Modelling Demographic Developments Driven by Housing Market Dynamics

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Abstract. This paper presents first results of modelling income and wealth inequalities solely from housing market dynamics. An existing behaviour based agent-based model of the English and Welsh housing market is used to analyse the demographies of more expensive and cheaper areas emerging from buyer, seller and realtor interactions. The model is analysed for a small set of macroeconomic configurations of interest rates and loan to value ratios.

Keywords: housing market dynamics, demographic development, income and wealth inequalities, adaptation of agent-based models

1 Introduction

Life expectancy and healthy life expectancy are falling in the UK. This is particularly the case for people at the bottom of the income scale and those who live in poor areas/neighbourhoods. A life expectancy gap or 17.6-year was estimated between males born in Greater Govan (65.4 years) versus Pollokshields West (83 years) for the years 2015–19 [4]. These areas are 5km apart. There are many drivers of this but one recognised factor is housing, which has become a central focus in UK social policy and public health research as it is one of the central determinants of health and wellbeing. Due to sharp increases in property prices over the last three decades there are increasing questions of affordability of home ownership or rent, exacerbated by a lack of affordable and social housing. This can lead to stress, anxiety and at the sharp end, to homelessness. The condition of a house can lead to physical health problems, through mould, draught and cold. The location of a house can lead to mobility and access problems for jobs, services and supplies [3].

This paper describes an agent-based model that shows the emergence of more or less deprived areas from housing market mechanisms. Based on a model of the England and Wales housing market developed in [2], it reanalyses the model outputs to describe the demographic developments resulting from constrained housing choices, in particular focusing on income and wealth inequalities emerging through simple market transactions. The paper will present some initial findings from the model dynamics (Section 2) and a methodological reflection on using an existing agent-based model for a different purpose (Section 3).

2 Modelling the Housing Market

Gilbert et al. [2] present an agent-based model of the England and Wales housing market. The restriction to England and Wales results from the specific legal processes for house buying and selling there which differ from those in other nations, not from adopting a particular geography, house building rate or quality, or price profile of the market. It was initially built to understand housing market dynamics such as price bubbles and crashes, and investigate the influence of macroeconomic factors, e.g. changes in interest rates or the loan to value ratio of mortgages, on the market. The agents in the model are houses, owners (who could be in the market to buy and sell) and realtors (or estate agents). Agents who do not own a house want to buy a house. Agents who own a house will put their house up for sale if they have a shock to their income (a rise or reduction of 20% or more). Agents buy the the most expensive house they can afford given their income and the capital they have available for a deposit downpayment). If an agent cannot find a house they leave the system after 5 ticks (a tick equates to a quarter of a year). Agents who have a house but want to move seek to sell their house for as much as they can. If they cannot find a buyer, the price is dropped incrementally. Realtors function as the middlemen who value houses (on their records of past sales plus a markup).

From an initialisation of a random house price distribution, more expensive and cheaper areas emerge through the above described agent interactions. Several features of the real housing market can be replicated, such as periods of steady house price increases followed by a dramatic fall. It also shows that changes to interest rates have a relatively minor effect on the housing market. One particularly interesting pattern this model replicates is the strong effect of a loan-to-value ratio (LTV) change to mortgages. A change from 100% to 80% temporarily crashes the market.

This behaviour was observed in the 2008 financial crisis, where banks were forced to reduce LTV. The model helps to understand the dynamics underlying this crash: having enough capital to finance a house purchase is most difficult for first time buyers. A sudden change to LTV means many first time buyers cannot enter the market. That means the next rung of people cannot sell their cheaper property to move up to a more expensive one, etc. This means there is a cascade of properties that are staying on the market for longer. Given that the price is reduced incrementally if a property is not sold, house prices reduce. At some point the savings of those not yet in the market are high enough and the house prices low enough so that the market can pick up again.

The possibility of modelling these kinds of cascades lies at the origin of the idea to model demographic dynamics resulting from housing market dynamics.

3 Modelling a Housing Market Driven Demography

Where we live has many drivers. We might decide to live close to our work, to live somewhere where we do not need a car, near a good school for the children or in

a rural area to have ease of access to countryside walks. However, where we live is driven to a substantial degree by where we can afford to live. This suggests that housing market dynamics and socio-economic segregation are tightly interwoven. It seems intuitive that an expensive area will have richer and a cheap area will have poorer people living in it. There are, however questions about demographic inequalities within areas, transition dynamics between areas and the cumulative dynamics of wealth for individuals. For example [1] investigates how “suburban flight" explains differences in the success of health investments between areas. In an evaluation of health interventions it appeared that the most deprived areas had no health improvements despite the highest level of investment. They formed a hypothesis that this is because those who could, would move away from the more deprived areas, and that the movers were likely to be the people with improved health outcomes. Testing this hypothesis with a small agent-based model, they found that the hypothesised dynamics were sufficient to explain the lack of health improvement in the most deprived areas.

