PEER REVIEWED

FINAL REPORT NO. 387

Filtering as a source of low-income housing in Australia: conceptualisation and testing

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Publication Date September 2022

DOI 10.18408/ahuri5124401

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ISBN

978-1-922498-54-0

Key words

Filtering, affordable housing, housing market dynamics, price elasticity of supply, rental depreciation metric.

Series

AHURI Final Report

Number

387

ISSN

1834-7223

Publisher

Australian Housing and Urban Research Institute Limited
Melbourne, Australia

DOI

10.18408/ahuri5124401

Format

PDF, online only

URL

https://www.ahuri.edu.au/research/final-reports/387

Recommended citation

Nygaard, C., van den Nouwelant, R., Glackin, S., Martin, C. and Sisson, A. (2022) *Filtering as a source of low-income housing in Australia: conceptualisation and testing,* AHURI Final Report No. 387, Australian Housing and Urban Research Institute Limited, Melbourne, https://www.ahuri.edu.au/research/final-reports/387, doi: 10.18408/ahuri5124401.

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Acknowledgements

This material was produced with funding from the Australian Government and state and territory governments. AHURI Limited gratefully acknowledges the financial and other support it has received from these governments, without which this work would not have been possible.

AHURI Limited also gratefully acknowledges the contributions, both financial and in-kind, of its university research partners who have helped make the completion of this material possible.

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Acronyms and abbreviations used in this report

ABS	Australian Bureau of Statistics
AURIN	Australian Urban Research Infrastructure Network
CBD	Central Business District
CD	Collection District (2006)
CRA	Commonwealth Rent Assistance
DELWP	Department of Environment, Land, Water and Planning (Victoria)
FHB	First Home Buyers
GNS	General Nesting Spatial model
GPO	General Post Office
NHSC	National Housing Supply Council
HILDA	Household, Income and Labour Dynamics in Australia
NOAH	Naturally Occurring Affordable Housing
PC	Productivity Commission
PRS	Private Rented Sector
SA2	Statistical Area Level 2
SDM	Spatial Durbin Model
SES	Socio-economic Status
WWII	Second World War

Glossary

Filtering is a market-based process whereby the supply of new, higher quality dwellings, for higher- and middle-income households may also lead to additional supply of dwellings for lower income households. Theoretically, dwellings may filter over time through successively lower market segments or sub-markets. As higher income households vacate their former homes for higher quality housing, vacated homes may become part of housing supply in adjacent (quality or locational) sub-markets.

Neighbourhood effects refer to influences on individual's behaviour and attitudes that are the result of interactions with others in a neighbourhood (Rodgers, Castree et al. 2013).

Social interactions refer to the relationship between people in particular social groups. For the analysis of housing markets and housing market change, social interactions matter where they give rise to positive and negative externalities, and where these increase disproportionately to the concentration of members of particular social groups.

Throughout this report social interactions and neighbourhood effects are used together. Social interactions may give rise to externalities (positive and negative). The externalities are a form of neighbourhood effect.

Executive summary

Key points

- Filtering is a market-based process whereby the supply of new, higher quality dwellings, for higher- and middle-income households also leads to additional supply of dwellings for lower income households as higher income households vacate their former homes. Theoretically, dwellings filter over time through successively lower market segments or sub-markets, becoming a supply of 'naturally occurring affordable housing'.
- This report tests for filtering dynamics in Melbourne and Sydney, using differently sourced data and different methods of analysis. Theoretically, filtering is traceable in the price dynamics of dwellings, and in the occupancy characteristics of residents in properties over time. Filtering dynamics are tested across the entire housing stock and in the private rental sector specifically.
- Overall, there is evidence that new dwellings – whether sold or rented – trade at a market premium. This is consistent with filtering dynamics.
- However, there is little corresponding evidence that these age-related price dynamics are sufficient to generate a supply of affordable housing for low-income households. Under the prevailing housing market and planning conditions, the evidence does not support relying on filtering as a substitute for the non-market provision of affordable housing for low-income households.
- The results show that the successive transfer of housing to lower income households as properties age (downwards filtering) may be negated or weakened by countervailing neighbourhood socio-economic determinants and locational characteristics (such as proximity to labour markets or urban amenities). While some properties are thus occupied by lower income households over time, the process is conditional on a number of locational and neighbourhood characteristics. For instance, the evidence from Melbourne suggests that many areas have largely retained their relative income status over the past 20 years.

- **Supply is central to addressing the affordability of housing for low-income households. However, a key condition for market-based filtering to deliver affordable low-income housing is that the rate of housing supply exceeds the rate of household formation and new demand. In Melbourne, the price elasticity of supply at the neighbourhood level (Collection District) is almost zero. Additional demand is therefore not met by additional supply, resulting in price appreciation that potentially also generates additional economic rent for older and existing properties in high demand areas.**
- **The private rental market analysis focuses on two cohorts of rental properties: one-bedroom units and three-bedroom houses. The evidence shows that the rate of rental depreciation is insufficient to offset the overall increase in rental values, leading to worsening affordability for low-income households.**
- **The evidence from Sydney suggests that dwellings are removed from the filtering process before they reach lower income households.**
- **While additional research is required to establish and identify more detailed housing market dynamics, the results in this report suggest that filtering may be inhibited and/or interrupted by local housing market contexts such as social interactions, low price elasticity of supply and a lack of substitutability between dwelling typologies and locations.**
- **From an affordable housing policy perspective, the results in this report suggests that filtering cannot be considered in isolation from the remaining determinants of occupancy or price change. That is, new supply will not necessarily free up existing housing for lower income households, unless the remaining determinants of demand for housing in specific locations is also addressed; *and* new supply also results in sustained downward pressure on sub-market specific property prices (that is, the rate of supply exceeds the rate of new household formation and demand; and new housing constitutes effective substitutes for existing housing).**
- **Greater use of market signals in planning and regulation can assist in improving the responsiveness of new construction to market signals. However, importantly, supply dynamics are also determined by landowners and property developers that benefit from withholding new supply housing. Public land banking can contribute to overcoming some of the private sector based incentives that inhibit greater supply responsiveness.**

Key findings

Filtering is a market-based process whereby the supply of new dwellings for higher- and middle-income households leads to additional supply of dwellings for lower income households. As higher income households vacate their former homes, lower income households move in. If new dwellings provide a higher level of housing services (quality) and demand for housing services is income elastic, then new dwelling construction may lead to older properties becoming cheaper. As properties become cheaper they, according to the filtering thesis, successively move down through lower quality market segments, ultimately providing affordable housing for lower income households.

However, this rests on a set of assumptions, the most important of which are that:

- The supply of new dwellings exceeds the rate of new household formation (new demand).
- New dwellings provide effective substitutes for older dwellings.
- The quality of housing depreciates independently of the characteristics of the residents of the dwellings or neighbourhoods.

Empirically, filtering is observable in the price and occupancy characteristics of dwellings. In the housing literature, property age is frequently taken as a proxy for the quality of housing services provided. This yields a number of stylised outcomes indicative of filtering. In this report, we test whether these stylised outcomes are evident in metropolitan Australia by using different datasets and analysis techniques for Melbourne and Sydney.

Dwellings age and cyclicality in neighbourhood status

Since housing is immobile, when dwellings filter it is actually the characteristics of occupants that change; higher income occupants vacate and lower income occupants move in. Therefore, filtering also leads to change in the relative income status of neighbourhoods. In the Melbourne analysis, relative income is measured as the median income at Collection District (CD) level (2006 boundaries), relative to the median income for the metropolitan area as a whole.

Over the past 20 years or so (1996–2016), there has been a degree of stability in relative income levels across metropolitan Melbourne. Twenty years, however, is a relatively short period of time for the housing market. Over a longer period (since the 1970s), the social geography of Melbourne has changed more substantially. Overall, the relationship between change in neighbourhood relative income levels and the age profile of the housing stock at first declines and then rises again. In other words, areas with the newest and oldest housing tend to improve their income level relative to other areas (a u-shaped relationship). This is consistent with filtering.

However, when examining the role of dwelling age on the change in relative income at the neighbourhood level, the analysis suggests that the impact of dwelling age is not independent of the socio-economic characteristics of occupants. That is, in neighbourhoods with higher levels of education or owner-occupiers, a concentration of older dwellings (pre-WWII) did not typically result in the neighbourhood filtering down market. A potential explanation for this persistence in the occupancy characteristics of higher (and lower) income areas are endogenous social interactions between residents in these areas. Social interactions refers to the relationships and behaviours between people. These can condition the demand for specific locations when behaviour and interaction give rise to externalities, such as social capital (positive) or costs (negative), disproportionately to the concentration of the specific social characteristic. In this case relative dwelling prices may exhibit persistence also following new dwelling developments.

Dwelling age and relative price depreciation

In both Melbourne and Sydney, the evidence shows that new properties trade at a market premium. New properties for sale in Melbourne are typically more expensive that older properties. However, the relationship between dwelling age and transaction price is not straightforward. The relationship depends upon, and interacts with, local housing market context, locational and institutional determinants of demand.

In Sydney, the results also show that the rental price for new dwellings is higher than comparable older dwellings. This is the case for both three-bedroom houses and one-bedroom flats. However, the relationship between age and rental price differs between these two market segments. Rental prices for three-bedroom houses have a u-shaped relationship with age, whereas rental prices for one-bedroom flats shows a near linear rate of depreciation.

However, in neither Melbourne or Sydney does the price premium for new dwellings appear sufficient to generate systematic supply of affordable low-income housing via filtering.

In Melbourne, the improvement in relative income status is associated with a higher proportion of both new and old (pre-WWII) housing. However, relative income change is greater in areas with greater concentrations of older housing than new housing.

In Sydney, the relative depreciation that takes place in rental prices is insufficient to offset the overall rate of price appreciation. That is, while the rental value of older rental properties declines relative to the median rental value, the rental value has still increased relative to the rent levels that are affordable to low-income households.

There is spatial variegation in filtering dynamics in both Sydney and Melbourne. In both cities, specific features and changes in urban structure and local housing market contexts have shaped market dynamics. These features and changes typically outweigh the impact of dwelling-age related effects. In both cities, the evidence of greatest relative decreases in property rents or neighbourhood relative incomes appears to be in areas with lower rates of economic growth, largely as a function of post-industrial urban economic restructuring. That is, areas developed in conjunction with suburban industrial growth of the post-war period are those most likely to experience relative income decline.

One implication is that housing affordable to low-income households is more likely to be spatially sorted into the parts of the cities with lowest socio-economic opportunities.

Finally, the volume of housing for low-income households supplied via filtering is also determined by the removal of economically and physically obsolete housing. As an alternative to allowing properties to filter down market, property owners may upgrade dwellings or convert to non-residential uses when (or if) new supply in a particular location or sub-market lowers demand for existing dwellings. The Melbourne analysis provides some tentative evidence that the role of demolitions may be different in lower and higher income areas.

Price elasticity of supply and filtering dynamics

For filtering to operate, new housing construction must exceed the rate of new household formation and other demand determinants; that is, new supply is elastic in response to demand changes. For the Australian housing market as a whole, the literature suggests new housing supply has not kept up with new demand (Ball, Meen et al. 2011; Burke, Nygaard et al. 2020). In the present research the price elasticity of supply is tested directly for local housing markets in Melbourne, and inferred for the Sydney housing market.

Overall the Melbourne analysis suggests that the price elasticity of supply is substantially less than one. This implies that when an area experiences additional demand (such as due to population growth, or expansion of nearby employment opportunities), there is insufficient additional supply to meet demand. This means there is no resulting surplus of dwellings. As a result, most (or all) of the housing market adjustment takes place in the form of higher dwelling prices or rents. In Melbourne the price elasticity of supply, at Statistical Area Level 2 (SA2) is approximately 0.3. For example, a 10 per cent increase in house prices would lead to only a very small increase in supply of 3 per cent. There is some variation in the price elasticity across areas with different age profiles of dwelling stock. Areas with a higher proportion of properties built in 1976–85 and 1926–35 appear to have particularly low elasticities. However, overall, elasticities remain very low.

Planning and zoning have some impact on price elasticity. For example, mixed use zoning (zones that have experienced particular growth in apartments and units) has a higher price elasticity, and heritage overlays have a lower price elasticity.

In Sydney, the increase in rents, relative to the affordable level of rent, provides indirect evidence that the supply of new dwellings is insufficient to offset changes in demand. This is also the case when taking price depreciation into account The Sydney analysis demonstrates that the parts of the city where price depreciation is most evident (areas with the highest observed relative decreases in rent over time) also had the lowest volume of low-cost rentals, particularly for houses.

This points to the overlapping influence of other market factors. Specifically, it can be inferred that the housing markets are shaped by expectations of continued capital growth. Consistent with theoretical work on filtering and property hierarchies, dwellings may be redeveloped (or upgraded) before they filter down to the affordable lower income houses segment. The expectation of capital growth reduces the risk of over-capitalising. Relatedly, the depreciating rental yields could also see landlords – at least those not looking to invest in the property's improvements – depart the market.

Both of these factors are functions of real property price appreciation. This condition of Australian housing markets is a barrier to filtering generating a supply of affordable low-income housing.

Policy development options

This research suggests that while new dwellings typically have a market premium, the effect of this market premium is insufficient to rely on filtering as a source of housing supply for low-income households.

Additional supply of housing is central to addressing the affordability of housing for low-income households. However, for market-based filtering to have a greater role in supplying affordable housing for low-income households, some structural features of Australian cities would need to be brought into line with the premises of filtering. These changes are not necessarily desirable or practical. Subject to that qualification, Chapter 5 reflects on three broad areas in which significant policy change would be required:

1. price elasticity and supply volumes
2. housing typology and location
3. local housing market contexts and social interactions.

Elasticity and volume of supply

As a market-based mechanism, filtering is premised on new supply generating a surplus of dwellings within specific sub-markets, or across sub-markets. This new supply causes a price depressing effect. To achieve such an outcome, the supply of new housing needs to be responsive to changes in demand. The price elasticity of supply is determined by a range of factors – many of which are not easily targeted by public policy. However, land use planning and taxation *can* contribute to housing supply becoming more responsive to price changes at local levels. Key policy insights include:

- More specific use of price signals as a guide for where new housing is provided and the type of housing that is provided. For instance, planning and zoning designation can become more responsive to price changes. There are important (and not easy) trade-offs between preserving the characteristics of areas as they currently stand, and the distribution of social costs when housing affordability worsens.
- Land in capital cities (and in high house price regions of those cities) is typically (and naturally) constrained. However, land supply constraints are further exacerbated through selective planning (zoning and overlay) of designations and concentrations. In order to generate housing systems impacts, design and dwelling typologies need to respond to market signals.

- The results in Section 3.1.2 shows that there are significant interdependencies between areas, in terms of how their relative income status changes. Coordination of new housing supply at metropolitan or sub-metropolitan regions (further research can establish appropriate functional housing markets) can additionally improve the overall price elasticity of supply.
- The supply of land in cities is not only determined by zoning or regulation. A greater use of broad-based land tax *may* spur owners to bring under-developed land to the market (Wood, Ong et al. 2012: 41).
- Government-led land assembly or public land-banking can ensure greater predictability in both the supply of land (for developers) and greater say in when development takes. As such it provides a policy alternative to established business practices around land banking (Murray 2020) and/or firm strategies designed to ensure business stability over future time horizons (Evans 2004).

Housing typology and location

Filtering assumes that new construction provides superior housing services to the existing housing stock. Without new dwellings being more attractive than existing dwellings, existing dwellings would not be vacated. If starting from the premise that demand for housing services in a particular location is a function of where households want to be based in order to live and work (either travel to/from or work from home) then housing services are a function of the physical characteristics of the property, location relative to work requirements and characteristics of the neighbourhood. Key policy insights include:

- Planning and design standards can assist in ensuring that new supply more effectively substitutes for older supply. However, this would need to be accompanied by detailed market research to ensure that planning and design standards are responsive to market signals.
- One implication of such an analysis – and use of planning and design standards – might be that the scale of developments (number of dwelling units) is traded off for dwelling stock that is better targeted to local demand characteristics. However, other infrastructure provision also plays a role in the extent to which different locations can become substitutes for each other.

Local housing market contexts, neighbourhoods and social interactions

Filtering is associated with a change in the social characteristics of dwelling occupants, resulting in neighbourhood change. Under the filtering hypothesis, the ageing of the housing stock exerts a sufficiently independent and strong effect to alter the occupancy characteristics of areas over time. However, neighbourhood externalities arising from social interactions – such as the social capital (positive) or cost (negative) arising from the behaviour and interaction with other residents in an area, or perceived status of particular neighbourhoods – also determine demand for dwellings in specific locations (Ioannides and Zabel 2003; Rosenthal 2008). Social capital can be conceived as both a community-level resource, such as the features of neighbourhood social organisation including trust, norms and networks (Putnam 1995), and an individual level resource arising from membership of specific social networks (Bourdieu 1986). In Australia, as elsewhere, social capital is associated with health outcomes (Ziersch et al. 2005). Homeownership is frequently shown to exert a positive effect on social capital formation (Ruskruge et al. 2013). Conversely, public housing tenants in Australia exhibit lower levels of interpersonal trust (Donoghue and Tranter 2012). The strength of neighbourhood externalities arising from social interactions will naturally vary across neighbourhoods. In the Melbourne analysis, proxies for neighbourhood specific social capital and cost are captured by homeownership rate and social housing, prime age workers, and residents with graduate level education.

In some locations, the presence of social interactions substantially complicate the potential of filtering to deliver housing options for low-income households. Social interactions can lead to threshold and tipping point transitions that lock-in area status over longer periods of time (thresholds), but also rapid change following relatively small changes in neighbourhood characteristics (tipping points). Under social interaction conditions and neighbourhood effects, supply side measures may be less effective in generating downwards filtering in some localities. Theoretically, the additional dwelling stock may accentuate existing neighbourhood externalities, or result in conversion of existing dwellings before filtering downwards. That is, additional supply may make areas more attractive (by increasing the strength and concentration of social capital as new residents bring additional social capital to the area; or increasing the supply of local amenities through an increased concentration of purchasing power). Instead of older properties becoming available to lower income households due to a decline in price, these may instead be redeveloped to take advantage of the additional price premium generated by the social interaction effects. Alternatively, very large supply shocks may be required to offset both these effects and generate a surplus of dwellings. Key policy insights include:

- In the presence of externalities or amenities that increase the attractiveness of areas, development options for ensuring a supply of housing for low-income households (in the same locations) is to provide housing options that are matched specifically to income profiles. That is, in these locations supply alone may not reduce the attractiveness of existing properties and thus existing properties do not become available to lower income households.
- For instance, social and affordable housing developments (or mixed tenure developments) provide the ability to ensure a supply of housing is targeted to specific income groups. Such a policy does, in practice, not rely on filtering dynamics – except in cases where a policy substantially alters the social dynamics of these areas.
- The results in Chapter 3 suggests that any impact is likely to vary across neighbourhoods, with lower quartile areas negatively affected by concentrations of social housing in 2006. In comparison, there was no statistically significant effect for upper quartile areas. In other words, the provision of social and affordable housing in particularly high housing cost locations may do less to alter the dynamics of social interactions, than in lower housing cost areas.

The study

While data about property prices is common in Australia, longitudinal data about dwellings and occupant characteristics is much less common. Accessing detailed property level information is typically costly, inhibited by data protection and proprietary data conventions, and requires a very high level of data manipulation and cleaning. As a result, the analysis in this research draws on data that was already available to the research team. Therefore, the data basis and research design differs quite substantially between the Melbourne and Sydney analyses.

Ideally, filtering dynamics would be evaluated in different locations of Australia, using the same methodology. Notwithstanding this limitation, the approach taken here offers a complementary approach to assessing the role that filtering can play in the provision of affordable housing for low-income Australians.

The Melbourne analysis draws on census data (1996, 2006 and 2016), Victorian Valuer General data (valuation data), and Housing Development Data and Planning Data released by the Department of Environment, Land, Water and Planning (DELWP). This data was used to test the role of dwelling (age) characteristics and socio-economic characteristics in the change in relative income status of neighbourhoods (CDs) in Melbourne; and dwelling (age) and planning characteristics and demolition trends. ABS (experimental data) for small area dwelling supply was used for analysis of supply elasticities. Spatial econometric analysis was used to test for the association between relative income change, demolitions and housing supply, and neighbourhood age of dwelling characteristics.

The Sydney analysis draws on New South Wales (NSW) Rental Bond Board data, NSW Valuer General data and NSW Department of Planning Industry and Environment data to chart the property biographies of private rental properties (1997–2019) and establish a depreciation metric for rental dwellings. Detailed statistical analysis is used to chart the nature of new rental supply and tenure transitions, construct a depreciation metric of private rental dwellings as they age and explore spatial differences and filtering-interrupting events.

The aim of the research is to provide insight on how filtering contributes to market-provided low-income housing in Australia. The objectives are to:

1. Critically reflect on the conceptualisation of filtering as a source of housing for low-income households
2. Test for the presence of stylised outcomes associated with filtering dynamics in housing markets.
3. Reflect on policy options for enhancing (if so desired) filtering as a policy tool.

1. Introduction

1.1 Why this research was conducted

The Australian housing system is primarily market-based and privately owned or rented. Private sector new dwelling construction constitutes some 98 per cent to 99 per cent of all dwelling construction (ABS 2020a). Throughout the 1990s and 2000s the rate of dwelling completions to population growth declined (Burke, Nygaard and Ralston 2020), the shortfall in rental housing that was affordable and attainable for lower income households deepened, and the increasingly scarce stock of affordable and attainable housing shifted towards the periphery of Australian cities (NHSC 2013; Hulse, Reynolds et al. 2015; Lawson, Pawson et al. 2018).

As in many other developed countries, Australian policy makers have focused on addressing housing affordability concerns by stimulating the supply of new housing. Since 2000s (but also in earlier periods) a number of Australian Government and state and territory government grants and fiscal measures have sought to stimulate new housing construction, such as demand side subsidies like the First Home Buyers (FHB) Grant. Grants, fiscal and monetary measures were again introduced following the initial COVID-19 lockdowns (June 2020) to stimulate housing construction.

Housing supply policies aim to alleviate housing shortages and thus pressure on property prices and the affordability of housing. One dynamic of market-based supply of housing affordable to low-income households (hereafter low-income housing) that has received attention in Australia, and elsewhere, is 'filtering' (Daley, Coates and Wiltshire 2018; Palm, Raynor and Warren-Myers 2020).

Broadly conceived, filtering is a process whereby properties obsolesce and move down market over time. By implication, new housing supply can, in principle, target housing at any part of the income distribution and still result in additional housing for groups lower down the income distribution. Much of the evidence-base for filtering draws on analysis in the United States of America (US) (see Section 2).

Recent proponents of filtering in Australia see these physical and economic processes, and the ensuing market-based change in occupancy, as viable mechanism for supplying affordable housing for low-income households (for example, Daley, Coates and Wiltshire 2018). In contrast to non-market social and affordable housing, filtering is a market-based process that is characterised as generating *naturally occurring affordable housing* (NOAH). NOAH is not a terminology used extensively in the Australian context. Throughout we therefore predominantly refer to housing for low-income households.

However, filtering is a dynamic process; depending on the circumstances, properties may filter up (reducing affordability for low-income households) or down (improving affordability for low-income households).

The aim of this research is therefore to provide insight on how filtering contributes to market-provided low-income housing in Australia. The objectives of the research are to:

1. Critically reflect on the conceptualisation of filtering as a source of housing for low-income households
2. Test for the presence of stylised outcomes associated with filtering dynamics in housing markets.
3. Reflect on policy options for enhancing (if so desired) filtering as a policy tool.

In analysing filtering as a source of low-income housing a distinction needs to be drawn between 'filtering dynamics' as a physical and/or economic process that results in the supply of housing for low-income households, and filtering as a housing policy. Policy is a set of principles and instruments to guide the attainment of specific outcomes. Pawson, Milligan and Yates (2020:9) define housing policy as 'government actions or policy settings that influence (a) the supply of dwellings and its spatial distribution, (b) characteristics and management of the stock, and (c) who gets access to housing and on what terms'.

In policy terms, filtering potentially provides a market-based alternative to direct (non-market) provision of housing provision. Non-market provision of housing typically comes with a set of access (often income related) and governance rules (such as tenure security) that shield low-income households from the price competition in market housing.

However, filtering as a source of affordable low-income housing rests on a number of enabling assumptions. First, housing assets become increasingly obsolete as they age. Obsolescence can be due to physical depreciation (absolute obsolescence), or economic obsolescence (relative obsolescence driven by technology, design or architectural changes) and locational obsolescence. Secondly, new properties must provide a superior level of housing services (quality). Thirdly, demand for new properties is income elastic. Fourth, and crucially, the rate of net new dwelling construction exceeds the rate of household formation. The first, second and fourth of these assumptions are inherently shaped by institutions, wider governance objectives and social interactions.

The applicability of these assumptions across different housing markets varies; consequently findings on the effectiveness of filtering as a source of low-income housing is mixed (Grigsby 1963; Galster 1996; Yates and Wood 2005; Rosenthal 2008; Weicher, Eggers and Mourmen 2016). Some studies (Margolis 1982; Skaburski 2006) find limited evidence of filtering, or that the processes of filtering operate too slowly to be a viable source of housing for lower income households. In analyses by Rosenthal (2014) filtering may not be effective across all segments of the housing system, particularly where the price elasticity of supply is low (Rosenthal 2014).

