along the transition

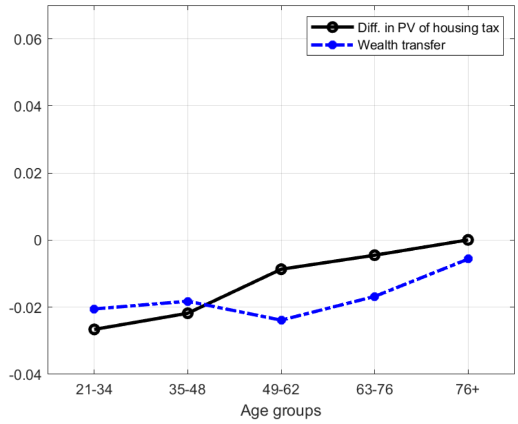
In this appendix, we investigate the connection between changes in tax burden and changes in welfare along the transition in the property tax experiment. Moving from stamp duty to a property tax maintains the steady state level of tax revenue but it may alter the burden of taxation across generations over the transition. We first calculate the average present value of stamp duty that would be paid by different age groups of existing homeowners and renters under the status quo (i.e. continued use of stamp duty) and the average present value of property taxes they would face if stamp duty is replaced by the property tax.[42]

[42] In calculating the present value of property taxes, we simulate each existing household's decisions over the transition and in the new steady state until they pass away, using the relevant policy functions for each period. This gives us the property taxes paid by each household in every period of life after the policy change, allowing us to calculate a present value of the property taxes using a discount factor associated with the borrowing rate. We then average households' present values by their ownership status and age. The present values of stamp duty are calculated in a similar way, using the same set of realised exogenous shocks and the baseline steady state policy functions in the simulation.

Figure C–6: Wealth compensating variation and the change in present value of housing taxes



(a) Homeowners



(b) Renters

This gives us the change in the average present value of housing-related taxes for each age group of existing homeowners and renters, as presented in Figure C–6 (black lines). We see that a shift from stamp duty to property tax raises the burden of housing-related taxes on homeowners and reduces it on renters.[43] This change in tax burden reflects the difference in tax incidence. Stamp duty is paid upon home purchase while property tax is paid periodically by homeowners. This alteration in tax incidence redistributes the tax burden from prospective homebuyers (renters) to current homeowners. Also, the increase in tax burden is more significant for young and middle-aged homeowners, who bear the property tax for a longer period of life, than for older homeowners. These changes in tax burden are qualitatively consistent with the welfare effects shown in panel (a) of Figure 10 in the main text. In particular, there is a relatively minimal increase in the tax burden for homeowners in the 76+ age group, which can be compensated by the increase in house price such that they experience a small welfare gain on average. While this is not the case for homeowners in all other age groups, as the increases in their tax burden are relatively large.

As the *cev* measure of welfare change is not directly comparable to the dollar change in tax burden, we follow Kindermann and Krueger (2022) (page 32) to calculate an alternative measure of welfare change – wealth compensating variation (*wcv*). That is, for each household in the baseline steady state, we compute the amount of initial wealth transfer that is needed to make them indifferent between the status quo and replacing stamp duty

[43]This is also true for the burden of total taxes; the average present value of total taxes increases by 0.9% for owners and decreases by 1.1% for renters. The smaller magnitude of the changes in total tax burden as compared to changes in housing-related taxes reflects the fact that the major component of total taxes is income tax which is largely unaffected by the policy change. The average present value of total taxes across all households has only slightly increased by 0.3%, and revenue neutrality is roughly maintained in every period over the transition.

with a property tax. Formally, for a household with state $x \equiv (a, z, s_{-1}, h_{-1}, \lambda)$, the *wcv* $\psi_0(x)$ is defined as

$$V^{cf}(a, z, s_{-1} + \psi_0(x), h_{-1}, \lambda) = V(x),$$

where V^{cf} refers to the value function for the property tax economy in the first period of the transition. A positive value of *wcv* indicates a welfare loss for the household, while a negative value indicates a welfare gain. The average *wcv*s for different age groups of homeowners and renters are also presented in Figure C–6 (dashed blue lines).