Taking this idea of demographic dynamics as a starting point, we use the housing model [2] to generate demography through housing market dynamics.

3.1 Forced dynamics

For a first modification the model space was divided into four squares. All realtors were clustered in one square. Realtors drive house prices and the clustered positioning of the realtors ensures an asymmetry in house prices across areas. Running this Our initial findings are that between area differences become rather stark, with clear developments of “gentrification” for the area with the realtor cluster.

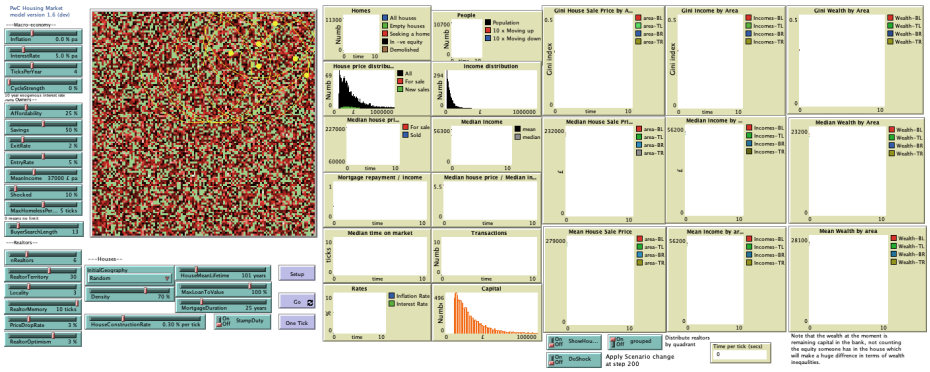

Fig. 1. The housing model with estate agents (yellow dots) concentrated in the top right corner.

The plots on the right hand side of 2 show the additional measurements across the four quadrants, measuring median house price, median income and median wealth.

Running the model with static macroeconomic settings of interest rates at 2% and 100% LTV, we are getting high levels of between-area inequalities. House prices rise sharply in the realtor area compared to the three other areas. Median income and wealth also increase considerably in the this area. Within area inequality goes down over time as areas become more homogeneous but some rise in within area inequality.

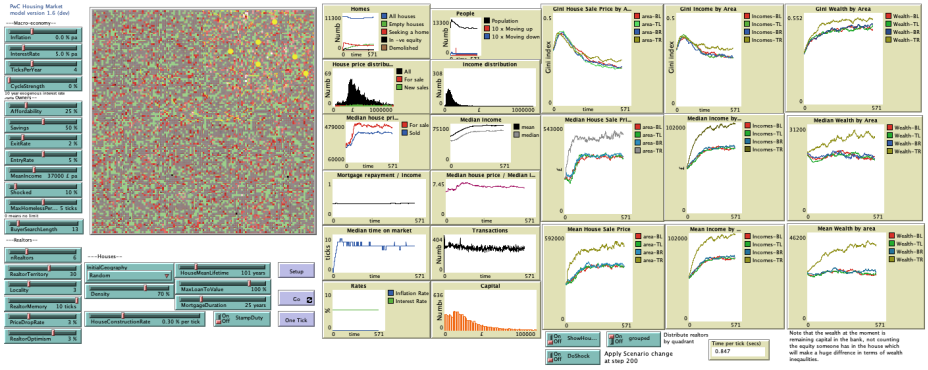

Fig. 2. Plots show within area inequality (gini coefficient) for house prices, incomes and wealth as well as between are inequalities for mean and median of prices, incomes and wealth.

LTV 100 IR 4%	Gini House Price	Gini Income	Gini Capital
Average Areas	0.24	0.28	0.47
Estate Agent Area	0.25	0.3	0.5
	Mean House Price	Mean Income	Mean Capital
Average Areas	470459	75256	30482
Estate Agent Area	560038	91734	39780
	Median House Price	Median Income	Median Capital
Average Areas	431140	65679	24004
Estate Agent Area	520364	78325	28675

Table 1. Differences between the realtor area and the average of the three other areas. Experiments were run for 300 ticks, the values are averaged over 3 runs, as variance between runs is negligible.