Housing supply in Australia will, for the foreseeable future, remain dominated by private sector supply and demand. In understanding the conceptual basis and its relation to housing market dynamics in Sydney and Melbourne, the research analyses whether filtering dynamics are evident and its basis for housing policy development in Australia.

1.2 Policy context

Housing affordability for private renters and home buyers in Australia has broadly deteriorated since the 1980s (Yates 2015; Thomas and Hall 2016; Burke, Nygaard et al. 2020). Since 2006, worsening housing affordability has contributed to a decline in aggregate homeownership rate (Hall and Thomas 2019; Burke, Nygaard and Ralston 2020). Research for AHURI shows that, for Australia as a whole and each state and territory, there is a current shortfall of some 430,000 properties to meet the housing needs of low-income households. This shortfall is projected to grow in coming decades (Lawson, Pawson et al. 2018). The shortfall in supply of housing to meet the housing needs of low-income households sits within a context of a declining rate of dwelling completions relative to population growth between 1993 and 2009. This declining rate of completions has only marginally reversed in the last decade, but remains below the average completion to population growth ratio between 1993 and 2005 (Burke, Nygaard et al. 2020). This decline in completions relative to population growth was primarily driven by an increase in the rate of population growth, rather than a decline in the number of completions. The number of completions remained largely unchanged throughout this period, exhibiting little responsiveness to changes in demand (low elasticity of supply).

The decline in the ratio of dwelling completions to population growth over this period also coincides with a shift towards greater emphasis on 'compact city' urban planning strategies and infill development, which seeks to mitigate the urban and environmental footprint of Australia's cities (Newton, Meyer and Glackin 2017). Urban infill targets in Melbourne and Sydney approached 70 per cent in the last decade, leading to an increase in higher density and multi-unit dwelling structures (Newton, Meyer and Glackin 2017) – a trend that has lasted somewhat longer in Sydney than in Melbourne (Bunker, Crommelin et al. 2017).

The impact of worsening housing affordability has been particularly marked for younger and lower income households (Burke, Stone and Ralston 2014; Yates 2015; Hall and Thomas 2019). In a series of reports for AHURI, Hulse and collaborators track the decline in availability and affordability of private rental properties for lower income households (latest Hulse, Reynolds et al. 2019). According to the Productivity Commission, half of low-income households in private rental pay more than 30 per cent (rental stress) of income on housing costs (PC 2020).

A number of housing policies are in place to address aspects of housing affordability for low-income households:

- Public and community housing (social housing) provides access to housing at below-market rents. However, the share of households living in social housing has declined over the past two decades and currently constitutes around 4 per cent of households (PC 2020). Annual Australian Government expenditure on social housing (through the Commonwealth State Housing Agreement, then National Housing and Homelessness Agreement) has remained nearly unchanged in nominal terms over the last two decades ($1.4 billion in 2000–01; $1.6 billion in 2019–20, the latter figure includes National Partnership agreement on remote housing expenditure) (PC 2002; PC 2020).
- Commonwealth Rent Assistance (CRA) provides an income supplement to eligible households (broadly benefits recipients) that can offset housing costs. Since 2000, the number of CRA recipients increased from 937,078 income units, to 1.4 million income units in 2019–20 (PC 2001; PC 2020). Over the same period, Australian Government expenditure on CRA increased from $1.7 to $4.7 billion (PC 2002; PC 2020). While CRA cost is regulated by rent thresholds and the fraction of assistance provided over the threshold, declining private rental affordability increases the number of households eligible for some and the maximum rate of CRA. Since rents are market determined, public expenditure on CRA is, to a degree, regulated by market processes.
- Direct assistance to foster entry into homeownership through a series of Australian Government and state and territory government grants to First Home Buyers (FHB), stamp duty rebates or deposit guarantees. Direct assistance has figured as part of the policy landscape since the 1960s, but was reintroduced (after an absence in the 1990s) in 2000 (Kupke and Rossini 2014). Unlike social housing and CRA policies, direct assistance to homeownership entry does not specifically target low-income households. Moreover, to the extent that such assistance is capitalised in property prices, the cumulative effect on low-income households may be overall detrimental.

While these policies have been effective in addressing housing costs for some Australians, they have been insufficient to address the broad trends in housing affordability emerging over the past few decades. Moreover, both costs (in terms of CRA) and spatial impacts (FHB assistance constitutes a larger proportion of housing cost in many outer and lower price city locations) are to some extent determined by market processes.

More recently, filtering has been proposed as a viable solution to improving affordability and housing supply for low-income households in Australia (Daley, Coates and Wiltshire 2018).

1.3 Previous Australian research

A fuller review of the literature on filtering is provided in Chapter 2, where we examine the key assumptions underpinning filtering, the complicating factors of space and tenure, and their relation to policy development and supply of low-income housing. Here we introduce the basic concepts of filtering and some of the leading studies with which the Melbourne and Sydney analyses engage.

A considerable amount of research has focused on scaling up the supply of affordable housing for low-income households (such as Rowley, James et al. 2017; Milligan, Pawson et al. 2017; Nygaard 2019). Many of these focus on the provision of housing for low-income households through social and/or private rental housing, underpinned by blended financing of new (below market) rental supply, using planning levers to ensure (reserve) land and housing supply for lower income households, and innovations in the management and ownership of public housing (Milligan, Pawson et al. 2017).

By comparison there has been relatively little research in Australia on filtering processes that may lead to naturally occurring affordable housing, or on filtering processes as housing policy for housing provision for low-income households. Much research draws on evidence from the United States (US) where there are important housing market dynamics that are not equally applicable in Australia. In particular, while Australian towns and cities practiced segregation against Indigenous people, US cities are arguably more differentiated by the effects of racist policies and practices.

In terms of Australian research, Yates and Wood (2005) and Palm, Raynor and Warren-Myers (2020) examine price filtering in private rental housing in Sydney and Melbourne, respectively. Yates and Wood (2005) examine the probability that private rental properties with a low real rent in 1991 filtered up (increased real rent) or down (decreased real rent) over the next decade.[1] Their results show that lower price rental units in 1991 were more likely to filter down (a reduction in real rents) than filter up (an increase in real rents). Rather than higher priced rental dwellings becoming more affordable over time, Yates and Wood (2005) observe an increasing polarisation of the market and neighbourhoods over this period, with properties filtering in opposite directions. One explanation for this outcome is related to restricted land supply in inner Sydney, with market adjustments leading to upwards pressure on land prices and rents.

A key determinant of filtering is a property's age. This is not controlled for in Yates and Wood (2005). Palm, Raynor and Warren-Myers (2020), on the other hand, estimate a hedonic price model of private rental prices in 2011 and 2016 with the inclusion of a non-linear age of dwelling term. The quadratic age term suggests that both old and new rental properties are higher priced than rental properties built in the post-war era (50 to 70 years ago). While a u-shaped age relationship is not inconsistent with filtering, the authors also examine whether today's affordable properties in this age range initially were built for higher income households. They conclude that most of today's affordable stock in this age segment was initially built as social housing or housing targeting low-income households. This finding resonates with Yates and Wood's (2005) finding that low-price rental units are more likely to filter down than up.

A key policy implication from the filtering thesis is that, in principle, new housing can target any part of the market, and still result in additional housing for low-income households. There is no direct testing of this proposition in Australia. Nevertheless, the examination by Hulse, Reynold et al. (2019) of trends in available and affordable private rental housing in Australia is suggestive. Rents are divided into quintiles (R1-5) and matched against income quintiles. Their analysis shows a near doubling of the private rental stock in the R3 quintile (mid-range) (2006–16). However, over the same period, the shortage of rental properties that were available and affordable to lower income households continued to worsen.

Trends in housing affordability are the outcome of a series of socio-demographic, population growth, financial and economic determinants that become capitalised in property prices and rents. The effects of these determinants are, however, not uniform across housing markets or across income groups. For instance, household growth (population growth and/or smaller households), increases the requirements for housing units in absolute terms. Employment concentration, agglomeration economies, income differentials and fiscal policies affect the spatial dynamics of demand for housing and types of housing. Planning and environmental strategies, such as compact city forms and land availability, shape the geography of housing supply (and cost) and types of housing.

1 Yates and Wood define filtering in absolute terms; that is, a change in real rent, as opposed to a change in relative rent (the rate of rent change relative to other rent change).

1.4 Research methods

Filtering is a dynamic process reflected in the price and quality characteristics of dwellings, and occupancy characteristics of dwellings, over time. In analysing filtering dynamics in the Melbourne and Sydney housing markets, and implications for housing policy development, the project uses a mix of conceptual, statistical and econometric analysis.

We have employed different approaches in the Melbourne and Sydney analyses, primarily because of differences in the available data. Notwithstanding this limitation, the approach taken offers a complementary method to assessing the role that filtering can play in the provision of affordable housing for low-income Australians. In broad terms, Sydney and Melbourne share similar urban economy characteristics and housing market pressures. Filtering dynamics are expected to differ across tenures so that the Melbourne analysis (occupancy of housing stock and sales transactions) and Sydney analysis (price dynamics in private rental housing) provide insights into filtering across metropolitan housing systems in Australia.

Presented in Chapter 3, the Melbourne analysis focuses on the change in occupancy characteristics at an area level as a function of dwelling age, spatial characteristics, and a number of variables capturing social interaction and neighbourhood effects. The modelling follows US research into the role of filtering in neighbourhood change (Rosenthal 2008). Relative filtering of income states is analysed econometrically; relative filtering tests the extent to which the social status of Melbourne census collection districts (CD) filter up or down between 2006 and 2016. Relative incomes are calculated using the median income category for each CD in each census year, divided over the median income category for Melbourne as a whole.

The Melbourne analysis also considers the price elasticity of supply and demolition rates. For new housing supply to generate the surplus of housing required to generate downward pressure on prices, the supply of housing needs to be responsive to price changes. Housing supply exceeding the rate of new household or demand formation is a requirement for filtering to provide affordable housing for low-income households. Demolition rates in different sub-markets (such as higher versus lower income areas) provides insight on the likelihood of dwellings filtering down or redevelopment before reaching lower income households. As with relative income status, the price elasticity of supply and demolition rates are analysed econometrically.

Chapter 4 presents the Sydney analysis, which is directed more towards the body of Australian research on the supply and location of low-cost private rental housing (Hulse, Reynolds et al. 2019; Randolph and Tice 2014; Yates and Wood 2005). This analysis adopts an experimental ‘property biography’ approach to filtering, examining where the present stock of rental properties, including those affordable to low-income households, has come from in terms of tenure, rental price point, and development history. This approach offers new insights into the changing shape of the rental market captured by that body of research, including into the likely condition of properties in the affordable rental segment, the type of landlord who owns them, and how long they may remain affordable rental housing.

The policy implications of both analyses are considered together in Chapter 5.

2. Conceptualisations of filtering

- **Residential filtering is a process whereby the supply of new dwellings for higher and middle-income households also can lead to additional supply of dwellings for lower income households as higher income households vacate older dwellings for newer dwellings. Theoretically, dwellings may filter over time through successively lower market segments or sub-markets.**

- **Conceptually, filtering contains a price/quality element and an occupancy element. Empirically, filtering can thus be measured as changes in absolute or relative property prices, and occupant or neighbourhood profile (such as social status).**

- **The analysis of filtering is closely associated with sub-market analysis. They both aim to inform housing policy formation under market dominated approaches. Filtering stands as a potential alternative to direct (non-market) provision of affordable dwellings for low-income households.**

- **Filtering is a dynamic aspect of housing markets. For filtering to effectively ensure a supply of housing for low-income households, the rate of new housing supply needs to exceed the rate of new household formation and/or housing demand, thereby creating a surplus of dwellings. However, a surplus in one sub-market does not necessarily lead to impacts on other sub-markets. Effects across sub-markets depend on the degree of substitutability between sub-markets. It also depends on sub-market specific conversion to higher or lower quality segments, non-residential use and abandonment (that is, property owners often have multiple options when faced with new supply in an area). A number of recent US studies find that filtering constitutes a key source of low-income housing supply. The impact on the affordability of low-income housing is, however, contingent on the housing market context.**

- **Theory and empirical analysis suggest that filtering as a source of low-income housing supply differs across owner-occupied and rental sectors. The rate of filtering is inversely related to the average length of residency in dwellings. The age of dwellings is a frequent proxy for quality and obsolescence. Filtering dynamics are thus more pronounced in the private rental market.**

2.1 Introduction

House prices reflect the interaction of supply conditions with households' desire to live and work in particular locations (Glaeser and Gottlieb 2009). Filtering, in turn, is concerned with the dynamics of housing markets. Specifically, filtering is evidenced by changes in price and quality characteristics of housing stock over time, and the movement (relocation) of households that follows because of these processes (Grigsby 1963; Galster 1996). In colloquial terms, and as a source of low-income housing supply, filtering is taken to describe a process whereby properties that once were out of reach for lower income households, become accessible due to a decline in property or rental values following new supply. This market-based logic is also evident in recent Australian analysis. This analysis suggests that any new housing supply improves housing affordability for lower income households by adding to total supply (Daley and Coates 2018). In policy terms, filtering potentially provides a market-based alternative to direct social housing provision as a means of addressing housing supply and affordability for low-income households.

A critical assumption in this market-based interpretation of low-income housing supply is that a chain of substitution exists that, in theory, encompasses the entire housing market of a city. However, housing is an immobile, durable and heterogeneous commodity. The issue of where a property is located may matter as much (or more) than what a property is. In the housing market literature, the location of properties and the characteristics of properties has given rise to sub-market analysis (Grigsby 1963; Maclennan and Tu 1996; Bourrasa 1999; Clapp and Wang 2006). In practice, the housing markets of our cities consist of a system of interconnected housing sub-markets (Galster and Rothenberg 1991), defined by both geographic and dwelling characteristics.

A large body of theoretical and empirical housing literature has engaged with filtering (and sub-market analysis). This literature, in part, emerged with a view to improve housing policy formation under market principles (Galster 1996). In this chapter, we examine key conceptual and empirical aspects of filtering as a mechanism for affordable low-income housing supply.

2.2 The dynamics of filtering

Filtering as described above contains two elements: first, a change in price/quality;[2] second a change in the occupancy. While the second elements potentially is related to the first, these processes can in practice be distinct (Grigsby 1963). The two processes are related when depreciation and/or obsolescence result in property quality changes over time, resulting in dwellings potentially passing through successively lower quality levels. In this process quality changes are reflected in lower market prices enabling lower income households to occupy properties once occupied by higher income groups.

2 Filtering can be analysed as a change in relative prices. For example, compared to all other properties; compared to the general price level; and compared to incomes.

2.2.1 Filtering and price dynamics

Change in property prices may follow from the ageing of properties (depreciation) and insufficient repairs to keep the quality level constant. The age characteristics of properties has thus been an important empirical component of filtering analysis. The potential role of depreciation in supply of low-income housing critically depends on properties being vacated. Depreciation of housing assets (and so a decline in property prices) is not necessarily accompanied by demand for new housing. Maintenance of existing properties reflects household incomes and preferences for a particular level of housing quality. Declining quality (alone) may thus not compel owners to purchase a new (more expensive) property (and so vacate an existing property).[3] A decline in property prices (due to lower quality) does therefore not necessarily lead to an exchange of property and, therefore, a change in occupancy. The situation may differ in the rental sector. Due to the higher turnover of residents in rental markets (independent of quality) adjustment in housing quality through depreciation may also more quickly be reflected in the tenant profile of residents.

Change in property prices may also result from technological or style obsolescence. For instance, improvements to building standards and/or design aspects of newer properties may make existing properties less attractive, also where quality otherwise is kept constant. And, property prices change as a result of households' desire live and work in particular locations. A change in the location of employment opportunities may thus lead to locational obsolescence. Technological, style and locational obsolescence can each result in demand for new construction. Technological and style obsolescence may be addressed by renewal of existing housing. However, locational obsolesce would likely lead to demand for housing in other locations. Filtering is thus also associated with neighbourhood dynamics.

The supply of new housing – at least equivalent in technological, style or locational characteristics – thus creates a surplus of properties that may have a price reducing impact. Sweeney (1974; 1974b) introduced the notion of a commodity hierarchy (for housing units) and theoretically analysed the impact of new supply at each housing hierarchy level.[4] The existence of sub-markets has two implications for filtering (Galster and Rothenberg 1991). First, the sub-market experiencing additional supply (or demand) may adjust independently of other sub-markets. This follows from restricted substitutability across sub-markets. However, and second, there is some substitutability also across sub-markets. Changes in one sub-market will thus also have repercussions in other sub-markets.

The extent to which new supply impact housing market dynamics in near (substitutability wise) sub-markets is inversely related to the quality differences between sub-markets (Galster and Rothenberg 1991), and the supply and demand dynamics of each sub-market (Sweeney 1974; 1974b). Moreover, unless all properties are perfectly substitutable (negating the notion of sub-markets), the effect of new supply weakens with distance (quality wise) from the sub-market experiencing supply. That is, properties are converted to other sub-markets (up and down), converted to non-residential uses, remain vacant, or are demolished. With respect to filtering as a source of low-income housing, sub-markets imply that new middle or higher income housing supply does not necessarily generate any impacts on the price dynamics or availability of low-income housing.

3 Maintenance and refurbishment may also keep the quality of properties constant or improved. There is thus no easy relationship between dwelling age and dwelling quality.

4 Sweeney's analysis abstracts from locational differences, but provided a theoretical framework for analysing depreciation, demolition, new construction, filtering and prices in housing markets.

2.2.2 Filtering and occupancy dynamics

The second element of filtering as described above focuses on change in occupancy. When some households vacate existing housing for new housing construction (or because of locational obsolescence), the properties they vacate may become home to households with lower incomes than those that left. This is a particular manifestation of a vacancy chain, models of which can be used to gain insights into local housing markets (Nordvik 2004). This approach to filtering has a distinct focus on who lives in properties over time. The approach assumes that as property values decline different households (with successively lower social status) will occupy dwellings.[5] Price dynamics, as described in 2.2.1, initiate this process, but by focusing explicitly on occupancy, the issue of price change without occupancy change (and so supply of housing for low-income households) can be addressed. Under this conceptualisation the social status of areas change (declines) as dwellings age.

Rosenthal (2008; 2014) test this proposition empirically. In Rosenthal (2008) neighbourhood change is modelled as a function of the age characteristics of properties as well as a set of variables capturing social interactions. The study found that age characteristics and social interactions largely affect neighbourhood status independently of one another and therefore concludes that filtering is an independent source of housing supply for low-income households. Notably, this focus on occupancy does not reveal whether housing also is more affordable to low-income households.

Rosenthal (2014) considers the occupancy of specific properties by observing the income characteristics of residents in a panel of properties. The study shows that, over time, new entrants into older properties typically have a lower income status than new entrants into recently constructed properties. This effect is particularly pronounced in the private rental sector where the income of occupants (relative to the age of the property) declines at a rate of 2.5 per cent per annum. The effect in the owner-occupied sector is much weaker—bordering on negligible at 0.5 per cent per annum. These outcomes are consistent with the theoretical literature on commodity (property) hierarchies. For instance, in Sweeney (1974; 1974b) the rate at which properties filter is inversely related to the average time that a resident stays in properties at different quality levels.

However, the decline in real incomes of new entrants does not necessarily indicate that affordability for the entrant has been improved. For instance, Zuk and Chapple (2016), using the results in Rosenthal (2014) shows that while the income of new entrants (in the San Francisco Bay Area) declined by 1.5 per cent per annum, their rents only declined by 0.3 per cent per annum. Rosenthal too points out that filtering is more pronounced in housing markets with low price inflation.

Mast (2021) similarly focuses on occupancy of new construction by tracing migration chains. In line with the price dynamics described in Section 2.2.1, there is some substitution across sub-markets (from higher to moderate income; and moderate to lower income), but the effect weakens across the income groups. In this study, the construction of 100 new market-rate building houses 100 residents results in 45 to 70 residents moving out of below-median income neighbourhoods. However, while new construction thus leads to household mobility, and so potentially neighbourhood change, the study also concluded that the price effect in the low-income housing segment is likely to be negligible due to already higher vacancy rates in this market segment.

2.3 Particulars of filtering for supply of affordable housing for low-income households

The above discussion of price and occupancy dynamics has a number of implications for filtering as a source of affordable housing supply for low-income households, including:

1. For new construction to have an appreciable impact on specific sub-markets and across sub-markets, new supply needs to exceed demand (Galster 1996). For instance, the replacement of one obsolescent property for a new property does not generate an increase in supply.

5 This conceptualisation is also close to the earlier colloquial understanding of filtering.

2. Sub-market specific new supply is more likely to generate a filtering effect when substitutability between different sub-markets (quality and location) is greater. When substitutability across sub-markets is low any filtering effect diminishes across a hierarchy of sub-markets. Housing supply at the higher end of the price spectrum is thus less likely to generate meaningful affordability impacts at the lower end.
3. Even where filtering does work, it may not result in an increase in the supply for affordable housing (for low-income households). Conversion and removal may result in the stock of low-income housing remaining unchanged. The process may nevertheless yield welfare enhancing outcomes *if* low-income households obtain access to, quality wise, superior housing as a result.
4. Unless new construction leads to a persistent oversupply of dwellings in low-income housing sub-markets, the cost of housing (affordability) may not improve.
5. The drivers of obsolescence do not necessarily work in the same direction. For instance, specific locations may become more desirable at the same time as the properties in those locations style-wise become less desirable. The net effect of this is difficult to predict. Consequently, the relationship between the age of dwellings, a frequently proxy for quality and obsolesce in the literature, and filtering dynamics is complex.
6. Filtering dynamics can be traced in neighbourhood dynamics.
7. Turnover of residents is higher in rental properties than in owner-occupied properties. The speed with which filtering dynamics are felt across interconnected sub-markets are thus likely very different. This also follows from Sweeney's (1974; 1974b) analysis where the rate of filtering is inversely related to the average length of occupation of housing products.
8. While new construction in many cases will generate within and across sub-market effects (such as through migration ripple effects), the affordability impact in lower income housing markets may be negligible (or even worsen).

Several of these dynamics are illustrated in a recent US study. Weicher, Eggers Mourmen (2017) use the American Housing Survey to track the US housing stock over three decades (1985–2013). In this period, the overall stock of housing increased significantly, but the share of rental housing affordable to lower income households remained largely unchanged. Over the period, some affordable rental stock disappears (due to gentrification, or changes to a non-residential use) and new affordable rental stock is added. In this study, some 62 per cent of new affordable rental housing is the result of filtering. Overall, the addition of affordable rental housing exceeds the rate of loss through gentrification by a ratio of 3:1. A key source, particularly after 2005, of new affordable housing was tenure shift – housing switching from owner occupation to rental. This research also found that the most common reason for loss of affordable rental stock was that a dwelling was no longer providing housing services at all.

In the following sub-sections we consider some of these insights in further detail.

2.3.1 Rate of dwelling supply and household formation

A key requirement for filtering to address the affordability as well as supply of low-income housing is that new construction creates an ongoing surplus of properties in the sub-market where new supply is provided, and that this surplus has a spillover effect to nearby (substitutability-wise) sub-markets. More formally, an assumption is that the rate of net new dwelling construction exceeds the rate of household formation (Grigsby 1963; Galster 1996).

Where new housing supply simply matches new demand (from new household formation), the effect of filtering may be limited or absent. In this case, new supply may not lead to 'freeing up' of dwellings for low-income households. Where the supply of housing is insufficient to meet new demand, housing affordability may even worsen in parts or throughout the dwelling chain. Burke et al. (2020) shows that new dwelling supply declined relative to the population growth after the 1990s, with some improvement in the mid-2010s. In this case, excess demand in specific sub-markets, or the housing system as a whole, is likely to result in an increase in property prices. Worsening affordability may also give rise to changes in household formation (Meen and Andrew 2008) and to more intensively utilised housing stock (crowding) that may have welfare reducing outcomes without reducing price of housing.

The required rate of dwelling construction is also conditioned by income growth. Housing is typically considered an income elastic good (as income increases households consume larger and/or higher standard housing). Meen and Andrew (2008) show that the rate of dwelling construction required to stabilise price appreciation thus depends on both population and income growth.[6] As incomes increase, the very lowest quality housing may become abandoned or empty without exerting downward pressure on dwelling prices in the lowest price segment. Income growth may thus lead to economic obsolescence of dwellings and demand for new construction.

2.3.2 Quality and obsolescence

A key driver of filtering is obsolescence of housing assets. Obsolescence can be due to physical depreciation, and to economic obsolescence (driven by technology, design or architectural changes, and locational preferences). While maintenance costs typically increase for older properties, the spatial effects of this process vary considerably.

In the literature, the age of properties is often used as a proxy for obsolescence. Since the distribution of housing by age is not typically random across cities, this can manifest itself in entire neighbourhoods filtering 'together' in cycles of decline and redevelopment (Rosenthal 2008; Brueckner and Rosenthal 2009). A consideration here is that many filtering studies take place against an urban form history with significant suburbanisation and urban sprawl. Densification, infill and urban growth (containment) strategies can in this respect alter context, key price determinants and residential relocation patterns.

However, the extent to which older housing becomes physically obsolete is also a function of capacity and incentive to re-invest in and maintain housing over time. Some owner-occupiers (such as those with higher incomes or locationally more attractive neighbourhood) may have greater incentives to do so (Davis and Whinston 1961). Social interactions and neighbourhood effects can thus condition the extent to which the age characteristics of dwellings independently determine the price and occupancy characteristics of dwellings, and demand for particular locations (Rosenthal 2008; Ioannides and Zabel 2003).