We note a couple of interesting observations from Figure C–6. First, the *wcv* results are consistent with the *cev* results presented in panel (a) of Figure 10. Renters in all age groups benefit from the policy change whereas homeowners in all age groups, except for the 76+ group, experience an average welfare loss. Second, the *wcv*s exhibit a similar pattern across different age groups of owners and renters as the changes in the present value of housing taxes and they are highly comparable in magnitude. These results suggest that the welfare changes from replacing stamp duty with a property tax arise, to a large extent, from changes in the burden of housing-related taxes caused by the policy change.

D Calibration of the model without housing preference shock

This section describes the calibration of the model without the housing preference shock. Tables D–4 and D–5 contain information on internally calibrated parameters and target moments, respectively. A selected set of non-targeted moments are reported in Table 12 in the main text. To illustrate the role of preference shocks in matching the housing transition rates, Table D–6 reports how model moments respond to changes in internally calibrated parameters. These experiments suggest that the O2O transition rate is strongly influenced by the preference shock but not by other parameters of the model. The exception is changes in β, which alters the O2O transition rate more significantly but shifts other model moments away from their targets. In particular, while an increase in β raises the home ownership rate, it sharply reduces the median loan-to-value ratio.

Table D–4: Internally calibrated parameters: Model without housing preference shock

	Parameter	Value
λ	Utility premium for homeowners	1.05
h_{min}	Minimum housing size for owning	0.625
h^r_{min}	Minimum housing size for renting	0.154
ϑ	Bequest intensity	35
$\underline{b}$	Extent to which bequest is luxury	0.730
ζ	Fixed cost of being a landlord	0.025
β	Discount factor	0.880
α	Share of non-durable consumption	0.710
ψ_1	Scale parameter in housing production	4.75

Table D–5: Target moments: Model without housing preference shock

Target Moments	Model	Data	Source
Home ownership rate (%)	67.1	68.5	SIH 13-14
Home ownership rate for under 35 (%)	40.3	37.4	SIH 13-14
Rental expenditure of the bottom 5%	0.055	0.058	SIH 13-14
Home ownership rate for 65+ (%)	78.3	84.0	SIH 13-14
Total wealth p75/p25 for 65+	2.53	2.89	SIH 13-14
Landlord rate (%)	13.2	12.7	SIH 13-14
Median loan-to-value ratio	0.51	0.52	SIH 13-14
Median rent-to-income ratio	0.23	0.25	SIH 13-14
Median housing value	1.88	1.78	SIH 13-14

Table D–6: Sensitivity of O2O transition rate

	(1) O2O rate (%)	(2) Hrate (%)	(3) Median LTV	(4) p^r/y	(5) Hrate under 35 (%)	(6) Lrate (%)	(7) Goodness of Fit
Data	2.5	68.5	0.52	0.25	37.4	12.7	–
With pref. shocks	2.5	68.1	0.51	0.24	40.9	14.3	3.52
w/o pref. shocks	1.9	67.1	51.4	0.23	40.3	13.2	9.82
Model w/o pref. shocks:							
5% lower α	2.0	72.1	58.9	0.26	45.2	16.8	24.1
5% higher α	1.7	62.5	40.0	0.20	38.2	13.9	24.4
5% lower h_{min}	1.8	68.5	58.9	0.23	43.7	13.2	14.0
5% higher h_{min}	1.8	65.6	46.9	0.22	40.7	17.0	25.4
5% lower β	1.5	64.8	60.0	0.23	41.0	15.0	117.9
5% higher β	2.3	66.1	40.0	0.22	33.6	15.0	28.4
5% lower λ	2.0	66.0	45.1	0.23	36.3	14.9	12.3
5% higher λ	1.6	71.0	58.9	0.23	46.2	12.2	25.0
5% lower ζ	1.8	68.3	51.4	0.22	42.0	17.2	25.1
5% higher ζ	1.6	65.2	51.4	0.23	41.1	13.5	16.4

Notes: This table presents selected moments from data, the baseline model with preference shock, the model without preference shock, and the model without preference shock but changing a set of parameters, one at a time, from their respective values reported in Table D–4. The moments reported are: (1) O2O transition rate; (2) average home ownership rate; (3) median loan-to-value ratio; (4) rent-to-income ratio; (5) home ownership rate under age 35; (6) landlord rate; and (7) Goodness of fit, which is defined as the sum of squared percentage deviations from *all targeted data moments* displayed in Table D–5. We have not experimented with bequest parameters ϑ and $\underline{b}$, and housing production parameter ψ_1, as these parameters are least related to the O2O transition rate.