This first modification shows that the model works to replicate basic residential socio-economic segregation and generates large between area inequalities but also show some rise in within areas inequalities (see in particular gini-wealth plot).

3.2 Changes in Macroeconomic Parameter Settings

One interesting feature to investigate with the model is the influence on macroeconomic configurations on the demography of different areas. In a set of experiments we investigate the influence of interst rates (IR) and loan-to-value ratio

(LTV) on house price, income and wealth inequality in the area where house prices are driven by estate agent competition and those where they are not.

To calculate the difference we subtracted the value for the estate agent area from the average in the three other areas. For example in 4 at 125% LTV and 1% IR the wealth of all other areas is over £10,000 higher than the estate agent area, but as interest increases the wealth in the estate agent area ends up higher (therefore the values are negative). All experiments were run for 300 ticks, the measures are taken at the final tick.

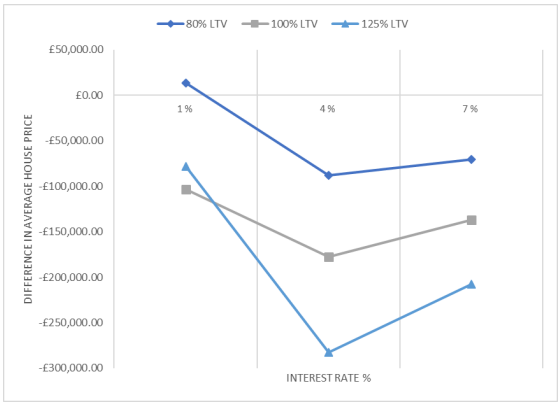

Fig. 3. Difference in mean house prices between the area where house prices are driven by house prices and the mean across the other areas.

Figure 3 shows the difference between more expensive and cheaper areas emerging form the estate agent driven dynamics compared to other areas. Generally the area driven by estate agent competition has higher house prices. This is particularly pronounced for higher LTV ratios. Only with an 80% LTV do the other areas do marginally better than the estate agent area.
Figure 4 shows the differences between mean income and mean wealth between areas. The difference in income is particularly pronounced at $£15,000$ per annum across all LVT values, except for very low interest rates of 1%. The difference in wealth is not particularly high at $£5,000 - 10,000$ (note that this is wealth accumulated over 300 ticks, corresponding to 75 years).

4 Discussion & Conclusion

Housing market dynamics are a substantial driver of socio-economic segregation. The model of housing market driven demography replicates some of the dynamics underlying this phenomenon. As an area becomes more expensive, for example from competition between estate agents driving up prices, the median income and wealth of the area also goes up, increasing between-area inequalities in income and wealth. Comparing a small number of macroeconomic scenarios combining

Fig. 4. Difference in mean income and mean wealth between the area where house prices are driven by house prices and the mean across the other areas.

LTV ratios and interest rates, high levels of income inequality but relatively low levels of wealth inequality.

In this paper we describe the adaptation of a model for a purpose it was not built for. There has been increasing focus on modular agent-based modelling to make it more efficient. At first glance it seems that this adaptation of the housing market model to a demography model should be straightforward. The model already consists of house owners who have incomes and wealth. The market dynamics of the interactions between interest rates, loan to value ratio and mortgage length are well calibrated. However, in order to look at demographic factors resulting from housing market dynamics, great care has to be taken to check that the operationalisations make sense for the reanalysis. For example, for the housing market analysis it makes no difference whether the owner is an individual or a household. For a demographic analysis it does, in particular once the demographic specifications are extended to include other variables such as age.

In current work we are extending the model to include a rental market. To analyse demographic developments and area attributes it is essential to also model renters and landlords. Future extensions to the model will use proxy relationships between income, neighbourhood profiles and housing quality to model the health consequences of housing.

Acknowledgements

References

1. Castellani, B., Rajaram, R.: Case-based modeling and the sacs toolkit: a mathematical outline. Computational and Mathematical Organization Theory **18**, 153–174 (2012)
2. Gilbert, N., Hawksworth, J.C., Swinney, P.A.: An agent-based model of the UK housing market. Tech. rep., CRESS, University of Surrey (2008), `https://cress.soc.surrey.ac.uk/housingmarket/ukhm.html`

3. Organization, W.H., et al.: Who housing and health guidelines (2018)
4. Whyte, B., Young, M., Timpson, K.: Health in a changing city: Glasgow 2021 (2021)