Similarly, the spatial dynamics of many cities change over time making older housing more desirable again. For instance, inner city revitalisation, employment growth and liveability have over time increased demand for older housing and neighbourhoods in many Australian cities. Physical obsolescence may, in this perspective, not necessarily imply economic obsolescence. Under these conditions, older neighbourhoods may experience a mix of knock-down and replacement (Wiesel, Freestone et al. 2013), as well as refurbishment and improvement. Over time, a straight age-quality relationship becomes a less precise measure of filtering.

An important consideration here is also the political economy and institutional (including planning) determinants of new housing supply. Inner city redevelopment is often accompanied by more intensive land use (densification). However, in many cities this process is spatially uneven, again decoupling age-related demand characteristics. In Sydney, in particular, new greenfield housing has been less of a premium product for some time. Housing market segmentation by demand geography (Randolph and Tice 2014) shows that the 'suburban conveyor belt' of households moving out to new dwellings stopped in Sydney's southwest. Empirically, these processes are sometimes captured by including non-linear terms for housing age, but overall it is clear that age is only a partial indicator of quality.

For filtering to work, the rate of obsolescence needs to exceed the rate of house price appreciation for older property to decline in value relative to other stock (Rosenthal 2014). However, house price appreciation is spatially uneven and frequently linked with planning policies and local political economy that is endogenous to income and other socio-economic factors (Hilber and Robert-Nicoud 2013). Thus, the factors resulting in attractive social interactions, may also shape the nature and volume of housing supply in a manner that further restricts the ability of supply side measures to generate filtering outcomes, and ensure that new housing supply does not exceed the formation of new households (in an area).

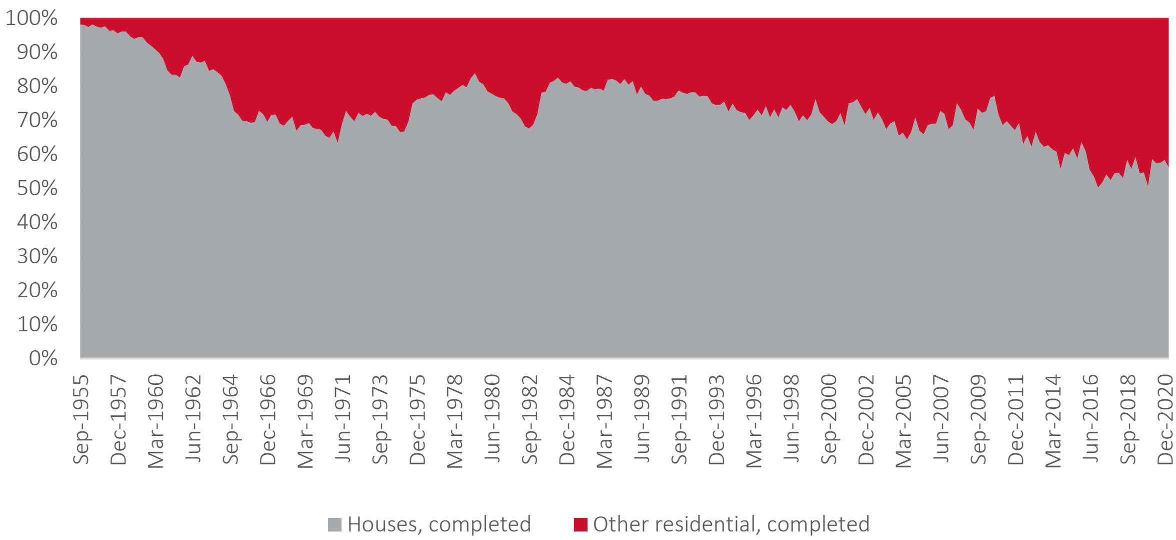
6 Demand for housing is also responsive to changes in the user cost of capital (UCC). The UCC is a measure of the real cost of purchasing a property in a given period (month, quarter, year). It incorporates both interest rates and capital gains expectations. A reduction in interest rates and/or an increase in capital gains expectations further increases the demand for housing. As a consequence the rate of new housing construction required to stabilise house price trajectories increases further (Meen and Andrew 2008). Capital gains expectations may also vary spatially, for instance as a result of gentrification processes and/or locational obsolescence.

2.3.3 Sub-market substitutability

Filtering as an affordability or housing supply policy for low-income households presupposes a degree of substitutability between sub-markets. In line with what constitutes sub-markets, substitutability thus has property specific (such as houses, low rise and high rise apartments) and area specific (such as geographic factors like inner and outer city, or classifications like gentrified and non-gentrified areas) dimensions. The higher the degree of substitutability, the greater the potential ripple effects generated by new supply in any particular property or area dimension on other property or area dimensions. In the absence of substitutability between sub-markets, new supply in one sub-market may simply result in within-sub-market adjustments (such as conversion, demolition or re-purposing), rather than generating ripple effects to other sub-markets. A low degree of substitutability thus means that the effect of new supply either does not ripple across to other sub-markets at all, or that the ripple effects do not extend very far. For example, vacancy chains may not extend across to sub-markets typically occupied by lower income households.

In Australia (as well as internationally) a planning and regulatory focus on compact cities, infill development and urban densification has contributed to an increasing supply of apartment developments. Rising land values similarly contributes to densification.[7] The process of densification is spatially somewhat broader in Sydney than in Melbourne (ABS 2018), but in both cities there has been considerable compositional change in new dwelling supply.

Figure 1: Residential construction of houses and other dwellings, 1955–2021



Source: ABS 8752.0 Dwellings completions.

Differences in dwelling types potentially manifest themselves in differences in housing services. Melbourne and Sydney are, by international standards, predominantly low-density and sprawling cities. From a filtering as housing policy perspective in Australia, the supply of apartments needs to be an effective substitute for existing dwellings to generate spillover effects between sub-markets.

For Australia as a whole, Figure 1 shows private sector total construction of houses and other residential dwellings since 1955. While there is a gradual increase in other residential dwellings since the 1980s, there is a marked acceleration in the proportion of flats and apartments being developed after 2006. The expansion of flats and apartments since 2006 also marks an acceleration of high-rise living. For instance, some 25 per cent of apartments in 2006 were four-storeys or more. By 2016 this had increased to 38 per cent (ABS TableBuilder). Chapter 3 provides additional detail on dwelling approvals by housing typology for Melbourne.

7 Land values and planning are not necessarily independent of each other. We do not explore the reasons for rising land values in this report, but note that planning and economics forces (such as agglomeration) separately and jointly are related to land value increases.

Residential densification (and additional housing supply) in inner city locations may provide an effective substitute for newly formed households (domestic and international) due to proximity to inner and middle ring employment. However, in the absence of a surplus of dwellings, competition for attractive locational characteristics may also result in higher rents and housing costs. Moreover, in the absence of a dwelling surplus, the price and availability impacts of new supply may have limited impact on low-income sub-markets. For instance, Australia experienced (2006–16) an increase in the supply of rental properties supplied at moderate to middle price range (second and third quintile of rental prices) (Hulse, Reynolds et al. 2019). A priori one might argue that these are properties that sub-market wise are close to the low-income price range or sub-market. If new supply results in filtering then a positive – either price (affordability) or availability – impact on low-income renters is expected. However, over the same period, affordability and availability has worsened for low-income renters (Hulse, Reynolds et al. 2019).

The area dimension is also related to a distinction between high and low demand areas. High and low demand areas may reflect geography and proximity to labour markets and other urban amenities, but also neighbourhood specific effects such as gentrified and non-gentrified areas.

US filtering studies show fairly consistently that filtering is a weak source of affordable housing in areas (and cities) experiencing high demand (house price growth) (Rosenthal 2014).

In terms of the supply and demand dynamics conditioning within and across sub-market effects, the implication is that new supply may not suffice to generate a surplus of dwellings, and thus a price dampening effect. From a social policy perspective, in high demand areas there is substantial evidence of displacement of lower income households (Pawson, Hulse et al. 2015; Zuk and Chapple 2016. In Australia, there is an increasing suburbanisation of low-income households and disadvantage (Randolph and Holloway 2005; Pawson, Hulse et al. 2015). Differences between overall regional and local outcomes is also evident in the US literature, including that by Zuk and Chapple (2016) for the San Francisco Bay area, and Rosenthal's distinction between high and low demand areas (2014). The empirical literature finds that the direction of filtering often is conditioned by neighbourhood characteristics, resulting in increased polarisation (Somerville and Holmes 2001; Yates and Wood 2005; Skaburski 2006). In the later empirical analysis of this report, socio-economic characteristics are used as proxies for social interactions that might generate neighbourhood effects.

The dwelling type and geographic dimension of substitutability introduce considerable complexity in how filtering might also work as a source of additional affordable low-income housing and as a substitute for directly supplied low-income housing (such as social housing). Even where the processes of filtering might work, for instance, through a decline in relative or absolute prices, the rate at which properties filter may be insufficient to improve the affordability of housing for low-income households. In addition to the Rosenthal (2014) and Zuk and Chapple (2016) studies mentioned above, Margolis (1982) and (Skaburski 2006) find limited evidence of filtering, or that the processes of filtering operates too slowly to be a viable source of housing for lower income households.

With respect to both dwelling type and location, the filtering potential of new supply is critically conditioned by the substitutability. The greater the dissimilarity between sub-markets (along these dimensions), the less the effects of new supply in one sub-market are likely to felt in other sub-markets.

2.3.4 Dwelling conversion costs

The above discussion primarily focuses on new supply (construction) and adjustments within and across sub-markets. Importantly, owners of properties in any given sub-market have multiple options available to them (Galster and Rothenberg 1991). New supply in any given sub-market may lead to a change in relative prices. For instance, the rents obtainable for existing properties may decline relative to new properties. As a consequence, landlords may reduce their maintenance expenditure (to maintain yields), resulting in further depreciation and change in quality level (crossing over of property from one quality sub-market to another). However, landlords may also decide to refurbish in order to upgrade existing properties to maintain yields, convert to a non-residential use, or abandon or demolish the property altogether.

At sub-market level, conversion costs (to either of these alternatives) thus determine the extent to which properties filter down or up (Galster and Rothenberg 1991; Galster 1996). For instance, Galster (1996: 1802) argues that the vacancies (and lower prices) triggered by new premium supply can constitute better value for some. This is because the decrease in price exceeds the decrease in quality, enabling some households to move up in quality. However, lower relative prices may also induce some households who are seeking accommodation in a higher (quality-wise) sub-market to relocate to the sub-market experiencing new supply. The net effect (rising or falling) in terms of market prices, quality changes and occupancy characteristics for any given sub-market may thus be indeterminate. Moreover, costs also condition the extent to which market adjustments following new supply (for instance, price declines) persist or dissipate over time (Galster 1996).

Dwelling specific conversion costs are conditioned by institutional factors, most notably planning regulations that regulate how and what conversion and reinvestment might take place, and the price elasticity of supply (Hilber and Robert-Nicoud 2013). They might also be conditioned by neighbourhood social interactions, such as the presence of social housing or wider tenure considerations.

2.3.5 Tenure

Capacity and incentive to re-invest or maintain may also be a function of tenure. The rate of physical depreciation of rental (both public and private) properties may well be greater than that of owner-occupied properties. Both Rosenthal (2014) and Weicher, Eggers and Mourmen (2017) find that the rate of filtering is greater for rental properties than owner-occupied properties. Rental properties 'filter' at a rate that is approximately five times faster than owner-occupied properties.

These tenure differential processes again have spatial implications. Areas with greater proportions of rental properties can, over time, expect to concentrate a greater proportion of lower income households. As noted above, the extent to which income filtering (the decline in tenant income) also reflects improvement in affordability depends on whether income changes are smaller (improving affordability) or greater (worsening affordability) than housing cost changes.

Historically, the penetration of institutional investors in purpose-built private rental markets in Australia has been limited. Rental housing, particularly private rental housing, was a key source of low-income housing supply (Hulse, Reynolds et al. 2019). However, over the 2000s, there has been a structural shift with an expansion of private rental housing at mid-market and higher market prices. Tenure change may also constitute part of the filtering process itself. For instance, a property might trade down through successive owner-occupiers before being sold to a landlord, or let by an erstwhile owner-occupier or their heirs. As a rental property, it might continue its downward drift, or go back up the income distribution, let to a higher income household. Tenure changes complicate the filtering story. As Nelson and Vandenbroucke (1996) characterise it, rental housing may become 'lost, stolen or strayed' – respectively, leaving the rental market, becoming occupied by a higher income household (filtering up), or filtering down (see also Yates and Wood 2005).

In a series of reports for AHURI, Hulse, Reynolds and Yates (latest Hulse, Reynolds et al. 2019) find a growing mismatch between the income characteristics of tenants and the rental characteristics of properties. Low to moderate rental properties are often occupied by mid and higher income renters, reducing the availability and affordability of rental dwellings for low-income households. Yates and Wood (2005) find that areas with a higher concentration of low-rent housing tended to increase their proportion of low-rent housing. Social interactions in low-rent areas, including areas with public housing and lower income private rental, may then induce downward filtering, and vice-versa in higher income areas. A recent Melbourne study similarly finds evidence of once-affordable rental properties filtering up, rather than down (Palm, Raynor and Warren-Myers 2020).

There are further incidental aspects of the filtering of properties between tenures that are relevant to the constitution of private rental sector and how it serves low-income households. These include the way in which properties transfer between owner-occupied and rental sectors: in particular, whether a property transfers through a deliberate decision to invest in rental housing, or by an 'accident' (such as inheritance). This may impact on the quality of the property and its position in the local market, the mode of tenancy management adopted (such as whether by an agent, or by the landlord themselves), and the degree of security the tenant might expect.

Analysis of HILDA data by Wood and Ong (2013) shows significant churn in rental property ownership, with about 25 per cent of landlords selling in their first year of ownership, and about 60 per cent having done so after five years. In research into recent rental property investment in low-income areas of western Sydney, Pawson and Martin (2021) find evidence for the emergence of a cohort of investors intending to hold properties longer, although the extent to which they are displacing short-term and accidental landlords is not clear. Their study also shows a significant degree of trading of properties within the rental sector, and of purchases with development potential in mind. Some forms of development may take properties out of the rental market altogether, but other forms of development that are evidently taking place – particularly the addition of secondary dwellings (granny flats) – would tend to keep properties in the low-cost segment.

2.4 Policy implications

In the housing literature, filtering (and sub-market) dynamics contains a price and an occupancy element. There is an extensive body of theoretical and empirical literature focusing on both these elements that generates a number of insights for recent market based filtering as an alternative to direct supply of affordable housing (for low-income households):

1. For filtering to work as a source of low-income housing there needs to be a surplus of properties. This surplus needs to exceed the rate of household formation and the rate of new demand arising from income growth.
2. The greater the quality differences between sub-markets, the lower the likelihood that new supply in one sub-market spillover to other sub-markets. New supply thus needs to be an effective substitute for existing supply to generate the price and vacancy chains required for supply in one sub-market to also result in price and occupancy changes in other sub-markets.
3. Sub-market specific conversion cost determine whether properties filter up, down or remain unchanged (quality-wise). Conversion costs are also related to the degree of substitutability between sub-markets.
4. Filtering is related to a number of obsolescence drivers. While the age characteristics of properties empirically often is used as a proxy for quality and style obsolescence, physical obsolescence is also a function of the income, and potentially tenure, characteristics of properties. Moreover, obsolescence drivers may work in opposite directions. Older properties may become locationally more attractive under conditions of urban economic restructuring and gentrification, leading to a net gain in relative property prices. The relationship between dwelling age and price and occupancy characteristics is thus complex.
5. The efficacy of filtering dynamics as a source of low-income housing may differ between owner-occupied and rental market segments. Tenure change may be indicative of downgrading of properties.

In the following two sections, we turn to analysing some of these insights in Melbourne and Sydney. The choice of Melbourne and Sydney is in part driven by data availability, but also key similarities that generate complementarities in our analysis. There is an acute lack of affordable low-income housing in both Melbourne and Sydney (Lawson, Pawson et al. 2018). Both cities have experienced an increase in the construction of apartments and higher density developments as part of their strategies to increase housing supply (Bunker, Crommelin et al. 2017). There are thus similarities in the dwelling composition and priorities of new supply. Prior to COVID-19 capital cities in Australia experienced higher rates of population growth than other areas (driven in part by international migration). There are thus also similarities in the context (population growth) within which new construction is taking place. Finally, the labour market context (locational trends and skills and knowledge intensity of employment growth) show broad similarities (Terrill, Batrouney et al. 2018).

Our analysis in Melbourne focuses on the occupancy dimension of filtering. Following the approach in Rosenthal (2008), we test the extent to which occupancy – measured as the change in relative income status of areas – appears to be a function of dwelling age (quality). In practice, this analysis spans all housing tenures. However, due to the higher share of owner occupation, the analysis is dominated by dynamics in the owner-occupied stock of housing. Our analysis in Sydney focuses on the price of private rental by examining private rental prices relative to median rents, and comparing price depreciation relative to the incomes of low-income households (measured by the minimum wage). Thus while focusing on two different cities and two different approaches, the insights generated are complementary and provide a more holistic assessment of filtering as a source of low-income housing in both cities. Combined the analysis engages with price and occupancy elements of filtering theory, and all housing and the private rental segment specifically.

Due to broad similarities in the housing market context of Melbourne and Sydney, filtering insights from one city largely generalises to the other city. Insights also generalise to other Australian capital cities. Although, the rate of population growth across other capital cities varies, as do housing and labour market contexts.

3. Occupancy characteristics and the age of housing: the Melbourne analysis, 2006–16

- **This chapter tests whether the occupancy characteristics of housing (measured by the median income at Collection District level) are associated with the age characteristics of housing stock (as a proxy for housing quality characteristics). Analysis of the price elasticity of supply and demolition trends augments the analysis.**
- **Areas with greater proportions of housing built before the Second World War (WWII) typically can not be characterised as low-income in 2006. Moreover, the relative income status of pre-WWII areas typically improved after 2006 (2006–16) (Table 4). New housing construction typically trades at a premium (consistent with filtering), but the scale of new construction within areas with older housing stock is insufficient to offset the effects from increases in demand.**
- **The relationship between property age and relative income status is significantly affected by the inclusion of proxies for social interactions. Social interactions affect the demand for properties in specific locations when the behaviour of different types of households generates either social capital or costs (externalities). Social interactions are proxied by tenure, prime working age adults and education level. Age of housing stock is thus not an independent determinant of the attractiveness of local housing markets or housing services. In terms of filtering, this means that whether or not housing physically depreciates (and becomes economically obsolescent) is not a function of age per se.**
- **A key enabling condition for filtering as a source of affordable low-income housing is that new supply generates a surplus of dwellings. However, the price elasticity of supply is low (close to zero) throughout Melbourne (Table 6). Additional demand for housing is thus not met by additional supply. This results in price appreciation that potentially generates additional economic rent for older and existing properties in high demand areas.**

- **Overall, there is limited evidence that age-related filtering is a significant source of low-income housing in Melbourne. This is particularly the case in areas closer to the CBD in which the oldest (pre-WWII) housing stock is concentrated. For areas in parts of middle Melbourne (with a higher proportion of post-war housing stock) there is greater evidence of relative income change consistent with filtering. However, there is also evidence that housing in these areas started out as lower income housing (Palm, Raynor and Warren-Myers 2020).**

3.1 Introduction

In Chapters 3 and 4, we examine a series of stylised outcomes associated with filtering dynamics. The extent to which Australian housing markets conform to expected outcomes under filtering is critical for assessing how the economic and physical dimensions of housing market dynamics are contributing, or can contribute, to low-income housing policy and spatial objectives.

The Melbourne analysis in this chapter analyses the occupancy characteristics (2006–16) of dwellings at the Collection District (CD) level using a spatial econometric model that includes a spatial lag for change in occupancy characteristics in neighbouring CDs, spatial lag in some independent variables in neighbouring CDs, and a spatial lag in the error term. The model specification follows Rosenthal's (2008) analysis of the role of filtering and social interactions in neighbourhood change.

Appendix A provides descriptive statistics and details on the spatial econometric modelling framework. Under filtering, the occupancy characteristics of dwellings (measured by the relative socio-economic status of areas) are expected to change over time if the age of housing is negatively correlated with the housing services *and* older housing is replaced by new housing as it approaches obsolescence. Under these assumptions, as the housing physically depreciates and become cheaper relative to new housing, it should increasingly be inhabited by lower income households. These dynamics form the basis for testing for filtering by Rosenthal (2008; 2014) and Brueckner and Rosenthal (2009). Under assumptions of filtering, neighbourhoods should therefore exhibit cyclicality; that is, neighbourhood status should vary over longer periods of time. Rosenthal (2008) finds that neighbourhoods cycle over an approximate 100-year period. Change over shorter periods of time (such as 10 years) is therefore relatively small.

Notably, these dynamics rest on a number of key assumptions. First, the rate of depreciation of housing takes place independently from the characteristics of occupants. Inhabitants' income characteristics determine the ability to re-invest in or maintain property to offset depreciation of housing services (Davis and Whinston 1961). The incentive to re-invest in or maintain a property is also determined by the value and upkeep of surrounding properties; as such, there are social interactions and neighbourhood effects that influence the rate of depreciation and demand for properties in specific locations.

However, neighbourhood externalities (such as social capital and cost, and area status) arising from social interactions and activity also determine demand for dwellings in specific locations (Ioannides and Zabel 2003; Rosenthal 2008). Social capital can be conceived as both a community-level resources, including the feature of neighbourhood social organisation such as trust, norms and networks (Putnam 1995), and an individual level resource arising from membership of specific social networks (Bourdieu 1986). In Australia, as elsewhere, social capital is, for instance, associated with health outcomes (Ziersch et al. 2005). Homeownership is frequently shown to exert a positive effect on social capital formation (Ruskruge et al. 2013). Conversely, public housing tenants in Australia exhibit lower levels of interpersonal trust (Donoghue and Tranter 2012).

Secondly, the rate of new housing construction exceeds the rate of new household formation or inflow.[8] The extent to which this assumption is, and can be, met rests on the interaction of determinants of supply and demand. Local planning, political economy, prior land use and geographical factors generate variation in supply elasticities (Saiz 2010; Meen and Nygaard 2011; Hilber and Robert-Nicoud 2013). Households' desire to live and work in different localities generates variation in demand for access to those localities (Glaeser and Gottlieb 2009). Jointly, the interaction of these factors determine the rate of house price appreciation which, if sufficiently high, may offset depreciation and lead to properties filtering up rather than down.[9] This process of upward filtering has been associated with gentrification in many inner-city neighbourhoods, including in Australian cities (Badcock 2001).

Thirdly, when dwellings depreciate (or become economically obsolete) they are successively inhabited by residents with lower income or social status, rather than being redeveloped. In practice, the rate at which dwellings filter down, or are upgraded or converted, is a function of sub-market-specific returns to owners or landlords (Galster and Rothenberg 1991).

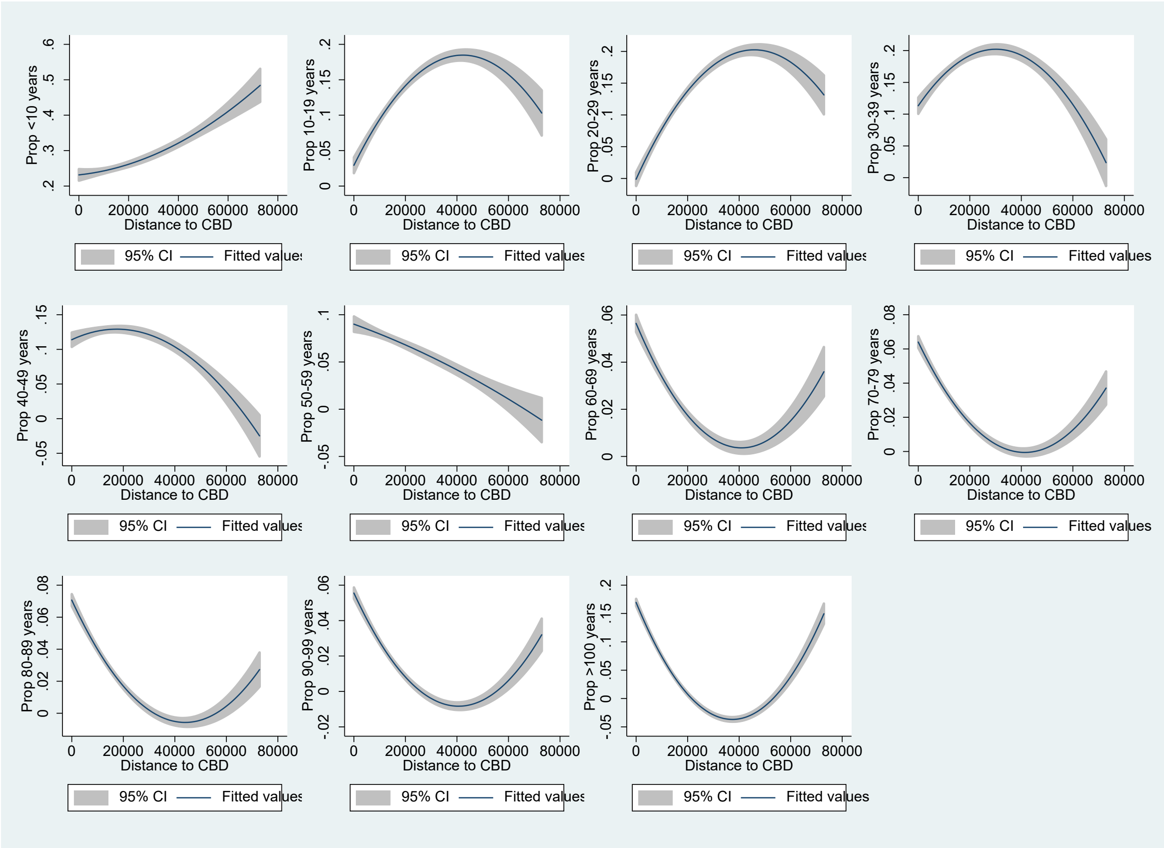
Before turning to estimation results, Figure 2 maps the main variable of interest — the proportion of housing stock in each 10-year age category — against the distance from the Melbourne General Post Office (GPO). The figure shows the change in average proportion of properties of a given age that are located within CDs as one moves out from the CBD in 2.5 kilometre intervals. Typically, the share of newer properties — those constructed in the last 30 years — rises with distance to the CBD. Older properties are located closer to the CBD, and then beyond some 40 kilometres from the CBD.