E Computational details

For computation of steady state and transitional dynamics, we closely follow computational techniques used in Cho, Li, and Uren (2023). We provide details on computing the stationary equilibrium and transitional dynamics below.

State and control variables. The state of a household in every period is determined by five variables: savings s_{-1}, housing asset h_{-1} obtained in the 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 consumption $\tilde{h}$, and non-durable consumption c. We discretize the housing asset into 10 discrete sizes, $h \in \{0, h(1), ..., h(10)\}$, with $h(1) = h_{\text{min}}$. The housing grids are finer at smaller house sizes. While the housing services grid for homeowners is the same as the housing asset grid, housing services grid for renters include 4 additional smaller grids, i.e., $h^{\text{rent}} \in \{h^{\text{rent}}(1), ...h^{\text{rent}}(4), h(1), ..., h(10)\}$, with $h^{\text{rent}}(1) = h^{\text{rent}}_{\text{min}}$. The risk-free asset is discretized into 70 gridpoints. Households are allowed to choose the maximum possible borrowing for each housing size, $s = -(1-\theta)ph$. Between a pair of these maximum borrowing grids, we allow for three equally spaced grids to give some flexibility in choosing mortgage size. 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 a constant house price p and a constant rental price p^r. We start by guessing these two equilibrium objects. Given p and p^r, we compute the optimal policy and value functions for the final period $A = 32$. Once the optimal policy and value functions for the final period is obtained, we solve the complete household problem using backward induction. Once we obtain policy functions, we simulate the economy with 10,000 households until a stationary distribution over the state space is achieved. Each household starts their life with initial savings and housing wealth drawn from the joint empirical distribution of financial and housing wealth for households aged 21 and 22. The initial housing wealth is then converted into a quantity of initial housing asset using house price p in the iteration and we select the housing grid that is closest to this quantity as the initial housing asset for the household. In the beginning of each period, households draw income shocks and housing preference shocks, make rent/stay/move decisions, and choose non-durable consumption, housing services, housing asset and saving/borrowing. At the end of each period, households receive an age-dependent death shock governed by the survival probabilities conditional on age. Households exit the economy with certainty after 32 periods.

If a household survives, they continue to make choices and we simulate the optimal behaviour of these households forward using the computed policy functions. If a household dies, they are replaced by a newly born household who starts the life cycle from the following period and draws initial savings and housing asset as described above. The stationary distribution is obtained when the age distribution, average savings, average income and average housing asset across all simulated households are all stabilized. We iterate the whole process until the prices p and p^r that clear housing and rental markets are found.

Internal calibration. Given candidate values for internally calibrated parameters, the stationary equilibrium of the model is solved and simulated following the procedure above. The targeted moments are then computed using the simulated data. If they are close enough to the data moments, we stop. Otherwise, the parameter values are updated and we repeat this procedure.

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. (2023) which is briefly summarised below:

Algorithm:

1. Choose the length of the transition phase, T.
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 rental price 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 $\{\hat{p}_t, \hat{p}^r_t\}$ and $\{p_t, p^r_t\}$. 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.

References

Australian Bureau of Statistics. 6401.0 Consumer Price Index, Australia. Accessed October 2023.

Australian Bureau of Statistics. 6416.0 - Residential Property Price Indexes: Eight Capital Cities. Accessed October 2023.

Cho, Y., S. M. Li, and L. Uren (2023). Investment housing tax concessions and welfare: A Quantitative Study for Australia. *International Economic Review forthcoming*.

Department of Social Services and Melbourne Institute of Applied Economic and Social Research (2022). The Household, Income and Labour Dynamics in Australia (HILDA) survey, GENERAL RELEASE 21 (Waves 1-21).