**Lifetime wealth simulation**

We simulate the experience of homeowners purchasing a home with a traditional mortgage and the experience of shared owners. The simulation allows for historical prices and for an assumed house price appreciation. The head of the household is required to enter the following information into a survey in order to calibrate the simulation.

* 3-digit postcode
* Type of property to choose between apartment of house
* Property size to choose between 1 bedroom, 2 bedroom, 3+ bedroom unit
* Household gross annual income
* Household net (after tax) monthly disposable income
* Savings of household
* Age of lead household member
* Size of household (not directly used in the simulation at the moment but in a later stage can be used to predict income growth more accurately)
* Profession (from a dropdown menu of options based on the types in the English Housing/Household Survey. Not directly used in the simulation at the moment but in a later stage can be used to predict income growth more accurately)

Optional fields for better calibration of the rental unit:

* Current rent per month paid
* 3-digit postcode of rental unit
* Size of rental unit to choose between 1 bedroom, 2 bedroom, 3+ bedroom unit

In the current version, we use the quarterly house prices for London from Nationwide for the time period Q4 1973-Q1 2023. We will also have Local Authority (LA) level house price indices from the Land Registry which we construct using the Price Paid Data for the same time period. We differentiate between apartments and houses and between 1 bedroom, 2 bedroom and 3 or more bedroom homes in those series. So, when the household enters the three-digit postcode, the type of property they decide (apartment/house) and the size (1/2/3+ bedrooms) when they fill in the survey, the simulation will allocate the relevant house price index for that LA, the type of property and the size.

Assuming that the same price dynamics will repeat itself in the next 50 years as the last 50 years, and given the current price (this is based on the month and year of the entry of the survey using the latest LR data. In the current simulation we use as an example £511,293), we can simulate the house prices in the next 50 years. This is a strong assumption which we can relax in the future. For simplicity, we go ahead with it now.

We can take the same approach with respect to income. For this we need historical income (earnings) data by type of occupation/profession from the ONS. For simplicity, in the current version of the simulation, we use the current disposable monthly income that the household enters in the survey and multiply this by 3 to get it at the quarterly level.

Income growth is assumed to be a linear combination of inflation and house price growth given by the formula:

where is inflation and is the house price appreciation/growth. We can vary the parameter . When alpha is zero, then income increases with inflation. When is different from zero, then income growth and house price growth are different, and affordability (as measured by the price to income ratio) varies over time. When alpha is 1, then income growth is the same as house price growth and the price to income ratio does not change.

We assume that private market rent per year is 4.5% of the value of the home. This is relevant for the rent equation below. In this setting, we examine the wealth accumulated at retirement (at the age of 67 years) for traditional home ownership and for shared ownership.

A major hurdle to home ownership is affordability. In our simulation there are two constraints to home ownership: the deposit constraint, for which the loan-to-value (LTV) ratio should not to exceed 95% of the value of the home; and the income constraint, for which the loan-to-income (LTI) ratio, as measured by the loan amount as compared to gross annual income, should not exceed a multiple of 4.5 (this can be amended to a maximum of 5.5).

The household accumulates savings to afford a home with a traditional mortgage. While it is doing this, it lives in a market rental accommodation, paying above rent (4.5% of house value). The quarterly rent is calculated as

where is the price of the rental property in period t. We assume that the consumption parameter is 35%, meaning that 35% of the income of the household is spent on (non-housing) consumption. The remainder goes to rent and savings.

Thus, the savings in period t are given by

Hereby, is the savings in period (quarter) t, which will also be used as a deposit to purchase a home, is the income in this quarter, is the rental payment for the quarter, and is the interest rate on a savings account, for which we can use the Bank of England rate over time.

The initial savings amount (the amount at the point where the household reports its age can be non-zero) is entered by the family as part of the survey on the website. These could be savings from parents or own savings.

**Traditional home ownership**

We then create a dummy variable which signifies whether the affordability constraint is still binding, i.e. the household needs to keep renting on the open market and cannot become a home owner, or whether the household can afford the home. This constraint is given by the deposit/LTV constraint:

where is home price/value using above house price data based on the entries in the survey and the historical data.

The second constraint is the LTI constraint given as:

Hereby, we assume that is used as a deposit. Both conditions need to be satisfied for a person to get onto the property ladder with a mortgage.

A dummy variable is constructed that checks whether these two conditions are satisfied. The first instance in which the two conditions are satisfied, we assume that the household transitions from the private rental market to traditional home ownership in that period and stays into home ownership.

We consider a mortgage with a maturity (in years):

Where is the age when taking the mortgage. This needs to be calculated by the simulation using the initial age of the household when entering the survey plus the amount of years it takes the household to save for the deposit.

The interest rate is variable and mortgage payments are calculated with this variable interest rate. The mortgage rate is calculated as the BoE interest rate plus a risk premium (RP) which we assume to be static at the moment (say 30 basis points):

where is the mortgage rate. If we decide not to consider default and assume fee-free prepayment, extra savings in each period are used as mortgage prepayment which reduces the mortgage balance. The mortgage payment in period t is calculated as:

where is the payment in period t going towards the mortgage payment and the mortgage pre-payment. The process continues until becomes zero (mortgage has been paid in full) or the household reaches the age of 67 if that happens before that. At the moment where is zero and there is still time to retirement, the household starts accumulating liquid wealth in a savings account which increases according to the rule

The final wealth of the household at the age of 67 years is

*Comment: it might be better to derive the price dynamic parametrically, and using the capabilities in Python to simulate, say 1000 house price, inflation and income paths and calculate the wealth at 67. We can also report the time at which getting onto the property ladder is possible and the distribution of the final wealth at retirement (67), along with its average. Also, how much of it is liquid and how much of it is tied in the house.*

**Shared ownership**

A shared owner can get onto the property ladder with a minimum of 10% shared ownership. The rent paid on the share owned by the housing association is 2.75% of property value and the service charge is assumed to be 1/3 of the rent. The shared ownership product is thus more affordable. We assume that the household will buy a shared ownership home as soon as it has the requisite deposit to purchase the minimum required stake in the property, which currently stands at 10%. The constraints are given by the conditions of a maximum LTV (SO) being 95% of the price of the share to be bought. So, same LTV ratio as for home ownership. In our case, since everyone buys 10% immediately when then have enough savings (and do not wait to get more savings for a bigger share while renting, as this is not optimal) we have the deposit/LTV condition for SO set as:

where is home price/value.

For the LTI (SO) condition one way to formulate the affordability constraint is to assume that the disposable income net of the rental payments is sufficient to cover the loan. That is, the loan does not exceed a 4.5 multiple of the disposable annual income after rent:

Let us denote by the share purchased at time t. The first share should be 10% or slightly higher as determined by the savings. The first share is purchased with a mortgage. However, any additional share is financed with savings (i.e. equity only). (We can alternatively assume that the household takes on additional mortgage and leverages the savings to buy more shares or buy shares more quickly. Here we do not consider this possibility.) The effect of this is that the accumulation of equity share is slower, than taking a mortgage when buying a share, and the shared owner might end up paying more if house prices go up quickly. The total share owned at time t is .

With these assumptions, the budget constraints are determined by the following equations:

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is determined as the fully amortizing mortgage on a loan which terminates at the age of 67. The interest rate may vary so as to reflect the interest rate uncertainty. Savings are used to purchase additional share of the home. Therefore, the rate of staircasing is given as:

Thus the shared owner staircases over time, depending on the rate of savings, until it reaches the point of 100% homeownership, or retirement (67 years of age), whichever comes first. The wealth at 67 years of age is determined in the same way as in traditional home ownership.