Figure 3 provides additional detail on dwelling approvals by typology for inner, middle and outer metropolitan Melbourne (2011–20). Noticeable over the period 2011–17 is the sharp increase in high-rise developments in inner Melbourne initially and later in both inner and middle metropolitan Melbourne. Notwithstanding this increase in higher density dwelling approvals for inner and middle areas of Melbourne, growth in outer Melbourne (including growth areas) is also noticeable over the period, such that the change in the *distribution* of new supply was less dramatic (Figure 4). The trends in Figure 3 continue a trend in dwelling approvals from approximately 2007 (DELWP 2018).

8 An alternative formulation of this condition is that the rate of new construction less demolition and depreciation (net housing services) exceeds the rate of new household formation and inflow.

9 In housing economics, the user cost of capital (UCC) is a frequently used indicator of the real period on period cost of purchasing a property. A lower UCC (real price) leads to an increase in demand. The UCC includes variables such as interest rates, tax rates, house price expectations (such as capital gains), transactions costs (stamp duty, mortgage insurance) and maintenance costs and depreciation. An increase in house price appreciation (such as capital gains) offsets costs of purchase, including the maintenance and depreciation costs, resulting in an increase in demand.

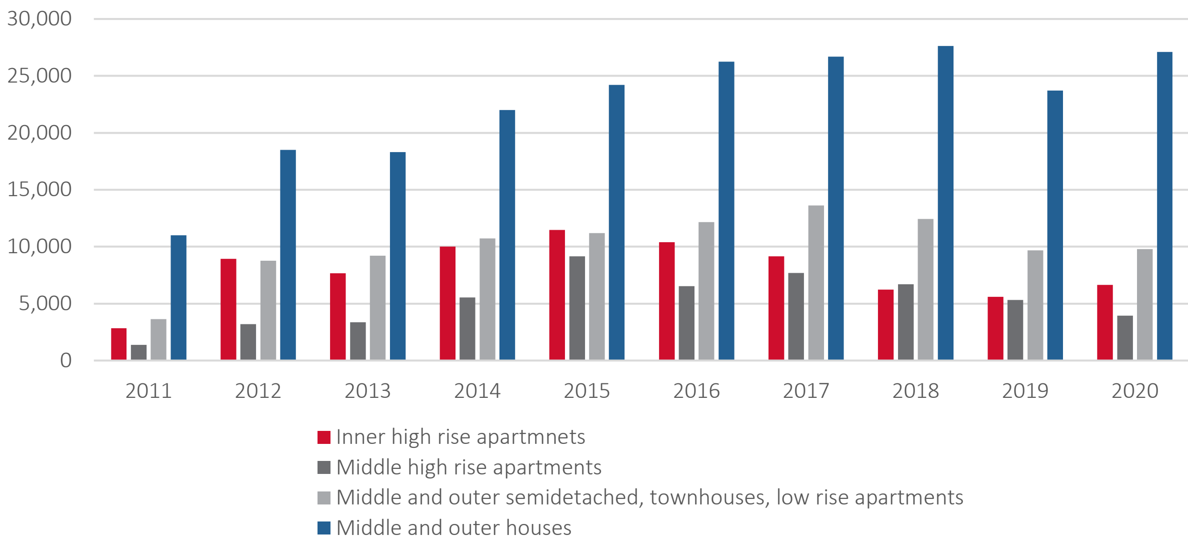
Figure 2: Proportion of housing stock by distance from the CBD



Note: Authors' calculation.

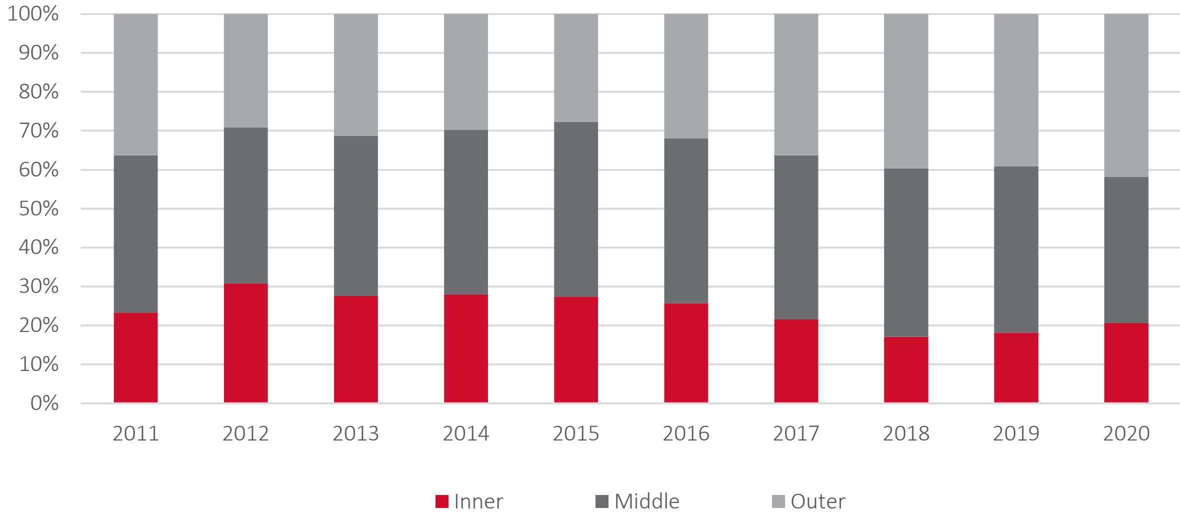
Source: Valuer General (valuation data).

Figure 3: Dwelling approvals by location and typology, Melbourne 2011–20



Source: Authors' calculations from 'Building approvals by SA2 and above' (http://stat.data.abs.gov.au).

Figure 4: Distribution of dwelling approvals by inner, middle and outer Melbourne, 2011–20



Note: For inner, middle and outer classifications see note to Table 5.

Inner Melbourne: City of Melbourne, City of Port Philip, City of Stonnington and City of Yarra. Middle: city of Banyule, City of Bayside, City of Boroondara, City of Darebin, City of Glen Eira, City of Hobsons Bay, city of Kingston, City of Manningham, City of Maribyrnong, City of Monash, City of Moonee Valley, City of Moreland, City of Whitehorse. Outer: City of Brimbank, Shire of Cardinia, City of Casey, City of Frankston, City of Greater Dandenong, City of Hume, City of Knox, City of Maroondah, City of Melton, Shire of Mornington Peninsula, Shire of Nillumbik, City of Whittlesea, City of Wyndham and Shire of Yarra Ranges.

Source: Authors' calculations from 'Building approvals by SA2 and above' (http://stat.data.abs.gov.au).

The following three sub-sections explore several of these assumption and their relation to stylised filtering outcomes. Section 3.1.1 starts by examining the spatial structure of relative incomes in 2006 and the extent to which there is evidence of cyclicality in neighbourhood status (relative income), where neighbourhood status is a proxy for the characteristics dwelling occupants. This serves as a starting point from which to assess subsequent change in relative income status (Section 3.1.2) and rates of housing stock renewal (Section 3.1.3). Due to restrictions on data availability, the analysis in Chapter 3 is based on Melbourne data only.

3.1.1 Spatial structure of relative income in 2006, Melbourne

Table 1 shows the total marginal effects after regressing relative income at Collection District (CD) level (in 2006) on the age of housing stock, distance to the CBD, and a number of socio-economic characteristics.

The results in Table 1 provide a descriptive starting point from which to consider subsequent change in relative income status (occupancy characteristics) and housing demolitions. Table 1 highlights four points in relation to the distribution of relative income status in 2006:

1. After controlling for Socio-economic Status (SES) characteristics and distance from the CBD, areas with a larger proportion of new properties typically have a higher relative income status than other areas. However, it is particularly areas with a greater proportion of housing built after WWII and into the 1960s that are characterised by lower relative income status. A key assumption underlying filtering as a source of additional low-income housing is that new properties trade at a premium (are preferred) over older properties. New construction, and areas with a greater proportion of new housing, should thus also concentrate a larger proportion of higher income households. *In terms of the static spatial distribution in 2006, this is partially the case.*
2. Holding SES characteristics and age of housing stock constant, relative income declines with distance from the CBD. Figure 2 shows that newer housing is typically found at a greater distance from the CBD, specifically in a band running 20 to 60 kilometres around Melbourne. Beyond this band, variability in age of properties increases again.

3. Holding SES characteristics, age of housing and distance constant, relative income is typically lower in areas with greater housing density. Like other Australian cities (Newton, Meyer and Glackin 2017), since the early 2000s Melbourne has explicitly sought to increase density of housing in relation to key transport nodes and through infill development. However, Melbourne still remains somewhat more mono-centric than, for instance, Sydney (Slavko, Glavatskiy and Prokopenko 2020). Mono-centricity is reflected when regressing (log) housing density on (log) distance from the CBD where a 1 per cent increase in distance is associated with a 0.5 per cent decline in density (*β=-0.55, s.e.=0.01, r^2=0.31*). Density, and therefore some new housing construction, is associated with lower relative income rather than higher relative income (after controlling for SES characteristics and so on). Apartment-style developments in middle and inner parts of Melbourne thus also contribute to housing supply for low- and moderate-income households (Daley et al. 2018). Density is, however, complex, with evidence of a positive spatial interdependency arising from density. (The effects in Table 1 are total marginal effects so that, on balance, density correlates with somewhat lower relative income.) Moreover, the share of newer dwellings (dwellings built between 1996–2005) is positively association with relative income. As per Figure 1, while apartment-style dwellings have increased as a share of total dwelling supply, houses still dominate the supply of new dwellings. The supply of houses tends to centre on growth areas in Outer Melbourne,
4. There is a significant spatial interdependency in the distribution of relative income. That is, areas with higher incomes typically cluster together over larger sections of Melbourne. One explanation for this may be social interactions and neighbourhood effects in the dynamics of household location patterns. For instance, social capital or cost arising from the behaviour other residents in an area, or perceived status of particular neighbourhoods can also determine demand for dwellings in specific locations (Ioannides and Zabel 2003; Rosenthal 2008) and incentive to maintain properties (Davis and Whinston 1961). Areas with higher shares of homeownership and graduate level education typically also have higher relative income. Unsurprisingly, areas with higher shares of social housing has the reverse, but also lower levels of interpersonal trust (Donoghue and Tranter 2012). Clustering may, however, also reflect the distribution of natural amenities (such as rivers and natural reserves) and access to labour markets and urban amenities. The latter is captured by distance to the Melbourne GPO. These processes generate spatial sorting and clustering.
5. Overall, the descriptive outcomes in Table 1 suggest that the 2006 snapshot of relative income distribution partially conforms to expectations under filtering dynamics. That is, areas with higher proportions of newer (property built in 1996–2005) and older (pre-WWII) (property built prior to 1935) housing stock are typically occupied by households with higher relative incomes than those with middle-aged housing stock (property built in 1936–65). This is, in principle, consistent with filtering where (under filtering): new housing (and areas) trade at a premium because it is more desirable, while the price premium of older areas (potentially) reflects the renovation and replacement of old housing (gentrification). Middle-aged housing, on the other hand, has not (yet) depreciated sufficiently and thus continues as a housing option for lower income households.

Table 1: Relative income status 2006, total marginal effects

Variable	Coefficient (St. error)
Marginal effects, total	
ln distance to GPO (m)	-0.1278 (0.0211)***
ln dwelling density 2006 (ABS)	-0.0451 (0.0101)***
Property age 1996-2005 (%)	0.1700 (0.0541)**
Property age 1986-1995 (%)	0.0852 (0.0538)
Property age 1976-1985 (%)	0.0156 (0.0552)
Property age 1966-1975 (%)	-0.0995 (0.0535)
Property age 1956-1965 (%)	-0.2854 (0.0554)***
Property age 1946-1955 (%)	-0.1380 (0.0542)*
Property age 1936-1945 (%)	-0.1899 (0.0786)*
Property age 1926-1935 (%)	0.0858 (0.0901)
Property age 1916-1925 (%)	0.1166 (0.0793)
Property age 1906-1916 (%)	0.1231 (0.0860)
Home ownership (%)	0.7394 (0.0497)***
Graduate education (%)	3.2368 (0.2215)***
Aged 30-49 (%)	1.0201 (0.1144)***
Married (%)	1.2152 (0.1059)***
Australian born (%)	0.3829 (0.0490)***
Social housing 2006 (%)	-0.8512 (0.0737)***
Spatial lag, contiguous	
ln dwelling density 2006 (ABS)	0.0156 (0.0052)**
ln relative income 2006 (ld)	0.2890 (0.0271)***
Spatial lag, inverse distance	
ln relative income 2006 (ld) (error)	2.8567 (0.3088)***
Pseudo R2	0.68
Number of CDs	6,185

*Note: General nesting spatial model (GNS), GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels.*

Source: Author's calculation from Victorian Valuer General data (valuation), ABS Census 1996, 2006, 2016.

Importantly, the results in Table 1 consider relative income at a point in time, not over time. However, filtering is a dynamic process. Under filtering, if properties are successively inhabited by residents with lower relative incomes, and then removed once reaching physical and economic obsolescence, then, due to the immobility of housing, neighbourhoods are expected to exhibit a degree of cyclicality in neighbourhood status. Table 2 displays a test of the extent to which CDs in Melbourne exhibit cyclical tendencies — that is, whether there is evidence of change in relative income status over time. Both Ordinary Least Square (OLS) and spatial regression results are shown.

Table 2: Correlation in relative income status (occupancy characteristics), CD level, Melbourne

	OLS	Spatial regression
	ln relative income change 2006–16	ln relative income change 2006–16
ln relative income change 1996–2006	-0.2302 (0.0126)***	-0.3033 (0.0206)***
Constant	0.01204 (0.0037)***	0.1036 (0.0096)***
Spatial lag contiguous		
ln relative income change 2006–16 (ld)		0.2128 (0.0889)**
Spatial lag inverse distance		
ln relative income change 2006–16 (ld) (error)		1.6985 (0.1204)***
R2 or Pseudo-R2	0.0508	0.035
Number of CDs	6,185	6,185

*Note: GNS model, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. ld=lagged dependent variable.*

Source: Author's calculation ABS Census 1996, 2006, 2016.

The key variable of interest in Table 2 is the coefficient for change in relative income status (1996–2006). This coefficient captures the degree to which areas (CDs) in Melbourne exhibit a degree of cyclicality – and the speed with which the relative income status of an area changes. A low value (close to zero) that is also statistically significant would indicate that the relative income status of areas changes, but very slowly. Given the longevity of housing, one expectation under filtering would be that areas only change their relative income status slowly, so that the process (build-depreciation-rebuild or refurbish) takes place over a longer period of time. A negative value indicates that areas return to their initial starting position over time. That is, an area experiencing improved relative income in the period 1996–2006 then experiences declining relative income in the period 2006–16. A large negative value would indicate that there is some fluctuations between years but that areas quickly regain their relative starting position over time. This would be inconsistent with filtering.

The results in Table 2 demonstrate that areas do show some change in relative income status (occupancy characteristics of residents) over time, but also that they tend to recover their relative income status relatively quickly. The OLS results imply that areas (CDs) recover their relative income status by some 23 per cent (coefficient on relative income change 1996–06 is negative, β=-0.23) over 20 years. The spatial modelling results show that, after taking spatial interdependencies into account, areas recover their relative income status by some 30 per cent (β=-0.30) over 20 years. Compared to some of the US filtering literature, this suggests a much higher degree of stability in relative income status in Melbourne over the past 20 years and much shorter 'neighbourhood cycles'.[10] An important caveat here is that these data only cover the most recent 20 years. Melbourne has experienced considerable change in its social and spatial structures since the 1970s (Logan 1985).

As such, the apparent stability in relative income status in Melbourne (over the last 20 years) contradicts the notion of filtering. Housing depreciates slowly and is long-lived. The shortness of the relative income cycle may therefore be more consistent with demographic and socio-economic determinants (changes to incomes of households as they age) than physical deterioration (obsolescence) of housing. This raises key issues with respect to filtering as a source of affordable housing for low-income households. That is, it prompts questions regarding extent to which filtering dynamics (ageing of housing stock) act as an independent source of variation in neighbourhood income status, or whether age-related filtering is a process that also reflects socio-economic (as a proxy for social interactions) and political economy dynamics. In the following two sections, we explore these issues in greater detail.

10 The corresponding rate of relative income status recovery in Rosenthal (2008) is 5 per cent over a 20-year period.

3.1.2 Change in relative income status 2006–16, Melbourne

Table 3 turns to the change in relative income status (occupancy characteristics) over time. Results presented below are based on a General Nesting Spatial (GNS) model that includes lagged dependent and independent variables, as well as a lagged error term. Spatial Durbin Model results are presented for comparison in Appendix B, Table 5. Variations in results are very minor. Results in Table 3 are total marginal effects after spatial (GNS) regression.[11]

These results are the primary tests for whether housing market dynamics in Melbourne conform to housing-age related stylised expectations under filtering. The key expectations are that:

1. Areas with higher proportions of new properties will experience greater improvement in relative income status than *all* other areas. There is an expectation that the relationship between age and change in relative income status may be u-shaped; it therefore matters whether new areas exhibit more or less change than all other areas.
2. The physical process of filtering and the socio-economic and political economy determinants that (as proxies for social interactions) may affect housing market dynamics operate *largely* independent of each other. This matters because, under dependence, planning, political economy and neighbourhood effects may condition the extent to which the physical processes of filtering take place (housing services delivered relative to existing housing stock). Dependence also has two further implications. First, a neighbourhood's relative income status may be affected by social interactions, which weaken the ability of supply side policies to give direction to neighbourhood's social status (such as to establish mixed communities). If social interactions and neighbourhood effects condition demand for areas, then additional supply may reinforce these effects as new households that are similar to established households move in. Second, the extent to which new development can take place that significantly alters local socio-spatial structures.

The results in Table 3 provide insight into whether new areas improve relative to all areas, and whether filtering and socio-economic determinants are independent of each other. To preview the findings somewhat, the results in Table 3 suggest that filtering dynamics and socio-economic characteristics are not independent. However, Table 3 does not provide insight on why this might be. From a policy perspective, the nature of the dependency becomes important. Appendix B (Table A4) therefore repeats the analysis on sub-samples (quartiles) of CDs based on their income characteristics in 2006. While also not providing direct estimates of social interactions, the results highlight that social interactions are a potential determinant of change in neighbourhood relative income status. Supply elasticity and demolition analysis in Section 3.1.3 and 3.1.4 provide further insight on particulars of filtering.

11 Additional estimation results comparing different spatial weights and different spatial estimation methods are provided in Table A5 (regression coefficients) and Table A6 (total marginal effects). Regression coefficients for Table 3 are reported in Table A5. All marginal effects associated with Table 3 are reported in Table A7.

Table 3: Filtering dynamics Melbourne, 2006–16, age of all housing, total marginal effects

	Change in ln relative income status, 2006–16 (total marginal effects)			
	All stock		Sold stock	
Variable	Restricted SES	Full SES	Restricted SES	Full SES
ln relative income 2006	0.0303 (0.0492)	-0.3271 (0.0411)***	0.0529 (0.0692)	-0.3812 (0.0436)***
ln relative income change 1996–2006	-0.1644 (0.0499)***	-0.0539 (0.0335)	-0.2898 (0.0921)***	-0.0651 (0.0380)
ln distance to GPO (m)	0.0754 (0.0203)***	0.0227 (0.0128)	0.1155 (0.0322)***	0.0368 (0.0140)**
ln dwelling density (ABS)	0.0658 (0.0221)**	0.0670 (0.0157)***	0.0830 (0.0290)***	0.0893 (0.0175)***
Property age 1996–2005 (%)	-0.4434 (0.0905)***	-0.2554 (0.0614)***	-0.3188 (0.1109)***	-0.2290 (0.0612)***
Property age 1986–95 (%)	-0.6007 (0.1037)***	-0.4183 (0.0714)***	-0.5011 (0.1164)***	-0.3689 (0.0601)***
Property age 1976–85 (%)	-0.5800 (0.1044)***	-0.3892 (0.0732)***	-0.4800 (0.1155)***	-0.3744 (0.0623)***
Property age 1966–75 (%)	-0.6166 (0.1043)***	-0.4298 (0.0751)***	-0.5233 (0.1173)***	-0.4244 (0.0632)***
Property age 1956–65 (%)	-0.3516 (0.0938)***	-0.2740 (0.0695)***	-0.2863 (0.1002)***	-0.2830 (0.0586)***
Property age 1946–55 (%)	-0.1162 (0.0918)	-0.0628 (0.0676)	-0.0052 (0.0871)	-0.0821 (0.0533)
Property age 1936–45 (%)	0.0644 (0.1244)	0.0443 (0.0963)	0.0239 (0.1416)	-0.0443 (0.0781)
Property age 1926–35 (%)	-0.0792 (0.1257)	-0.0431 (0.0933)	0.1743 (0.1314)	0.0247 (0.0740)
Property age 1916–25 (%)	0.0362 (0.1103)	0.0081 (0.0857)	0.0502 (0.0980)	-0.0117 (0.0543)
Property age 1906–16 (%)	-0.0865 (0.1417)	-0.0472 (0.1050)	-0.1177 (0.1322)	-0.1242 (0.0737)
Home ownership (%)		0.3307 (0.0681)***		0.3925 (0.0730)***
Graduate education (%)		1.3155 (0.3091)***		1.2560 (0.3255)***
Aged 30–49 (%)		0.2590 (0.1086)*		0.0295 (0.1133)
Married (%)		0.0538 (0.1396)		0.2672 (0.1530)
Australian born (%)		0.3165 (0.0599)***		0.3494 (0.0676)***
Social housing 2006 (%)		-0.4520 (0.1071)***		-0.3495 (0.1560)**
Spatial lag, contiguous (regression coefficients)				
ln dwelling density 2006 (ABS)	-0.0371 (0.0091)***	-0.0334 (0.0086) ***	0.4639 (0.0351)***	0.3966 (0.0368)***
ln relative income 2006	0.5138 (0.0366)***	0.4651 (0.0355)***	-0.0517 (0.0085)***	-0.0372 (0.0084)***
ln relative income change 2006–16 (ld)	0.5780 (0.0836)***	0.4560 (0.0847)***	0.7228 (0.0764)***	0.4540 (0.0865)***
ln relative income change 2006–16 (ld) (error)		-0.2147 (0.1009)*		-0.2330 (0.1028)**
Spatial lag, inverse distance (regression coefficients)				
ln relative income change 2006–16 (ld) (error)	1.2336 (0.4041) **		-0.3585 (0.6318)	
Pseudo-R^2	0.2512	0.2841	0.2329	0.277
Number of CDs	6,185	6,185	5,605	5,605

*Note: GNS model, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. ld=lagged dependent variable; ln=natural log. Appendix B, Table A5 provides additional estimates based on all spatial dependency matrices taking the same form (inverse distance and contiguity). Appendix B, Table 5 also provides comparison of regression estimates of the model by GNS and Spatial Durbin Model (SDM). Appendix B, Table A6 compares total marginal effects following spatial regressions in Table A5.*

Source: Author's calculation from Victorian Valuer General data (valuation), ABS Census 1996, 2006, 2016.

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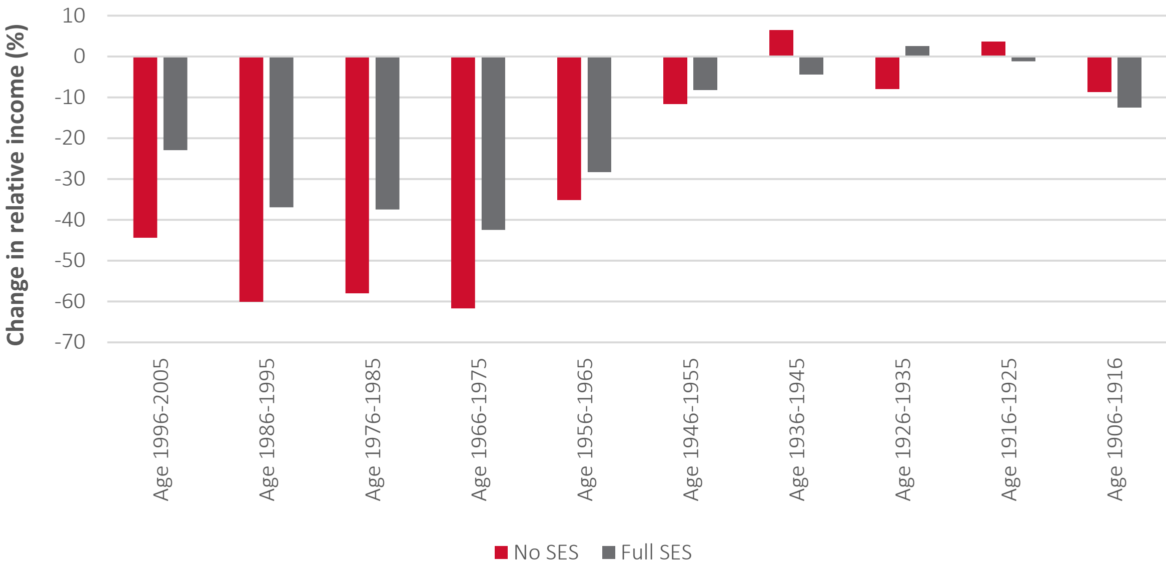
We first turn to the issue of age-related filtering and social interactions. Filtering is associated with change in the social characteristics of dwelling occupants, resulting in neighbourhood change. However, neighbourhood externalities (such as social capital and cost, and area status) arising from social interactions and activity also determine demand for dwellings in specific locations (Ioannides and Zabel 2003; Rosenthal 2008). The socio-economic variables in Table 3 (homeownership, social housing, education level and prime working age) provide proxies for social interactions.

For ease of interpretation, the key filtering relationships from Table 3 are summarised in Figure 5. Solid colours indicate a statistically significant effect (p<0.05). The results in Table 4 (Figure 5) are the total marginal effects, after controlling spatial interactions and spillovers. Two key conclusions can be drawn from the results.

Figure 5: Change in relative income and age of all housing stock



Note: Author's calculations.

Source: Regression output Table 3.

First, there is a u-shaped relationship between the age of housing and the change in the characteristics of dwelling occupants (relative median income status). This is the case when including SES variables and not. However, the income change in areas with larger proportions of more recent construction (properties built 1996–2005) are not improving their income status relative to older areas (properties built prior to the mid-1950s). Under filtering the demand for new construction is income elastic (high-income households vacate older properties for newer properties). Thus the occupancy characteristics of areas with more new builds should exhibit positive change not just relative to properties built nearer in time (such as 1956–95), but also all housing (including that built before 1955). The implication of this is not that areas do not change in relative income status. They do, and relative to areas built between 1956-1995, areas with a higher proportion of new build typically improve their relative income status. New builds therefore contribute to an improvement in relative income status. However, areas built prior to WWII maintain or improve their relative status compared to areas with recent developments and areas with a higher proportion of development in 1956–95.

Second, the impact of dwelling age and change in relative income (occupants' characteristics) is substantively affected by the inclusion of the full set of socio-economic variables. Under independence, the inclusion of SES controls should have little impact on the age coefficients (Rosenthal 2008). That is, if the age of properties exerts an independent and systematic effect on the relative income status of neighbourhoods (consistent with filtering), then the magnitude of the age coefficients with and without the inclusion of the SES variables should be comparable. The results in Table 3, and shown in Figure 5, do not conform to this. After including the full set of SES controls, the magnitude of the age coefficients is halved in some instances and, in all instances, is substantially reduced. Notably, the structure of the coefficients remains unchanged, suggesting that ageing of property does play a role (new housing is attractive, at least compared to other post-WWII housing). However, the key issue when comparing the estimates with and without full SES controls is whether the ageing of housing stock is a process that takes place independent of socio-economic determinants. The significant difference in the coefficients suggests that this assumption is less likely to hold in the Melbourne context.

This is further underlined by comparing the coefficient (in Table 3) for relative income in 2006. Without the inclusion of SES controls there is a positive relationship (column 2) between relative income in 2006 and subsequent change. That is, there is a divergence, rather than convergence, in income status.

After including the full set of SES, the coefficient for relative income in 2006 becomes negative, capturing again that areas tend to recover their relative income status over time. These estimates also provide insight on the socio-economic determinants that contribute to stability of relative income status over time. For instance, areas with a higher rate of homeownership in 2006 typically improved their income status. In terms of social interactions, some of the literature finds that homeowners have greater incentives to invest in their neighbourhoods (see Rosenthal 2008), with the level of investment also affected by the behaviour of neighbours (Ioannides and Zabel 2008). A 10 percentage point higher level of homeownership in 2006, is associated with an approximate 3 per cent improvement in relative income status. Similarly for education (a form of human capital transferrable through interactions in neighbourhoods), a 10 percentage point higher level of residents with graduate degrees in 2006 is associated with a 13 per cent increase in relative income status (2006–16). This is also the case for areas with a greater proportion of Australian born residents in 2006. Areas with a larger proportion of social housing have typically fallen behind in relative income status. A 10 percentage point higher level of social housing in 2006 is associated with a 4.5 per cent decline in relative income status.

When combining the results in Table 1 and Table 3, the Melbourne evidence suggests that areas with older housing stock start off with higher relative income *and* increase their relative income more than areas with newer housing stock. Rather than filtering down over the period 2006–16, areas with greater proportion of older housing stock is filtering up.

This conclusion should be viewed in light of wider spatial labour and economic realignments in Melbourne over the past 30 years, as also reflected in the negative relationship between age and relative income change across the post-war housing stock. In the post-war period, Australia experienced a significant increase in migration, and post-1970s the origins of migrants became much more diverse. As inferred from Figure 3, new housing construction in this period radiated out from Melbourne, filling out a band located 20 to 60 kilometres from the CBD with lower density housing. There was also housing that was well located in relation to manufacturing and industrial employment (O'Connor and Healy 2002).

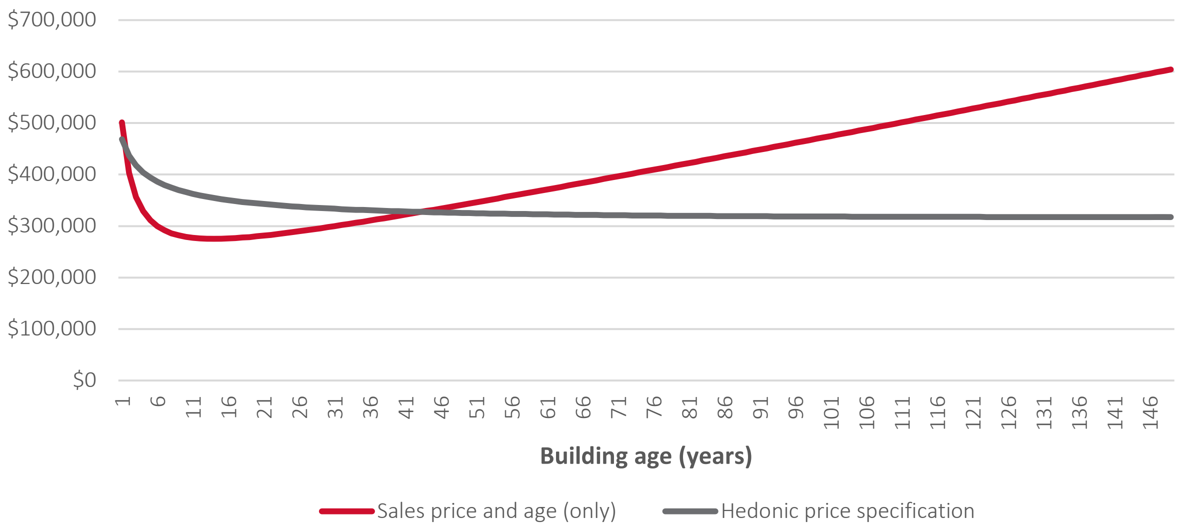
With economic restructuring, and the emphasis on growth in the knowledge and service economy, the relative attractiveness of these areas as residential locations has declined relative to older inner city locations (O'Connor and Healy 2002), reversing the doughnut characteristics of Melbourne (Collie 2018). This reversal of residential attractiveness is, in practice, consistent with filtering type dynamics (such as locational obsolescence and housing demand). Notably, however, a key determinant of this process is change to the economic geography—the spatial re-alignment of job and labour markets during the 1990s (O'Connor and Healy 2002; Collie 2018). This suggests that, rather than the physical processes associated with filtering being the key determinants of relative income status and affordability of local property markets, processes of physical depreciation and filtering are (co-)determined by socio-economic, labour market and institutional changes.

This outcome differs from some of the US literature (such as Rosenthal 2008), but is consistent with other research undertaken in Australia and the US. This research demonstrates that the direction of filtering often is conditioned by neighbourhood characteristics, resulting in increased polarisation (Somerville and Holmes 2001; Yates and Wood 2005; Skaburski 2006; Kim, Chung et al. 2016; Palm, Raynor and Warren-Myers 2020).

This outcome is also reflected when regressing sales prices on age of properties. For instance, when regressing the log purchase price of properties sold in Melbourne (2006–15) on the age of buildings (only) the relationship between property age and sales price is u-shaped. That is, more recent and older properties trade at a premium relative to properties in the mid-range of building ages. When estimating a fuller hedonic specification, newer properties retain a price premium, whereas the impact of age becomes largely flat for properties older than some 25 years.[12]

The effect of dwelling age on property prices is thus highly contingent on locational as well as institutional context. For instance, properties within heritage zoning overlays typically trade at an additional 7.7 per cent premium. Dwelling prices decline with distance from the CBD. Consequently, properties of the same age and physical quality trade at very different prices in inner and outer locations. The opposing price dynamics associated with depreciation (age) and location (distance to the CBD) may thus either cancel each other out or result in older dwellings in central locations increasing in price relative to similar dwellings in less central locations. The latter price dynamic would also inhibit lower income households to occupy housing previously occupied by higher income households in these locations.

Figure 6: Dwelling sales prices and property age



Note: Author's calculations from Valuer General sales and valuation data. Full regression results are reported in Appendix B, Table A8. Dwelling sales price calculated at the mean value for all variable except dummy variables (excluded) and age of property.

Source: Appendix B, Table A8.

12 Full results are reported in Appendix B, Table A8. The regression includes controls for distance to CBD, distance to activity centres (1-3), neighbourhood property density, size of property, distance to major roads, trains, trams, schools, parks etc., property type, SEIFA index, main planning classifications (residential, mixed, etc.), planning overlays (heritage and flooding) and fixed effects for year/quarter, and postcodes.

An interdependency between the characteristics of dwelling occupants (and property values) and socio-economic and locational characteristics *can* be caused by social interactions. Table A4 (Appendix B) reports the results based on the dividing the CD sample into four similar sized groups based on their relative income in 2006.[13] This highlights a number of additional issues that point towards heterogeneity in how the relative income status of neighbourhoods changes over time. These differences also suggest that social interactions *may* determine neighbourhood dynamics.[14]

1. Both the lower and upper 'quartile' of areas show a high degree of stability (mean reversion) over a relative short period of time. However, for the interquartile range this income cycle may be somewhat longer.
2. The age characteristic of the housing stock is largely u-shaped in each of the groups, but age of housing stock is not significantly correlated with subsequent change for the lower quartile, and the effect (while significant) is much weaker in upper quartile areas. For upper quartile areas, a higher proportion of both new and old housing stock is associated with a subsequent increase in relative income.
3. The impact of the socio-economic variables across the three estimation groups show some important differences. *This is not evidence per se of the presence of social interactions, but a necessary condition for social interactions to be a possible explanation*.[15] Prime earning age (30–49) is a significant determinant of subsequent income change for the lower quartile (weakly so $p<0.1$) and interquartile group ($p<0.05$); it is negative for the upper quartile group. Homeownership is positively correlated with subsequent relative income change in the interquartile range and upper quartile; it is not significant (and with a low point estimate) in the lower quartile group. Density has a positive effect in each of the groups, but the effect of density in the upper quartile is roughly 50 per cent of the effect in the lower quartile. Moreover, adjacency to more dense areas is positive for subsequent relative income change in the lower quartile areas, but negative in the interquartile and upper quartile groups. Finally, concentration of social housing has a negative effect on subsequent relative income change in the lower quartile group, but is not statistically significant in the other groups. A 10 percentage point greater concentration of social housing in 2006 is associated with a subsequent decline in relative income of 6.4 per cent.

Finally, the results in Table 3 are based on the age of all properties in a collection district. However, not all properties are necessarily equally likely to be sold in any particular period. An alternative way of testing the filtering regression is therefore to regress change in relative income status on the age profile of properties sold in the period 1996–2005. For instance, Rosenthal (2014) conducts a repeat-income analysis to test for filtering. Rosenthal's argument is that if properties indeed filter, then the income profile of residents should change with the change in occupant. In our case, we do not have information on individual residents. Nevertheless, significant differences in the results when using these alternative age profile variables may indicate that our age profile measure in Table 3 does not adequately capture the relationship between age of housing stock, filtering processes and change in relative income status. These alternative estimation results are reported in columns 3 and 4 of Table 3. Quantitatively, the results are very similar to the results using the age of all housing stock. In terms of the structure of the age variables, this is the same as in Table 4.

Overall, the results in Section 3.1.2 suggest that over the period 2006–16, areas with a larger proportion of older properties started off being advantaged (in terms of relative income), and largely maintained this advantage. The (implied) shortness of the neighbourhood (CD) income cycles in Tables 2 and 3 weakens the argument for substantial filtering as a source of low-income housing. That is, they provide evidence that lower income households, over time, are not likely to occupy the former properties of former higher income households.

13 Due to the collection of income data by bands, it is not possible to construct these groups based on income quantiles precisely. The results in Table A4 are for a low-income group (broadly lower quartile), a middle-income group (broadly the interquartile range) and a higher income group (broadly the upper quartile).

14 Our analysis employs a number of socio-economic factors as proxies for social interactions. We are not suggesting that this is an exhaustive list of factors that can generate social capital or costs. The critical aspect of including *any* proxy for social interaction is the extent to which the age related coefficients are affected by the inclusion of the socio-economic variables or not.

15 If the coefficients were the same across the three areas then the likelihood of social interactions as an explanation for co-dependence (housing age and socio-economic characteristics) would be reduced.

Moreover, there is some evidence that housing age-related and socio-economic determinants of change are co-dependent, thus again weakening the evidence for filtering as a source of low-income housing. Notably, the results do not imply that new housing construction is not also desirable (and so a source of neighbourhood change), but rather that the dynamic process upon which filtering rests is spatially and socially complex and so becomes 'interrupted' as a source of low-income housing.

In Section 3.1.3 and 3.1.4 we turn to additional insight on supply elasticity characteristics and demolition that may also result in 'interrupted' filtering.

3.1.3 New construction and supply

A key requirement for filtering to enable the supply of affordable housing for low-income households is that the supply of new housing exceeds household (demand) growth. A surplus of housing is required to generate downward pressure on prices within specific sub-markets, and where there is a positive cross-elasticity of demand also downward pressure on prices in other sub-markets. If the supply of new housing is unresponsive to price levels or changes then downwards filtering is no longer expected. Time series estimates of the price elasticity of supply in Australia suggests that the overall elasticity in Australia is lower than that of the US and is less than one (that is, unresponsive or inelastic) (Ball, Meen and Nygaard 2011).

Yet filtering also has spatial dimension. That is, since cities have typically developed outwards from a core, the age of properties will systematically differ with distance (as per Figure 2). It is therefore possible that, while overall price elasticity is low, it may vary at finer spatial scales. In Table 4 we therefore turn to new housing supply at SA2 level in Melbourne. Of particular interest here is whether new housing supply at SA2 level is responsive to price changes at SA2 level, and what role age or planning characteristics play.

The results in Table 4 draw on recently released (and experimental) data produced by the ABS (2020a). This data provides small area estimates of dwelling construction for total dwellings; houses; semi-detached housing and townhouses; and units or flats. Our focus is on total dwelling supply over the period 2016–19. Descriptive statistics are provided in Appendix A. Dwelling supply over this period is regressed on the level of house prices in 2013 and change in house prices (2013–16).[16] Unlike the house price data in Table 3, average house price data is from the Australian Property Monitors' Timeseries Property Data, sourced via the Australian Urban Research Infrastructure Network (AURIN) and available at SA2 level. Other variables are as before. The regression specification follows Meen and Nygaard (2011) estimates of small-area supply elasticities in England. Table 4 reports the regression coefficients. Note that this differs from the convention in earlier tables where total marginal effects are shown. Due to the limited significance of the price elasticity and positive spillovers (spatially lagged variables), none of the total marginal effects are significant.

16 We also ran the regressions with house prices in 2015 and change in house prices 2015–18. The presented result provide marginally better fits, and are consistent with lags in adjustment created by planning and construction. The regressions where also run with change in housing supply weighted by number of occupied private dwellings in each SA2. These results tended to have negative and mostly statistically insignificant price elasticities.

Table 4: Housing supply and price elasticity 2016–19, SA2 Melbourne

	New dwelling construction 2016–19			
	Simple	With dwelling density	With age of properties	With zoning
Ln HP 2013	-0.1335 (0.1287)	-0.1108 (0.1274)	-0.0214 (0.1675)	0.3174 (0.1856)
Change HP 2013–16	0.1545 (0.3611)	0.2134 (0.3985)	0.3323 (0.5517)	0.0527 (0.4397)
Dwelling density		-0.0227 (0.0358)		
Property age 1986–95 (%)			-1.6081 (0.6835)**	
Property age 1976–85 (%)			-3.0214 (0.7918)***	
Property age 1966–75 (%)			-1.7159 (0.8282)**	
Property age 1956–65 (%)			-1.8111 (0.6791)**	
Property age 1946–55 (%)			-1.5138 (0.7042)**	
Property age 1936–45 (%)			-1.0439 (0.6695)	
Property age 1926–35 (%)			-8.3769 (1.9770)***	
Property age 1916–25 (%)			1.7646 (2.1102)	
Property age 1906–16 (%)			-0.6967 (1.3646)	
Property age > 1906 (%)			-1.0922 (1.3646)	
Zoning (park) (%)				0.6127 (0.6988)
Zoning (commercial) (%)				1.5018 (1.1472)
Zoning (capital city) (%)				2.0705 (0.6022)***
Zoning (industrial) (%)				0.9055 (0.4971)
Zoning (low density residential) (%)				-1.2382 (0.6482)
Zoning (mixed use) (%)				4.1206 (1.4590)**
Zoning (other) (%)				0.4505 (0.2278)*
Overlay (heritage) (%)				-1.0795 (0.4657)*
Constant	0.5906 (1.3312)	0.3608 (1.4524)	1.9393 (2.2589)	-4.1285 (2.3311)
Spatial lags contiguous				
Ln housing supply (ld)	1.1825 (0.1256)***	1.1909 (0.1137)***	0.8331 (0.1169)***	0.9461 (0.1234)***
Ln housing supply (ld) (error)	-0.936 (0.1941)***	-0.9220 (0.1962)***		-0.4852 (0.2094)*
Spatial lag, inverse distance				
Ln housing supply (ld) (error)			-4.6040 (1.7170)***	
Statistics				
N	297	297	297	297
Pseudo-R2	0.002	0.020	0.257	0.091

*Note: GNS model, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. Omitted categories: Property age 1996-2005; Residential, zoning (%). The regressions in Column 3 and 4 were also run with interactions between zone/age and change in house prices. The results are qualitatively unchanged.*

Source: Author's calculation from Victorian Valuer General data (valuation), DELWP HDD and Planning data, ABS (2020a) and Australian Property Monitors Data (APM Timeseries Property Data).

With respect to filtering dynamics, Table 4 provides a number of insights:

The price elasticity of supply in each of the estimates is, in practice, zero (this is the case also for total marginal effects). The estimates range from 0.05 (with zoning) to 0.33 (with age of properties). None are significant, hence statistically they are zero. Neither the level of prices in 2013 (or 2015, see footnote 16) or the change in prices 2013–16 (or 2015–18) are significant. This is a critical finding, because in the absence of a price responsive supply in dwellings, an increase in demand leads to a large increase in price, and a small increase (none) in supply. That is, there is little evidence of supply exceeding demand.

Moreover, a low price elasticity in areas experiencing demand growth may also result in physically obsolete stock continuing to return an economic rent. Going back to key assumptions for filtering, this means that at finer spatial scales (such as neighbourhoods) the rate of dwelling construction does not exceeds the rate of household formation or new demand.[17]

There are good reasons for why this might be the case at this level of spatial aggregation. Existing land use, as well as planning and political economy dimensions of new housing supply can limit the potential, capacity and willingness to accept new dwellings locally. Note in this respect that there is a positive spatial interdependence in that areas with higher levels of supply are typically in close proximity to other areas with higher supply. Residential growth zones are an example of this.

Therefore, columns 2 and 4 provide some insight on existing land use and planning. The inclusion of overall dwelling density (column 2) is not a statistically significant determinant of new supply. However, when examining new supply by zones, there is some evidence that the elasticity of supply may be greater in areas zoned as mixed use and capital city zone. Mixed use zoning is a facilitator of densification with a positive impact on housing supply. Conversely, heritage overlays reduce the price elasticity further. Low-density residential zoning is only significant at the 10 per cent level — indicative, but not strong evidence of lower price elasticity in this zoning classification too.

Finally, when adding the age of the housing stock (column 3) to the supply regression there is little difference in price elasticity between areas with more recent housing stock and areas with older housing stock. Areas in the intermediate age range (1935–95) appear to have somewhat lower price elasticities (though all areas have low price elasticities). While some variation in the age variables, the effective elasticities are only marginally changed. Both more recent and older areas have a non-significant elasticity of approximately 0.33 (statistically zero). Again, there is little to suggest that new supply, at the local level, is responsive to changes in demand.

The overall low price elasticity of supply and the ensuing absence of a dwelling surplus thus limits the extent to which filtering effectively can generate a supply of affordable housing for low-income households.

3.1.4 Demolitions and removal of economically obsolete housing

The effect of filtering dynamics on demolition and removal of economically obsolete housing is complex. On the one hand, if properties do filter (are inhabited by residents with successively lower socio-economic status) and the demolition rate of older properties is low, then filtering dynamics contribute to expanding the stock of low-income housing.[18] However, if the very lowest quality housing is removed, then the net expansion of housing supply for low-income households may be negligible. On the other hand, as noted in Chapter 2, owners of dwellings have multiple options open to them following sub-market specific additional supply. In addition to letting dwellings depreciate, owners can upgrade dwellings and take advantage of returns in higher quality housing segments. The analysis in Chapter 4 shows that the rent of properties undergoing capital investment between tenancies depreciates less, than properties not undergoing capital investment, and they can convert dwellings to alternative uses. Dwellings in sub-markets experiencing additional supply may therefore not filter downwards, but instead be redeveloped (or removed as residential housing altogether).

17 National level estimations for Australia also suggest that the price elasticity of supply is below one (Ball, Meen et al. 2011).
18 The analysis in Table 2 and 3 already shows that older housing stock is not necessarily inhabited by lower income households.

Table 5 provides some tentative insight on these competing outcomes. Table 4 reports the total marginal effects following the 'demolition regression' (Appendix A, Equation 2) that examines the demolition rate at collection district level for Melbourne over the period 2006–15.

Table 5: Demolition regression results

	Number of dwellings demolished	
Variable	All stock	Sold stock
Property age 1996--2005 (%)	0.0024 (0.0086)	-0.0224 (0.0103)**
Property age 1986–95 (%)	-0.0569 (0.0091)***	-0.0378 (0.0102)***
Property age 1976–85 (%)	-0.0492 (0.0091)***	-0.0388 (0.0103)***
Property age 1966–75 (%)	-0.0509 (0.0092)***	-0.0362 (0.0106)***
Property age 1956–65 (%)	-0.0106 (0.005)	0.0187 (0.010)
Property age 1946–55 (%)	0.0881 (0.0120)***	0.0747 (0.0102)***
Property age 1936–45 (%)	-0.0092 (0.0157)	0.0039 (0.0132)
Property age 1926–35 (%)	0.0013 (0.0162)	0.0011 (0.0131)
Property age 1916–25 (%)	0.0277 (0.0205)	-0.0011 (0.0145)
Property age 1906–16 (%)	-0.0159 (0.0174)	-0.0099 (0.0138)
Low-density residential, zoning (%)	-0.0246 (0.0051)***	-0.0244 (0.0048)***
Mixed use, zone (%)	-0.0039 (0.0147)	0.0059 (0.0122)
Industrial, zone (%)	-0.0111 (0.0129)	-0.0153 (0.0122)
Park, zone (%)	-0.0065 (0.0081)	-0.0092 (0.0078)
Commercial, zone (%)	0.0088 (0.0192)	0.0132 (0.0177)
Capital city and activity centre, zone (%)	-0.0121 (0.0080)	-0.0053 (0.0070)
Other, zone (%)	-0.0167 (0.0030)***	-0.0140 (0.0029)***
Heritage, overlay (%)	-0.0453 (0.0061)***	-0.0442 (0.0062)***
HP Change in $/sqm 1995-2005	-0.0029 (0.0026)	-0.0030 (0.0024)
HP $/sqm 2006	0.0124 (0.0057)**	0.0072 (0.0057)
ln dwelling density 2006 (ABS)	-0.0111 (0.0025)***	-0.0124 (0.0024)***
ln relative income 2006	-0.0146 (0.0045)***	-0.0030 (0.0042)
Spatial lag, contiguous		
Demolition rate (ld)	0.3667 (0.0351)***	0.3211 (0.0364)***
Spatial lag, inverse distance		
Demolition rate (ld) (error)	5.4155 (1.0982)***	5.6052 (1.3520)***
Pseudo-R2	0.4142	0.4109
Number of CDs	5,362	5,362

*Note: GNS, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. ld=lagged dependent variable, sqm=square meter. Omitted categories: Property age 1915 or older; Residential, zoning (%).*

Source: Author's calculation from Victorian Valuer General data (valuation), DELWP HDD and planning data.

Again, our primary interest here is the relationship between the age profile of properties at the CD level and the rate of demolition taking place. Second, relative income status in 2006 and zoning classifications provide further insight into potential sub-market specific adjustment processes. Typically, areas with a larger proportion of properties constructed between 1966 and 1995 have lower demolition rates and areas with larger proportions of properties constructed between 1946 and 1965 have higher demolition rates than areas with older (pre-WWII) construction.

The lower demolition rates in areas with a higher proportion of housing stock developed between 1966 and 1995 may indicate that more of the existing housing stock is retained as new construction becomes available. In other words, less housing exits the market (in this market segment), which potentially has a price dampening effect. When compared to the results in Table 3, it is evident that these are also areas that experienced some decline in relative income status (2006–16).

Demolition rates in areas with a higher proportion of housing stock developed in 1936–65 tend not to exhibit lower demolition rates. Instead, the demolition rate in areas with a higher proportion of housing developed in 1946–55 appears to be higher. When compared to the results in Table 2, these are areas with typically lower relative income status. The higher demolition rate (1946–55) may indicate that new supply is accompanied by removal of obsolete housing stock. The overall (net) outcome in terms of housing surplus is thus less clear. The removal of obsolete housing stock is consistent with filtering dynamics. However, it also means that the required surplus of dwellings that is required to achieve a price dampening (affordability) effect is weakened or absent.

Finally, for areas with a greater proportion of housing stock developed prior to 1936 there is little evidence of a lower demolition rate. When compared to Table 2 and 3 these are areas starting out with typically higher relative incomes and with loss of relative income status over time (2006–26). Under filtering, for properties in these areas to be inhabited by households with successively lower incomes a lower demolition rate would be expected. The absence of a significantly lower demolition rate in these areas may suggest that, rather than filtering down, properties in these housing segments are redeveloped before filtering down to lower income households.

Older housing stock is, in part, protected by heritage overlays. The results in Table 5 show that demolition rates are typically lower in areas under heritage overlays. Moreover, as shown by Figure 6, the relationship between dwelling age and property price is not straightforward. This means that the housing services rendered by this stock does not become economically obsolescent over time *in a manner consistent with filtering.* Spatially, the distribution of pre- and post-war housing stock (Figure 3) means that older housing stock typically is located within closer proximity to inner Melbourne jobs.

Two further results are of note in Table 5. First, areas zoned as low-rise residential typically have a lower demolition rate than all other residential areas. Second, areas with higher relative incomes in 2006 had a lower demolition rate in the following decade. These two results are important, as they highlight the institutional and socio-economic processes that condition both physical and economic obsolescence. Higher income households are more likely to have the resources to maintain the physical quality of older properties (thereby avoiding physical and quality deterioration). They may also benefit from the investment that is made by their neighbours. As per the house price regression in Section 3.1.2, this means that some of the older housing stock that has 'survived' until today provides, at least in a market sense, a superior level of housing services. The spatial interdependencies in both Table 3 and 4 show that these effects are not spatially random but instead spatially clustered. In other words, whether the age of the housing stock indicates inferior or superior quality tends to be spatially concentrated.

This is not very surprising. Any casual wander through some of Melbourne's affluent and less affluent suburbs makes this obvious. However, from an affordable housing policy perspective the implication is that the dynamics of physical (or economic) obsolescence are not independent of the socio-economic and institutional context of local property markets. Local socio-economic and institutional determinants thus shape the direction of filtering.

3.2 Policy implications

This chapter analyses the income characteristics of dwelling occupants in Melbourne, as a function of dwelling age. Under filtering, properties should, over time, be inhabited by successively lower income households. A key aspect of this analysis is whether age-related filtering – that is, the extent to which new properties result in existing properties becoming the residences of lower income households over time – takes place independently of other demand characteristics. Other demand characteristics includes positive and negative externalities arising from the behaviour of other residents in an area, or locational characteristics, such as access to labour markets and urban amenities. The analysis is complemented by testing the price elasticity of supply at SA2 level, and demolition rates at CD level. Overall, the results suggest that processes of physical and economic obsolescence interact with socio-economic and institutional factors, rather than functioning separately from them.

The implications of this are that:

- New properties typically trade at a premium to older properties. Hedonic regression of sales (2006–15) show a price premium for newer properties. Moreover, this price premium does generate some impetus for socio-economic change. Area level (CD) change in relative income status (2006–16) shows that areas with a greater proportion of newly built properties (younger housing stock) typically improved their income status relative to areas with a high proportion built after WWII.
- However, this is not necessarily so when compared to areas with a higher proportion of housing built before WWII, and the effect of housing age is significantly reduced by the inclusion of the socio-economic characteristics of areas before the change period.
- There is, therefore, limited evidence of downwards filtering of properties as a function of age alone. Significant spatial restructuring has taken place, and continues to take place during our period of analysis (2006–16), but the evidence that this is the result of age-related housing market filtering is not strong. Instead, spatial dynamics are, on the one hand, the result of socio-economic and institutional factors (inclusion of these variables significantly reduces the effect of age of housing stock variables), and also changes in proximity to labour market and urban amenities over the preceding decades.
- Areas with a higher proportion of older housing stock started the period (2006) with higher relative incomes, a gap that increased in the following period (to 2016). New areas also increased their relative income, but less so compared to older areas. New build, then, is an instrument for changing the relative incomes and occupancy characteristics of areas (consistent with filtering), but less so in areas with a greater proportion of older housing (inconsistent with filtering). These trends suggest greater disparity (or polarisation) in the local housing market fundamentals that condition housing affordability.
- A key assumption behind filtering (as a source of affordable low-income housing) is that the rate of housing supply exceeds the rate of new household formation or demand. At SA2 level, price elasticity of dwelling supply is very low, suggesting that this key assumption is not present in the Melbourne housing market. Additionally, controlling for age and zoning reinforces this conclusion further, but also shows that planning instruments (such as heritage overlays) provide a means of ensuring a housing market status quo and resist changes to neighbourhood character through new housing supply. Institutional factors (planning) are therefore likely to contribute to inhibit significant supply shocks in some high demand areas.
- Finally, owners in areas (or sub-markets) experiencing additional supply have alternative options open to them instead of letting properties filter downwards. The age of housing stock is related to demolition activity, but the relationship with expectations under filtering is only partial. Areas with a greater proportion of housing stock built in 1966–95 have lower rates of demolition. These areas also have very low supply elasticities and, typically, declining relative income status (2006–16) compared to areas with very recent development and (even) older housing development. Though these areas cannot typically be described as either higher or lower income areas in 2006.

- Overall, one interpretation of lower rates of demolition and declining relative income, is that physical obsolescence in these areas (built 1966–95) is resulting in additional housing for low-income households. This is an interpretation consistent with filtering. An alternative interpretation is that these areas housed new migrants and aspirational middle classes (relocating from inner Melbourne) during the post-war metropolitan expansion. These households would initially have increased their relative income status (prime working age households, see results for 2006–16 in Section 3.1.2) before transitioning into retirement (resulting in lower relative incomes). A second alternative interpretation is that housing built between 1966 and 1995 is disproportionally located in a band (20 to 60 kilometres) from the Melbourne CBD (see Figure 2) – areas from which manufacturing and light industry has retracted. Yet another interpretation is that many of these areas contain the bulk of Melbourne public housing stock (nearly two-thirds of Victoria's housing stock stems from this time period), shown in Section 3.1.2 to result in declining relative incomes. Neither of these two latter explanations are consistent with filtering as a source of affordable housing supply for low-income households. The analysis in Section 3.1.2 shows that the effect of property age on change in occupancy characteristics is substantially conditioned, or co-dependent, on the socio-economic characteristics, thus weakening the strength of the filtering interpretation above.

  However, areas with a greater proportion of housing built in 1936–65 did not experience lower demolition rates. These are also areas that in 2006 typically housed lower income households. The somewhat higher demolition rates in this housing segment may thus also indicate a removal of existing lower income households and thus the availability of affordable housing options. Finally, the absence of lower demolition rates in the pre-WWII housing stock suggests that, for segments of the older housing stock, housing is replaced or renovated, before it can become available to low-income households.

- In practice, each of the above interpretation plays a role in how market processes contribute to or shape the provision and location of affordable housing for low-income households. The evidence here suggests that there are considerable interactions between the various factors underlying each interpretation of occupancy and neighbourhood change. Importantly, this also means that from an affordable housing policy perspective, filtering cannot be considered in isolation from the remaining determinants of occupancy change. That is, new supply will not necessarily free up existing housing for lower income households, unless also the remaining determinants of demand for housing in specific locations is addressed. Moreover, new supply also needs to generate sustained downward pressure on sub-market specific property prices (that is, the rate of supply exceeds the rate of new household formation/demand; and new housing constitutes effective substitutes for existing housing).

- In the absence of these conditions, one can reflect that the affordable housing gains from property-age related filtering (in areas with housing from 1966–95) potentially is lost through demolition, redevelopment and neighbourhood change dynamics in other parts of the housing system. In this interpretation filtering becomes a mechanism for socio-spatial sorting, rather than a supply of affordable housing for low-income households. If one takes the view that declining relative incomes (in areas with housing built in 1966–95) is also driven by life-cycle dynamics, locational obsolescence or public housing neighbourhood dynamics (such as housing explicitly built as affordable housing instead of housing that has filtered down), then property-age related filtering does not appear to be mechanism of supply of affordable housing for low-income households.

4. Price characteristics in private rental housing: the Sydney analysis

- **This chapter tests the price characteristics of rental housing in Sydney over time. Theoretically, filtering dynamics are expected to be more pronounced in rental housing due to the higher turnover of occupants.**

- **Analysis of Sydney markets shows that private rental properties move down market over time when measured by rent received for a specific property relative to market medians. However, rent increases remain above increases in income, largely offsetting the effect of the affordability of individual properties due to price depreciation. As such, very little low-cost, or 'naturally affordable' private rental housing is generated through the process.**

- **There is a high degree of variability, and evident complexity, in rent depreciation. In line with theory, areas with the most new housing supply showed greater rental depreciation. The apartment market in North Sydney-Hornsby represents the model well. For house markets, high depreciation aligned with lower volumes of rental properties. This suggests landlords depart markets with lower returns, reducing the potential for filtering to add to a supply of low-cost private rental housing. In other markets with high volumes, there is a lower rate of depreciation.**

- **Dwellings new to the private rental market (no evidence of previous rental history) also have a high degree of diversity and broadly match the overall rental stock in the market at the time. Notably, a majority of properties new to the private rental market were not the result of a change in owner or of new development.**

4.1 The property biography method and data sources

As outlined in Chapter 2, filtering is the process of dwellings moving down market as they age and as other, newer, dwellings with higher amenity (however measured) occupy the higher end of the housing market. Theoretically this process is also seen as a means of generating a steady supply of low-cost housing that is affordable to those on lower incomes (sometimes called 'naturally' occurring affordable housing).

This chapter operationalises that process by examining a sample of the current supply of rental housing in Sydney and, by tracking the biographies of the sample, where (in terms of market segment) that stock of housing originated. That is, for a given property, we catalogue events like sales (and so change in ownership), bond lodgements and returns (and so change in tenants, and even tenures if there is an isolated bond lodgement or return), and development applications (and so extensions and renovations through to new construction and sub-divisions). The resulting database can then help track aggregate changes (like median rents over time). It can also break down the particular circumstances that precede, and so influence the likelihood of, those changes for individual properties, as well as circumstances that follow. Appendix C provides details on data preparation and further methodological aspects, and describes the nature of the collected data.

The particular objectives of this analysis are to explore the extent to which low-cost housing enters the market through filtering processes, and what—if any—factors influence processes of filtering (either catalysing or inhibiting the process).

In this novel approach in the Australian context, the analysis focuses on four questions:

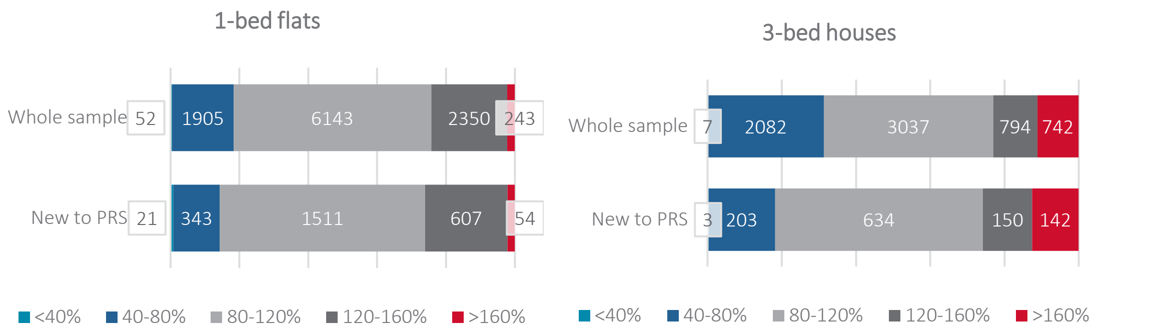
1. How do properties 'end up' in the private rental sector? Under filtering, the assumption is that properties successively move down market (and so down tenant income status). In Australia, private rental properties historically constituted an important supply of dwellings for lower income households (Yates and Wulff 2005). Properties transitioning from owner occupation to private rental may therefore indicate filtering. Notably, there is evidence that over the past two decades there has been a gradual shift in the profile of private rental tenants, with a larger proportion of middle-income households now residing in private rental. This trend is particularly marked in Sydney (Hulse, Reynolds et al. 2019).
2. How do rental prices change relative to the rental market as a whole when properties age? This analysis focuses explicitly on the relative price, or price depreciation, of rental properties as they age.
3. Are there differences in the nature of relative price depreciation across Sydney? As in Chapter 3, social interactions and supply characteristics are important to assessing the role of filtering dynamics in ensuring a supply of housing for low-income households.
4. How does housing re-investment affect tenure transitions and price depreciation?

4.1.1 New private rental supply and tenure transitions

Significant minorities of both the house and flat samples appear to have entered the Private Rented Sector (PRS) for the first time in Q1 2020, having no prior record of a rental bond lodged. One in four one-bedroom flats (n 2,536) and one in six three-bedroom houses (n 1,132) were new to the PRS.

These new-to-PRS one-bedroom flats enter the market at rental price points closely reflecting those for all one-bedroom units; the new-to-PRS three-bedroom houses skew slightly higher. This can be seen in Figure 7, which compares the rental price point distribution of all dwellings in each sample with the distribution of dwellings new to the rental market. (See Appendix C for details on the market segments.)

Figure 7: Distribution of sample and 'new rentals' by market segment (% of median rental)

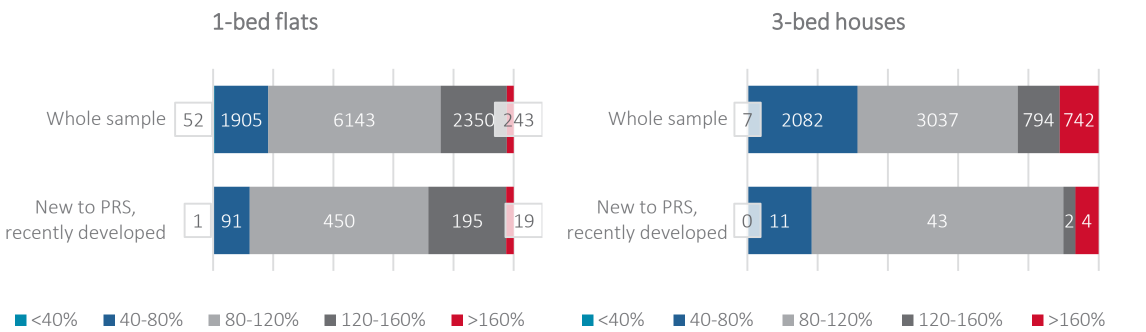


Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

Although new to the PRS, most of these properties are not newly developed and had a previous life, most likely in the owner-occupied sector. In contrast, Figure 8 compares the rental price point distribution of only recently developed new rentals with the overall sample. By identifying development approvals recorded over Q1 2020 and the previous eight quarters (to the start of 2018), we find five per cent of new-to-PRS three-bedroom houses were recent developments. Most of these dwellings enter the PRS at around the median rent, with relatively few in lower rent segments. New development is more significant among new-to-PRS one-bedroom flats, with 30 per cent recording a recent development approval.

Although still a minority, this reflects a significant proportion of properties that are 'built to rent', so to speak. These newly developed dwellings are entering the PRS at a distribution of rental price points similar to the whole of the one-bedroom flat cohort (Figure 8). Although, as discussed below, this similarity potentially masks a compositional change in the cohort.

Figure 8: Distribution of sample and 'recently developed new rentals' by market segment

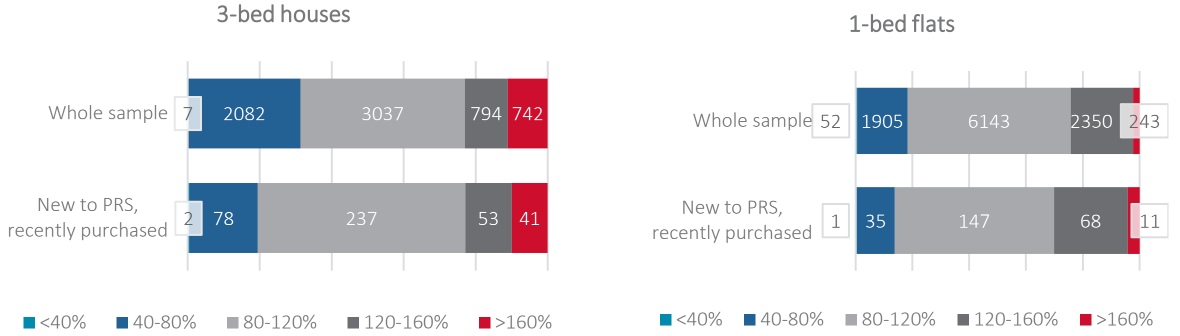


Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

Aside from development, another potentially significant event precipitating a property's entry to the PRS is a recent prior sale, which suggests a purchaser making a deliberate investment in the PRS. Figure 9 compares these 'recently purchased new rentals' with the whole sample. Looking over Q1 and the previous four quarters (to the start of 2019), we find recent sales recorded for 36 per cent of new-to-PRS three-bedroom houses (compared 13 per cent for the entire three-bedroom house sample). While this too is a minority, it points to a notable degree of purposive investment bringing properties into this part of the PRS. It also means that about one in 20 of all the three-bedroom house cohort is both new to the PRS and new to the landlord who owns it.

Just 10 per cent of new-to-PRS one-bedroom flats had recorded a recent sale (and 6 per cent of all the one-bedroom flat sample). In light of the relatively high rate of new development among these properties, the low rate of recent purchases is significant. This is consistent with a significant number of those recently developed one-bedroom flats being studio apartments, student accommodation units and (to a lesser extent) secondary dwellings, which are not separately sold. These built forms are relatively novel and represent a compositional change in the one-bedroom flat market; they also represent a different sort of purposive PRS investor.

Figure 9: Distribution of sample and 'recently purchased new rentals' by market segment



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

For the majority of new-to-PRS dwellings for which no recent prior sale is recorded, we can only speculate as to the circumstances behind their movement into the PRS: an owner-occupier (or their heirs) deciding to turn their former home into a rental investment; or a temporarily absent owner-occupier renting their home for a short spell before their intended return. This underscores the close integration of the owner-occupier and rental sectors.

4.1.2 Rental depreciation in Sydney

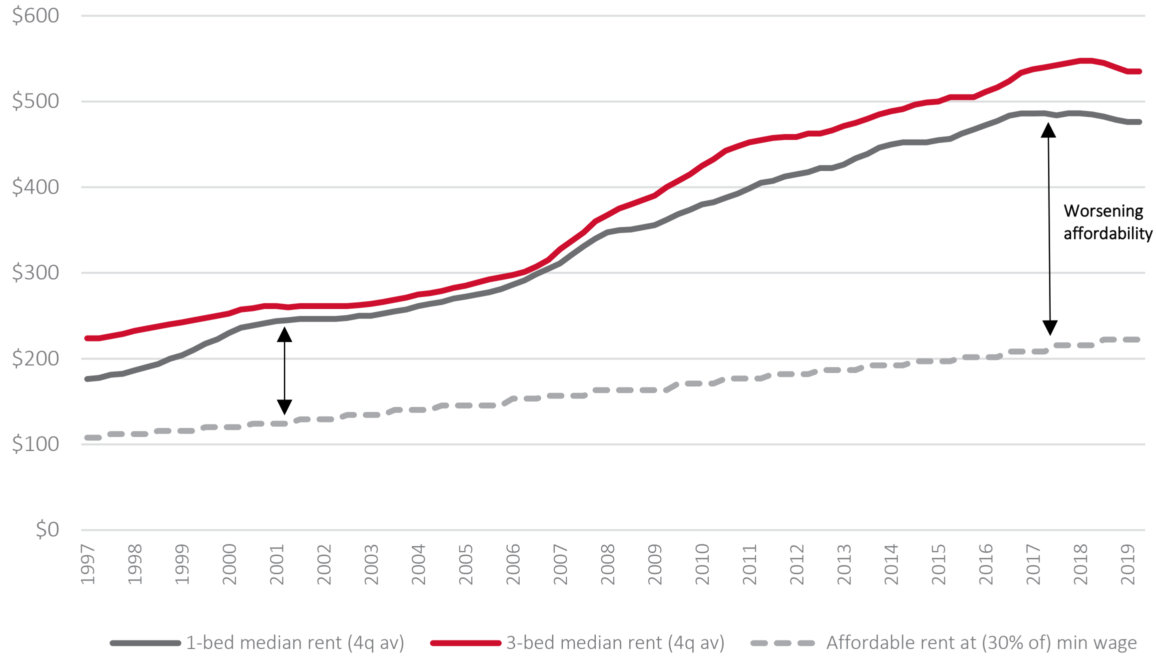
A number of properties have several bond lodgements on record. This enables testing of whether rental prices, over time, depreciate relative to other rents. It also provides a measure of whether filtering dynamics may be present. In the following analysis, rents recorded at bond lodgement are measured relative to the median rent at the time of each bond lodgement.

One central tenet of the stylised filtering process is the movement of properties down market over time. That is, relative to the rest of the market, properties get cheaper as they get older. Based on the sample of properties described above, it is possible to compare their current rent (relative to the current market median) with historical rents paid for the property (relative to the market median at that time).

Of the sample described in Appendix C, 83 per cent of the three-bedroom houses and 76 per cent of the one-bedroom flats have previous bond lodgements that provide a point of comparison. In almost all cases, the rent (in nominal dollar terms) is higher or the same as the point of comparison.

Similarly, the market median is also almost always higher or the same now, when compared to previous periods. Figure 10, below, shows the trend in median rents for three-bedroom and one-bedroom dwellings. Additionally, Figure 10 shows the affordable rental price for a low-income households.

Figure 10: Quarterly median rent over time, by bedroom



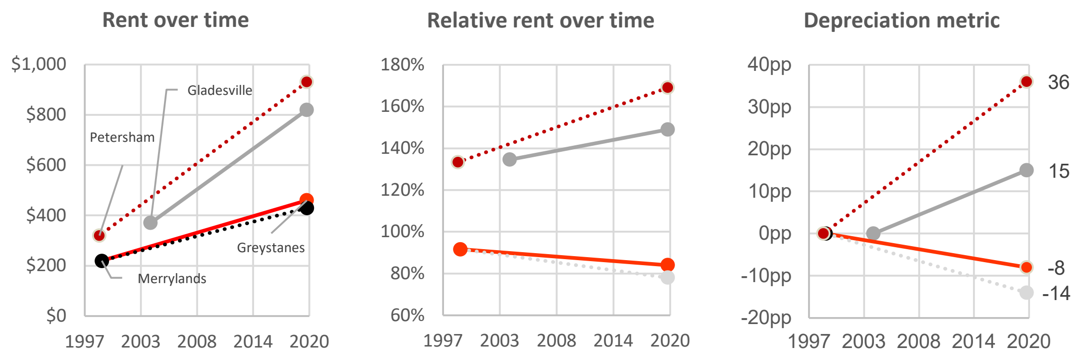
Note: Affordable rental price is defined as a maximum of 30 per cent of household income. In Figure 10, income is based on the minimum wage.

Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C; minimum wage from FWC 2019.

There is some risk of composition differences in a given quarter affecting the median. For example, if in one quarter more bonds were lodged in a cheaper part of Sydney, then the median would be lower. However, the market median for each bedroom count is based on a large sample (including all dwelling types) for each quarter to reduce any composition effect on the median. Also, the composition of available stock in a given quarter has a bearing on how much rent a landlord can secure. So the composition, and any associated fluctuation in median, is not entirely irrelevant when examining markets. The one potential lingering composition effect could be the rise of purpose built student accommodation, and to a lesser extent granny flats, being lodged as one-bedroom flats (as described in Section 1.3.1 above). The substantially lower amenity in student accommodation (at approximately half the floor space) could account for the decrease (in absolute nominal terms) of median rent for one-bedroom flats since 2017. However, as shown in Figure 10, median rent for three-bedroom houses was also flat over this period (2017–19).

Figure 11 illustrates how the depreciation metric works for four individual three-bedroom houses located in Petersham, Gladesville, Greystanes and Merrylands. From left to right the three panels show the nominal rent of each property at two points in time; the nominal rent at those two points in time relative to the median rent at that time; and finally, the change in the relative rent at the two points in time. In this analysis we consider only the oldest data point for each property, and then look only at the percentage point change, relative to that oldest data point. This is gives a 'depreciation metric'.

Figure 11: Examples from the sample: rent over time; change in rent relative to median; the 'depreciation metric'



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

Across the entire sample, the median 'depreciation metric' is:

- -7 percentage points for three-bedroom houses
- -4 percentage points for one-bedroom flats.

This is evidence that properties typically move down market over time. However, it is a naïve indicator on its own for three reasons.

First and most importantly, it is silent on the extent to which, over time, median rents have changed relative to incomes (if everything is more expensive, even the median is less 'affordable'). This is illustrated in Figure 10, which depicts an 'affordable rent' for someone earning minimum wage. As expected, the median price is above that affordable rent, but some other income-based measure would show a similar rate of increase over time (minimum wage has closely followed the wage price index over this period). There has been an overall deterioration in affordability as a result of rent prices having a higher rate of inflation than wage prices. In most cases, the observed depreciation of a given property is offset by this overall rent inflation. Only in the most recent three to four years, where rents have been flat while wages have risen, is the depreciation enough to make the property more affordable in real terms (albeit modestly).

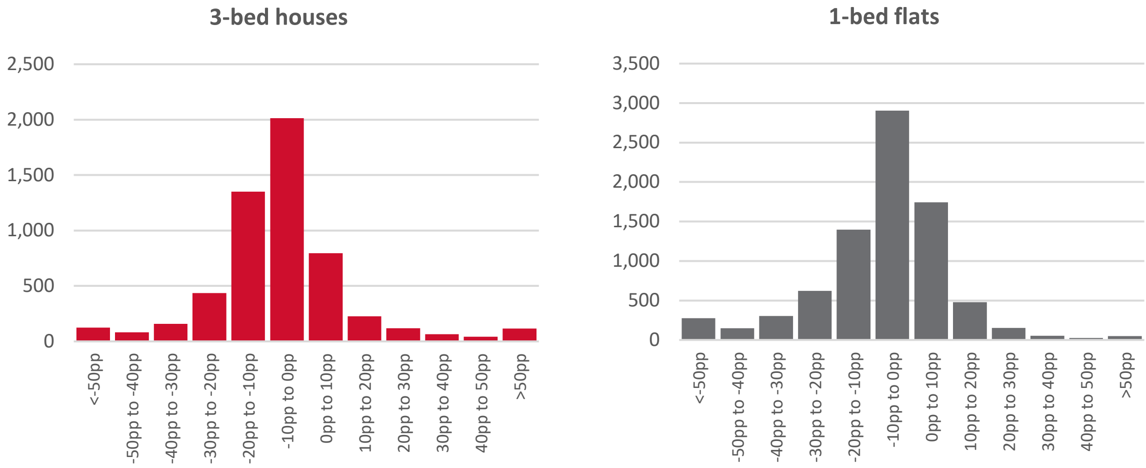
Relatedly, there is no direct measurement of tenant income for a given property at different points in time. That is, there is nothing to directly confirm that the incomes of tenants move in line with the changes in rents – itself a central tenet of the stylised filtering process. This could be countered by adjusting historical rents for inflation to an equivalent value in 2020 dollars. This limitation notwithstanding, it is a useful metric to examine housing market patterns.

Overall, the widening gap between median rents and affordable rents has important implications for stylised filtering dynamics. First, it may indicate that the supply of new rental properties is unresponsive to changes in demand. In other words, new households (demand) may exceed the supply of new properties. Secondly, (and as a result) the depreciation that is taking place (new properties do command a price premium) is insufficient to offset overall price increases leading to a reduction in the availability of low-income housing. In other words, areas may be filtering upwards, rather than down, over time.[19]

Second, the 'median' depreciation metric conceals the variations within the sample. Below are the distribution charts for the depreciation metrics for the two samples. A significant proportion of properties have actually moved up market over time, as witnessed by the bars with positive signs (>0pp) depreciation metrics. Conversely, there are instances of larger rates of depreciation (<10pp).

19 One consideration that we are unable to test in this analysis is the extent to which a given property in the sample has become more intensively utilised. That is, multi-household rentals or shared accommodation, may in principle be consistent with increasing rents and entry of (multiple) low-income households.

Figure 12: Distribution of 'depreciation metrics'



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

Third, and related to the above noted variation, the median is silent on what influences this depreciation metric. Most evidently, if properties gradually move down market then the amount of time that has passed since the benchmark (initial) rent was observed should influence the metric. However, so too could different sub-markets by geography and potentially different market segments, an issue we return to in Section 4.1.3.

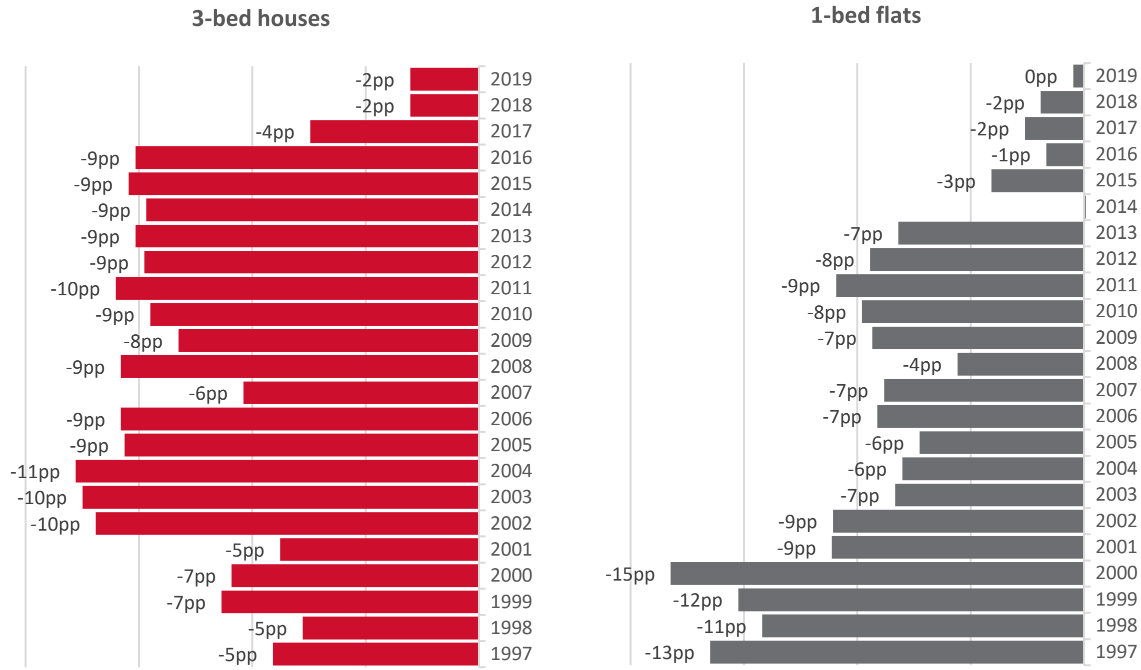
The depreciation of the rents for older dwellings, relative to the market rents overall, implies a gradual trend that dwellings will progressively depreciate over time. The data here suggest something quite different, more akin to a 'threshold effect'. Figure 13 shows the median depreciation metric (the relative change from first bond to current bond), based on the year of the first bond.

For both three-bedroom houses and one-bedroom flats, there is very little movement for dwellings that first appear in our sample – effectively those that were first rented – in recent years. Three-bedroom houses first rented since 2017 and one-bedroom flats first rented since 2014 have little depreciation, with rents dropping (relative to market median) by less than 4 percentage points.

Before that, however, properties that were first rented any time since around 2001–02 have depreciated by similar amounts, irrespective of time that has elapsed. For three-bedroom houses, the median depreciation metric for properties first rented in all but two years from 2002–16 is between eight and 10 percentage points. Similarly, for one-bedroom flats the median depreciation for properties first rented in the 13-year period from 2001–13 is almost always between six and nine percentage points, again irrespective of the time that has passed since the first bond.

Finally, for the oldest data in the sample – properties that were first rented more than 20 years ago – houses and flats show two different patterns. For flats, the depreciation metric is even greater, consistent with the filtering process of older properties moving down market. However, houses move in the opposite direction, with properties first rented before 2002 depreciating by less than those first rented in the period since.

Figure 13: Depreciation metric by year of initial (oldest) bond record



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

Overall, the evidence in Figure 13 is indicative of somewhat different age and price dynamics across market segments. Rental houses exhibit a u-shaped relationship, not unlike the relationship in Chapter 3 (but over a much shorter time period). Flats, on the other hand, exhibit a largely steady degree of price depreciation over time. Notwithstanding this price depreciation, actual rent increases for one-bedroom flats are still greater than the corresponding rise in the affordable rent. For instance, in 1997 the actual rent for a one-bedroom was approximately 1.65 times the affordable rent. By 2019, the one-bedroom rent, *adjusted for a 13 per cent depreciation*, had increased to 1.86 times the affordable rent. In other words, affordability for low-income households continued to worsen, even though the nominal rents of older properties did not increase at the same rate as the median rent.

An explanation for these differences might relate to both market segment and locations (both of which are examined in greater detail in Section 4.1.3). Houses that have been rented for over 20 years are necessarily in neighbourhoods that are established, with stable communities, mature trees and more, all of which are valued by prospective tenants. Flats that have been rented for more than 20 years, on the other hand, pre-date the apartment design requirements that have been in place in Sydney since the early 2000s. That suggests this older stock will have lower levels of amenity, but not likely to have a significantly different geography to more recent additions to the rental market (as apartments are largely constrained to inner cities across all periods).

Both of these patterns point to the nature of the dwellings that each year represents. In other words, to the composition having an effect on the measured depreciation. It is important to note that dwellings that were first rented more recently are not necessarily newer dwellings, potentially having been previously owner-occupied. But the opposite is not possible: dwellings rented earlier in the dataset cannot be newer than this. This creates an asymmetry in the comparison of 'recently added to rental market' and 'longstanding component of rental market' that would require other data to disentangle.

There is also a potential 'survivor bias' present in this data. Houses, in particular, that were rented more than 20 years ago and which would have seen more significant depreciation in their rent are more likely to leave the rental market. This might take the form of a sale to an owner-occupiers (followed by refurbishment) or sale to redevelopment if the property value is increasingly comprised of the underlying land value. For flats, the latter is less likely, perhaps explaining why depreciation in rents is 'tolerated' by landlords. As noted, though, while these effects can be seen as 'skewing' this metric of depreciation, it presents a real-market picture of filtering, which is more complex than is captured in the stylised concept.

4.1.3 Rental depreciation across locations and market segment

As noted in Chapter 2 and 3, filtering is premised on new properties being effective substitutes for older (or existing) properties. In practice this extends to both the physical characteristics of the property as well as its location and the characteristics of its location (neighbourhood). Unsurprisingly, the two samples have different geographies. Houses are more distributed to include outer regions, with flats more dominant in the inner regions (Figure A1, Appendix C).

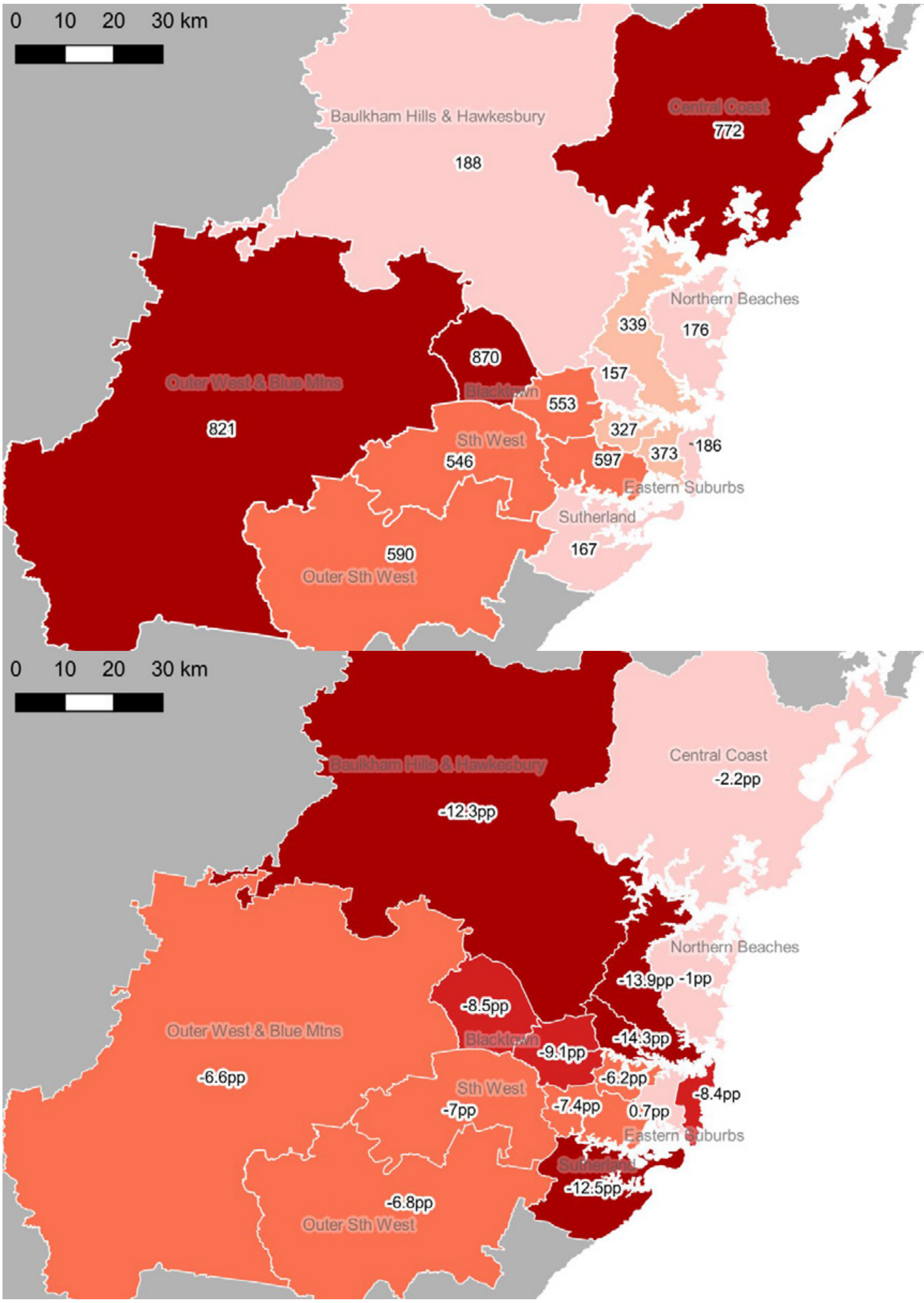
This volume will likely have some bearing on the depreciation metric, particularly where high volume corresponds with a growth in supply over the period measured. In essence, this represents a more elastic supply to respond to demand. As such, there is an expectation that existing stock is having to 'compete' with newer stock, coming up short in terms of relative amenity and quality offered, and therefore filtering down market.

There is a second geographical variation, relating to the relative size of the rental market in comparison to other tenures, particularly owner-occupants (including mortgagees). Large parts of Sydney are dominated by owner-occupants, particularly for houses, and so have quite small volumes of rentals in the sample.

For houses, the maps show a pattern of middle-to-outer ring regions with low volumes of rental as having the highest levels of depreciation: through Ryde, North Sydney and Baulkham Hills in the north and Sutherland in the south. Interpreting these data suggests that – as outlined above – there is a lower supply of rentals where rental depreciation is high. Where depreciation is lower, there are higher volumes of rental houses. As such, counter to the above expectation that elasticity in the outer regions would increase filtering and thus provide more low-cost rentals, it also seems to reduce the proportion of properties that are rented out. The result of this is that filtering does not produce a consistent volume of low-cost private rental. The extent to which the process generates a supply of low-cost owner-occupied housing would need to be explored separately.

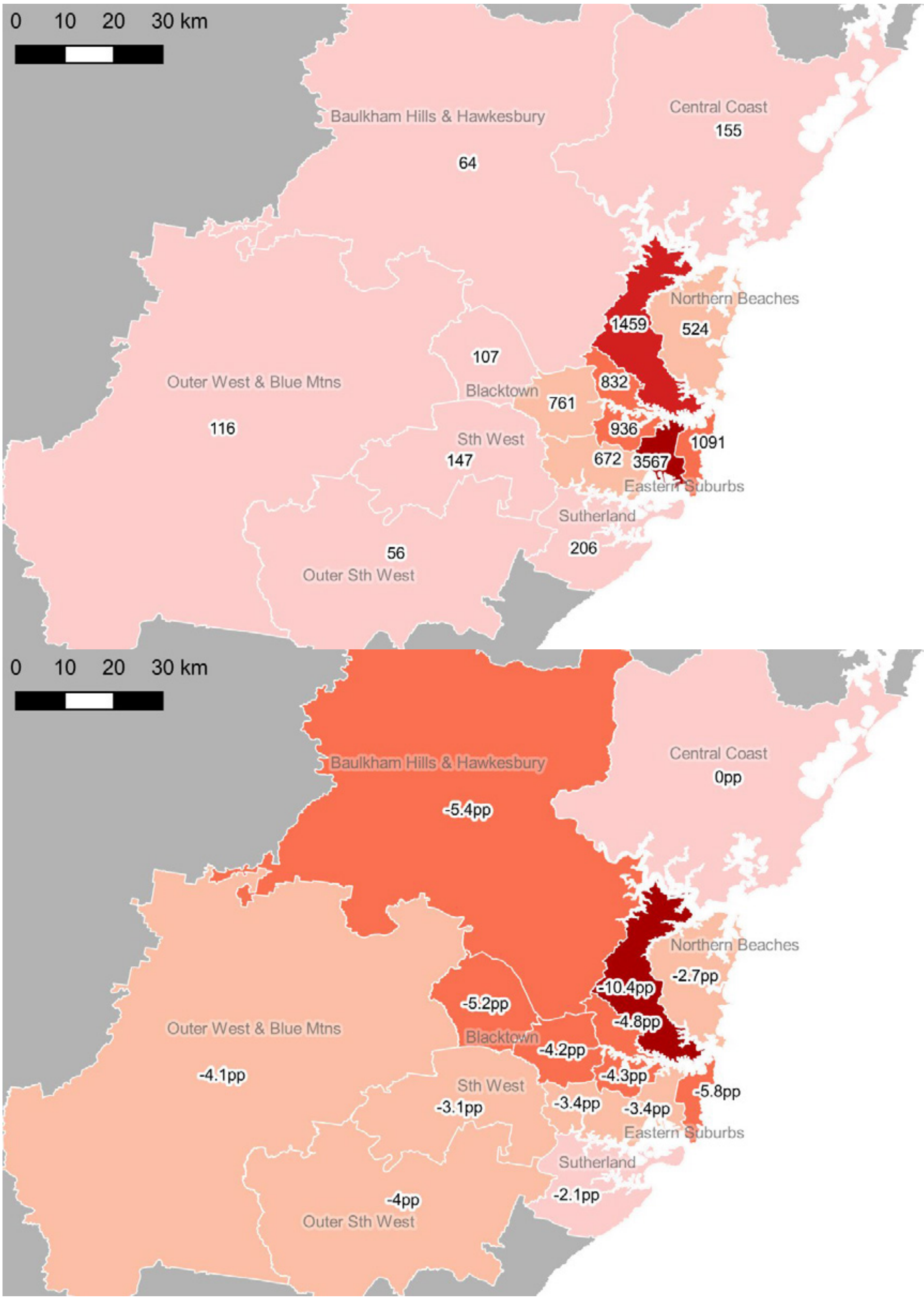
For the one-bedroom flat sample, the smaller geography of meaningful data (setting aside the regions with very small numbers of one-bedroom flats), shows similar tensions between supply levels and depreciation of rents over time. The inner city, with the highest volume (and, although not shown by these data, the site of both more historical apartments and recent apartment growth) has a smaller observed depreciation than other areas. In contrast, North Sydney has much higher depreciation, despite similar qualitative conditions (such as historical and recent apartment supply and strong demand based on jobs geography). One potential distinction between these two areas is the proximity to educational institutions, central city amenities and shopping.

Figure 14: Volume (t) and depreciation metric (b) by subregion (SA4), three-bedroom houses



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

Figure 15: Volume(t) and depreciation metric (b) by subregion (SA4), one-bedroom flats



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

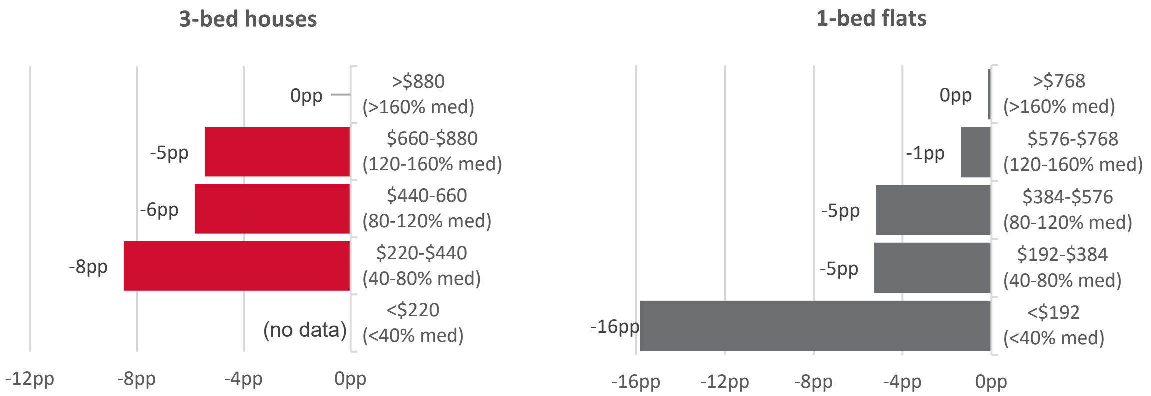
A third pattern that can be explored when examining the depreciation of the sample is the segment of the market each observation represents. That is, by looking at different rent amounts, based on the current (2020) observation. This approach also suggests a degree of price depreciation, with both three-bedroom houses and one-bedroom flats rented below 80 per cent of median rent having a higher depreciation metric than the overall sample (Figure 16). That is, those properties that are rented 'cheaply' have effectively become cheaper over time, previously renting for much more (relative to the rest of the market).

There are two important considerations here with respect to price depreciation as a supply of low-income housing. First, those in the highest rental segment have not, overall, filtered at all. This reflects the fact that some dwellings in the highest range have positive filtering metrics; against the general trend, they have filtered up market from lower price segments to reach their current segment. Second, the volumes at the lowest rental segments (below 40% median) are vanishingly small. For three-bedroom houses, it was too small to report, and even for one-bedroom flats this segment represents less than 0.5 per cent of the sample.

In other words, dwellings may well filter down the market over time, but there is a high level of attrition, with most dwellings' trajectories down the rental market disrupted before they reach an affordable price for those on low incomes. That is, in some markets properties do not filter down; but in those markets where filtering processes are most likely, some event will cause the dwelling to leave the rental market completely or undergo some reinvestment to increase rental income.

Possible events are considered in the next section, but it is worth unpacking the general point. There is evidence that properties are depreciating in value over time. This is consistent with filtering. However, there is also evidence that properties are removed *before* they reach low-income households. That is, under filtering, properties are expected to eventually be redeveloped, but for filtering to become a supply of low-income housing it is necessary that properties filter all the way down. The evidence here suggests that this may not be the case, and instead properties are removed (sold for owner occupation or redeveloped) before reaching low-income households. The increase in rental tenure amongst middle-income households may be one explanation for filtering-interrupted.

Figure 16: Depreciation metric by market segment (weekly rent): (l) three-bedroom houses; (r) one-bedroom flats



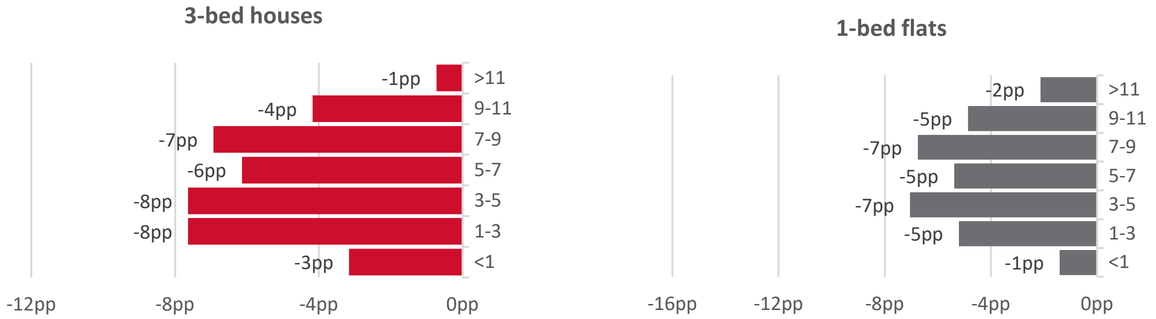
Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

4.1.4 Filtering interrupted: effect of intervening events

There are, qualitatively, a number of possible events that will disrupt the filtering process. Four are considered here. First is a turnover in tenant, with a new bond being registered. Second is a 'gap' in the rental history: a converse to turnover and used here as an indicator of a period out of the private rental market, where an owner occupies the dwelling instead. Third is a sale event: a change in owner, and therefore landlord. Fourth is a development approval, indicating some significant renovation or extension, or even change in the makeup of the dwellings on a property (such as conversion from house to duplex).

Superficial analysis of the average period between rental bonds being lodged — an indicator of (the inverse to) tenant turnover, shown in Figure 17 — suggests it has little impact on depreciation. There is little depreciation in the sample that has changed tenants every year, but this is mostly because that count comprises new properties.

Figure 17: Depreciation metric, by 'average tenancy' (years since oldest bond/no. of bonds)

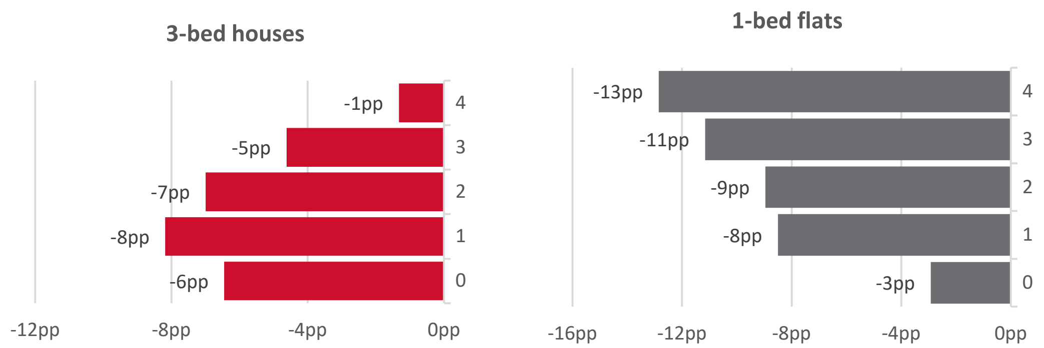


Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

At the other end, there is an indication that there is lower depreciation for very long tenancies, although again this is a composition effect. These properties necessarily have older observations (more than 10 years ago), but also large gaps between bond lodgements. As shown in Figure 18, a high number of five-year periods without a bond lodgement—an indicator of gaps in tenants (when the dwelling is outside the rental market)—also indicates a lower depreciation for houses, although it too is a small effect. This aligns with the anecdotal notion that 'good' tenants and owner-occupiers (if there is a gap in tenancy) will take better care of the dwelling, reducing any filtering effect. Or, perhaps, the inverse: insofar as better quality properties will be sought after by 'better' long-term tenants or even owner-occupiers. A third explanation relates to potential differences in the investment motivations of landlords. The Australian private rental sector is historically characterised as the domain of 'mum and dad' investors. However, over the past decade the growth in multi-property and 'professional' property investors has growth disproportionally (Hulse, Reynolds et al. 2020). Particularly in institutionally owned (such as built-to-rent) market segments, price dynamics may operate differently to those of 'traditional' private sector landlords.

Of note, the equivalent breakdown by number of five-year gaps in one-bedroom flats, suggests the opposite. (Little weight should be given to the metric for dwellings with four such gaps, as the sample size is quite low. Even setting that aside, though, the trend is opposite for the two samples). This aligns with the aforementioned divergence of depreciation for dwellings first rented more than 20 years ago. That is, much older apartments have depreciated more than much older houses, and much older properties are those that can accommodate large gaps in tenant history.

Figure 18: Depreciation metric, by gaps in rental history (no. of five-or-more-year gaps)



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

A change in owner can also disrupt the filtering process. In some cases, which will not be present in this sample, it can result in the dwelling leaving the rental market. It can also result in an increase in rent. Again, such an event might not be captured, except where a new bond is lodged. However, where a sale and rent increase precipitates a change in tenant it will be captured by this sample. Dividing each sample into those that had a sale event between the two bond observations and those that did not enables consideration of the impact of change in ownership on the filtering process.

Analysing these two sub-samples does not reveal a clear effect of a sale on filtering. The three-bedroom house data suggests a sale (and staying in PRS) will slow depreciation. That is, rent does not decrease as much as it otherwise would. This potentially reflects the fact that when a property is for sale, a new landlord is more likely to purchase it (compared to an owner-occupant) if the rental income is robust.

However, one-bedroom apartments have the opposite relationship: a sale increases the depreciation of rent. We can speculate on possible reasons for this. Some are artefacts of the data: older apartments (which would be those with older bond data) are more likely to have been sold than newer apartments, but also more likely to have depreciated. Or perhaps landlords purchasing apartments (in the inner city) are pursuing capital growth rather than rental return, so are less concerned about rental return.

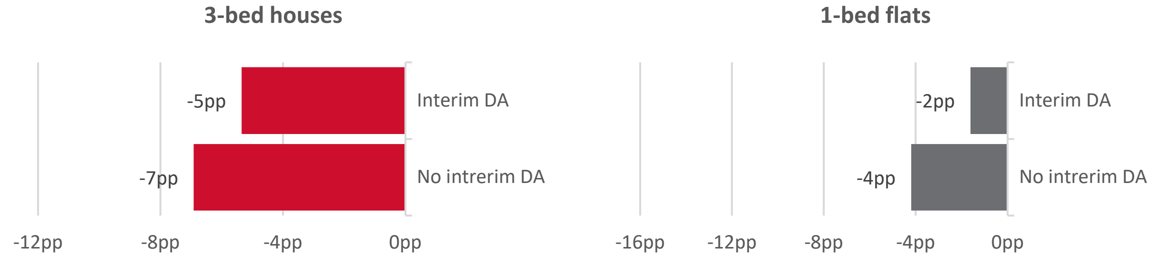
Figure 19: Depreciation metric, by sale between tenancies

Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

Drawing any conclusions would require analysis beyond the scope of the current samples. Future analysis of the available data could first ensure the sample is large enough for reliable comparison of specific sub-samples based on a larger number of conditions as alluded to above (such as initial bond from a certain period, sale at a certain point in time, subregion, market segment, and so on). However, some tentative indications of complex patterns in the dataset are discussed in the final section of the chapter.

Finally, investment in a dwelling, through renovations, extensions and the like, presents another event to disrupt the filtering process. Data available on development approvals provides an indicator of such an event. As expected, and as illustrated in Figure 20, dwellings undergoing such capital investment depreciate less than those without such an event.

Figure 20: Depreciation metric, by interim development approval between tenancies



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described in Appendix C.

4.2 Policy implications

The analysis in this chapter uses real property-level housing market data in Sydney to explore filtering dynamics in the private rental sector of Sydney and the extent to which it generates a supply of low-cost housing. The analysis confirms that existing properties do move into the rental market (tenure filtering) and that properties charge lower rents, relative to the market overall, as they age. However, the analysis also found many real-world disruptions that undermine the stylised model of filtering dynamics.

Overall, the evidence in this Chapter suggests that while newer properties typically rent at a price premium, the ensuing price depreciation of older properties is insufficient to offset the overall increase in rental values. In other words, rental affordability continues to decline for low-income households.

The implications of this are that:

- The private rental market also exhibits evidence that the responsiveness of new supply to demand characteristics (such as location, quality, and dwelling typology) is low, resulting in an overall increase in rental prices.
- Across houses and flats there is some evidence that existing properties filter into the private rental market from other sectors of the housing market (primarily owner-occupied sector). This might indicate tenure filtering. However, there is little to suggest that these properties are, compared with the rental market generally, contributing to housing at the lower end of the rental market. Instead, the composition of properties newly entering the rental market tended towards the middle of the rental market (by price), meaning a smaller proportion were below-median rentals, compared with the overall sample of current rentals.
- Across houses and flats alike there is a significant presence of purposive investors, who have purchased or developed housing for rental. There is also, conversely, a significant number of properties entering the rental market without a recent change in ownership or redevelopment. Further research is required to establish the impact of this for filtering dynamics as a source of low-income housing.
- There may be considerable differences in how filtering dynamics operate in different market segments (location and dwelling types). For instance, Sydney areas with greater supply of new dwellings do not necessarily exhibit similar price depreciation trends. This points to both important sub-market dynamics and potentially social interactions as factors determining what impact potential policy interventions might have.
- There is some evidence that depreciation metrics superficially accelerate as properties move down market. However, there is a survivor bias here. In the higher price segments of the rental market there is a mix of properties slowly depreciating (and so still fetching high rents), and new properties entering the market. Those entering the market might be new to rental, or they might be properties previously rented, but subsequently filtering up due to location or investment (renovations and so on). There is also an absent cohort of properties that have left the private rental market before filtering down to a lower price segment. As such, the sample in the lower price segment represents only those properties that continue along as rental properties and are 'left to' filter down as a result. The rate of attrition is quite high in the lower price segments.
- Further research is required to identify these processes more directly, but filtering dynamics may be interrupted before reaching the low-income household. To be clear, the filtering dynamic fully expects properties to attract reinvestment and therefore see the loss of low-cost rental properties to other market segments. However, the dynamics observed in the Sydney market suggest that such reinvestment aspects of the filtering cycle kick in before properties reach a price point that would be affordable to lower income households. As with limits on the effect of filtering generally, this is attributable to high capital growth in underlying land values, in turn attributable to low elasticity in supply of housing. Investment in existing stock or replacement of existing stock is predicated on a property's (predevelopment) value reflecting the underlying land value rather than the improvements upon it. As such, despite the property not being low-cost, or affordable to lower income households, there is little risk of over capitalising on the improvements, as the overall value of the property is expected to rise in any event.
- Finally, the potential of data to reveal insights that can, in turn, shape policy prescriptions is limited by the quality of the data. As outlined in Appendix C, the data used in Chapter 4 was collected for a specific purpose and, understandably, the agencies involved gave little thought to how their data management would limit the use of the data outside that specific purpose. But in this age of 'big data', there is a clear onus on government data collection to be more robust and amenable to diverse usage.

5. Policy development options

- Consistent with filtering dynamics, the Melbourne and Sydney analyses show that new dwellings command a market premium. However, the evidence also suggests that changes to the occupancy characteristics associated with filtering dynamics are not widely present; nor is the relative decline in rental prices for older rental properties sufficient to offset general rental increases.
- The current housing market dynamics in these cities are incompatible with filtering as a reliable source of additional affordable housing for low-income households in Australian cities. To enhance the role that filtering can play in the provision of affordable housing for low-income households, both more supply and more responsiveness of new supply to market signals is needed. Filtering as a source of affordable low-income housing rests on there being a surplus of supply, providing a price reducing impact.
- However, greater supply and market responsiveness in planning of Australian cities is not necessarily a sufficient condition to ensure a greater role for filtering in the provision of housing for low-income households. Filtering as a supply of low-income housing also rests on the assumption that dwellings, over time, are inhabited by occupants with successively lower incomes. Yet owners of dwellings can redevelop existing dwellings before they become affordable to low-income households, or convert dwellings to other uses altogether.
- These observations suggest policy options to better enable filtering to generate a supply of affordable housing for low-income households are likely to be impractical and politically undesirable. Dedicated social and affordable housing products will therefore likely remain necessary to ensure a supply of housing for low-income households, particularly in Melbourne and Sydney.

- **There are, however, policy options for more specific use of price signals in strategic planning and zoning designations to enhance the role of filtering as a source of housing for low-income households. By guiding where new housing is provided and the type of housing that is provided, such signals can improve both the supply and responsiveness of the housing market, thereby reducing (other things similar) the rate of house and rental price appreciation in general.**
- **The responsiveness of dwelling supply to market signals is also a function of business practice. Government-led land assembly can counter current private land-banking practices and protracted land assembly process to enable a more predictable supply of developable land across sub-markets.**

5.1 Synthesis of empirical findings

5.1.1 Evidence of filtering dynamics in Sydney and Melbourne

In both Sydney and Melbourne the evidence presented here suggests that new build and new rental properties command a market premium. That is, in line with the filtering hypothesis, newer properties are more likely to attract higher income households.[20] However, in both cities there is also evidence that the ensuing housing market dynamics are not resulting in the occupancy changes or relative price declines required to constitute a source of affordable low-income housing.

In Melbourne, areas with a higher proportion of new build property experienced an improvement in their relative income status when compared to areas with higher proportion of middle-aged properties. However, this was not the case when compared to areas with higher proportions of pre-WWII housing. The relationship between age and change in occupancy characteristics (neighbourhood income status) is thus u-shaped, and significantly reduced by the inclusion of variables capturing the effects of social interactions. The relationship between dwelling transaction prices and age is similarly u-shaped, until locational and institutional characteristics are included. Overall, the independent effect of age (as a proxy for quality) as a driver for affordable low-income housing (filtering) thus appears limited.

Similarly, Sydney private rental properties move down market over time when measuring rent received relative to market medians. However, this decline in rental price for older rental properties only partially offsets the overall increase in rents. In other words, rental costs relative to incomes are not necessarily improving as a result of this process, thereby interrupting downwards filtering dynamics.

In both cities, then, there is evidence that the demand for new housing (own or rent) is income elastic, so that new housing supply does have the potential to contribute to filtering dynamics. However, in both cities there is also evidence that filtering as a source of low-income housing supply is interrupted by a number of factors.

20 This insight describes the typical situation. Notably, there may be some differences here between owned property and rented property. Shared properties for instance, make it possible that lower income individuals pool their incomes in larger households and so can pay for higher rents. Hulse, Reynolds et al. (2019) show that in the private rental sector some mismatch of rental properties (when matching income ranking of household to rental ranking of housing) is evident.

5.1.2 Observed limits to filtering as source of housing affordable for low-income households

Residential filtering is concerned with the dynamics of housing markets, specifically changes in price and quality characteristics over time, and the movement (relocation) of households that follows because of these processes (Grigsby 1963; Galster 1996). Over time, filtering as a source of affordable low-income housing thus implies a degree of change in both the occupancy characteristics (such as relative income status) of a given neighbourhood and the relative price points of housing within it. That is, over time, neighbourhoods are expected to move down market. While not definitive, the analysis in this report suggest a number of factors that may be inhibiting generation of housing affordable to low-income households through filtering.

First, there is evidence that the socio-economic characteristics of neighbourhoods strongly mitigate the impact of any age-of-housing-stock related processes of neighbourhood income or price change. For instance, neighbourhoods with relatively high socio-economic profiles are less likely to move down market over time. A potential explanation of this is the role of 'social interactions' and neighbourhood effects in generating positive externalities that are capitalised in property prices (such as high value and upkeep of neighbouring properties and environments encouraging reinvestment). Conversely, social interactions and neighbourhood effects can also generate negative externalities. Over time, this results in socio-economic stability, rather than cyclicality. In areas with higher socio-economic status, properties may thus be maintained at a higher level or redeveloped before they filter down.

Second, socio-economic characteristics are often embodied by local political economy and planning practices that inhibit change in the built form through new construction. Chapter 3 suggests that low-density residential zoning and heritage overlays reduce the rate of demolitions and price elasticity of new housing supply. A corollary (albeit not examined here) is that the large share of new housing supply delivered in outer areas enable more restrictive planning policies in established parts of Melbourne and Sydney.

Third, a low price elasticity of supply overall prevents sufficient scale and responsiveness to meet changes in housing demand. A key requirement for filtering as a source of low-income housing is that new housing supply exceeds the new housing demand. New housing demand may result from new households, but also higher incomes and lower interest rates. The consequence of a low price elasticity is that the volume of new housing that *is* produced is insufficient to offset the upward pressure on transaction or rental prices arising from additional demand. Consequently, the price of housing rises relative to incomes (worsening affordability). While older properties may lose their value relative to new properties, the overall increases in property values and rents exceed the ability of low-income households to 'access' these properties. This is illustrated in Chapter 4 when comparing rental depreciation relative to a 30 per cent affordability threshold for low-income earners.

Fourth, there may be a lack of 'substitutability' across sub-markets. This point is only indirectly examined in the report. For filtering as a strategy for affordable low-income housing a lack of substitutability means that, for instance, supply at the periphery of cites is not having a dampening effect on prices in the inner city, or that the supply of apartments is not having a price dampening effect on the price for detached and semi-detached housing. That is, the cross-elasticity of demand is low. From the discussion in Chapter 2 the implication of this is that new supply in any particular sub-market firstly has limited impact across the housing system as a whole, but also that within sub-market adjustments may result in dwellings redeveloped (or converted to non-residential uses) before filtering down to low-income households.

5.1.3 Generalisability of lessons for Australian cities

Filtering is a dynamic process reflected in the price/quality characteristics of dwellings, and occupancy characteristics of dwellings, over time. In broad terms, Sydney and Melbourne share a number of urban economy and housing market characteristics. The Melbourne analysis (occupancy of housing stock and sales transactions) and Sydney analysis (price dynamics in private rental housing) thus provides insight on filtering as a source of additional affordable low-income housing that is applicable to both cities.

Moreover, key institutional features – such as planning and urban governance systems, infill and densification objectives of planning systems (to some extent; see Newton, Meyer et al. 2017), construction and development practices and land market stakeholders – are also, in broad terms, shared across other Australia metropolitan cities. As such, the analysis and insight generated here also relates to the role that filtering can play as a source of affordable housing for low-income households in other cities.

In transferring these insights to other metropolitan cities in Australia it is, nevertheless, also important to note that specific contextual differences between Melbourne and Sydney and other metropolitan cities will condition how specific housing markets adjust to new supply and where the spatial adjustment might take place. For instance, Sydney and Melbourne are considerably larger; their population growth accounted for nearly half (49%) of Australia's population growth (2009–19) (ABS 2020b), including the majority of international migrants. Sydney and Melbourne are also responsible for nearly half (45%) of Australia's production of goods and services (SGS 2019). Compared to Brisbane, Perth and Adelaide, jobs growth in Melbourne and Sydney was stronger in inner (CBD) and central areas (Terrill, Batrouney et al. 2018). This distinction is of particular relevance when considering the spatial distribution of demand for housing, location of old and new properties, and access to jobs.

5.2 Policy development options

Additional supply of housing is central to addressing the affordability of housing, also for low-income households. However, for market-based filtering to have a greater role in generating a supply of affordable housing for low-income households, a number of structural features of Australian housing markets require consideration. In the following sections, we consider three broad areas in which significant policy change would be required:

1. price elasticity and supply volumes
2. housing typology and location
3. social interactions and neighbourhood effects.

Importantly, in order to assess the appropriateness of the different policy development options within each of these areas, additional research is required. A final note then concludes with the methodological insights this research offers, particularly the potential for comparable analysis in other cities.

5.2.1 Price elasticity and volume of supply

The price elasticity of supply is determined by a range of factors, many of which are not easily targeted by public policy. However, land use planning and taxation *can* contribute to housing supply becoming more responsive to price changes at local levels. Options for enhancing the contribution of planning to price responsiveness can include more specific use of price signals as a guide for where new housing is provided and the type of housing that is provided, including:

- Zoning designations can restrict local supply-side responsiveness to price changes. The degree to which restrictions caused by zoning need to be loosened, in order to enable filtering to the point of generating a supply of housing affordable to low-income households, is often not clear. There are, in this respect, important and difficult (and so often political) trade-offs between preserving the characteristics of areas and limiting disruptions to existing communities, and the distribution of social costs when housing affordability worsens.
- Land in capital cities (particularly in high-price areas) is typically constrained. Limitations on land supply naturally limits the ability of a supply-side response. While infill development is a part of many metropolitan strategies in Australia (Newton, Meyer et al. 2017), zoning designations tend not to respond to specific price signals, focussing on selective infill precincts over a more general trend towards higher densities. However, scale of supply is not everything, and such precincts, in being spatially confined, can result in poorer neighbourhood amenities and a very different product to prevailing typologies (see 5.2.3 below).

- A related issue is that, in addition to being more responsive to price changes *at local levels*, an overall increase in supply of housing is required.[21] Coordination of new housing supply at metropolitan or sub-metropolitan regions (further research can establish appropriate functional housing markets) can additionally improve the overall price elasticity of supply.

However, the elasticity of supply and the volume of supply are also determined by the incentives and actions of landowners and property developers. In practice, while planning and regulation may become more responsive to market signals, this does not ensure that urban housing systems become more responsive to market signals. The following two points provide additional policy development options that, while not directly derived or substantiated by the analysis in this report, nevertheless highlight the role of private sector actions as co-determinants of low price responsiveness and overall levels of supply.

- The supply of land in cities is not only determined by zoning or regulation, but – and perhaps just as importantly – the actions of landowners who face incentives to await continued price appreciation before considering selling or leasing land for housing development. A greater use of broad-based land tax can spur owners to bring under-developed land to the market (Wood, Ong et al. 2012: 41).
- Similarly, land banking enables property developers to tailor housing supply to maximise gains from further land value changes. Murray (2020:2) shows that some of Australia's largest property developers strategically delay the use of land already approved for development and housing construction in order to capitalise on property cycles. Evans (2004) further argues that land banking provides developers with predictable production horizons. That is, from a firm's business perspective, land banking provides a means of ensuring 'business survival' over multiple periods; land is an input factor without which developers cannot construct housing. From a prudential business perspective, ensuring a steady supply of land in future periods is a requirement for ensuring business survival. One option for addressing both of these business-practice determinants of low market responsiveness is to establish a system of government-led land assembly or public land banking that can ensure predictability in both the supply of land and greater say in when development takes place. Public land-banking can serve as a mechanism for enhancing the availability of land when developers need it, thus reducing the need of developers to land-bank or speculative land-banking for the purpose of trade without development. It may also reduce the cost of land, if the public sector is in a position to sell land without charging market prices.

The argument here is not that planning in all cases should follow price signals, or that price (market) signals should entirely determine housing policy setting. However, a greater use of market signals and analysis can inform strategic policy making by identifying the effect of planning decisions at a neighbourhood, but also sub-metropolitan or metropolitan levels. Notably, in terms of inducing filtering mechanisms – that is, a market approach – to supply housing suitable to low-income households requires a housing market that responds to market signals. However, this may induce a greater degree of cyclicality in relative income status of areas.

5.2.2 Housing typology and location

Filtering pre-supposes that new construction is superior to the existing sub-market specific housing. Superiority relates to the 'housing services' offered by the property, including the physical and quality characteristics of the property, location relative to work requirements, and characteristics of the neighbourhood (parks, beaches, design and architectural features, and so on). The substitutability and cross elasticity of demand of units and apartments and houses in different locations will have a bearing on whether dwellings in specific sub-markets filter down, are redeveloped (to higher quality), or converted to non-residential uses.

21 Burke, Nygaard and Ralston (2020) show that, at the national level, the rate of housing completions relative to population growth declined over the period 1993-2010, recovering marginally 2010-2018. We refer here though back also to the issues raised by social interactions where supply side policies become less effective.

This is particularly germane to current urban policy trends towards higher density developments, in Sydney and Melbourne, as outlined in Chapter 2. In the absence of substitutability of new dwellings for older dwellings, filtering dynamics become (by definition and in practice) restricted.

Planning and design standards can assist in ensuring that new supply, and the services and amenities where it is added, more effectively substitutes for existing supply. But this would need to be accompanied by detailed market research to ensure that planning and design standards are responsive to market signals. One implication of such an analysis – and use of planning and design standards – might be that the scale of developments is traded off for dwelling stock better targetted to local demand characteristics. As discussed above (Section 5.2.2), this may also require measures to enhance the volume of supply (such as zoning flexibility, government-led land assembly or developer practices around land banking).

This 'substitutability' has a clear spatial dimension too; that is, the location relative to work requirements and characteristics of the neighbourhood mentioned above. Infrastructure provision (the other side of urban planning to its regulatory role) also influences the extent to which different locations can become substitutes for each other. This includes policy decisions around transport infrastructure provision, to ensure outer areas are connected to job markets, and around local character and amenity of new developments relative to established neighbourhoods.

The above two paragraphs highlight that housing services are a composite product. It matters not only whether different housing typologies are substitutes for each other but whether the joint bundle of housing services in a specific location is a functional substitute for another bundle. House prices and changes in location capture both of these elements (that is, the price component that relates to physical characteristics of the house and the locational characteristics), and hedonic modelling can be used to provide information on the demand elasticities of separate bundles of housing services.

5.2.3 Local housing market context, neighbourhoods and social interactions

The analysis in Chapter 3 suggest that the change in occupancy characteristics of areas—as measured by the relative income of residents—has a tendency to revert to its initial position relatively quickly. Under the filtering hypothesis, the ageing of the housing stock exerts a sufficiently independent and strong effect to alter the occupancy characteristics of areas over time. However, a property's age is only one of many determinants of the level housing services provided by a property, and its location. Social interactions is a potential explanation for persistence in social structures. They might condition the substitutability between housing sub-market segments (and thus the extent to which new supply generate demolition or conversion effects, rather than filtering effects). They may also constrain the potential of supply side policies more generally to deliver price dampening outcomes. Social interactions can generate (positive and negative) externalities that are then capitalised in property values. Under social interactions, the expansion of supply may also result in an amplification of the external effect as additional residents with particular forms of social capital join existing neighbourhoods.

The demand amplification of social interaction effects may offset or exceed the price dampening effect of new supply. Additional outcomes can include property owners looking to upgrade or convert existing properties, rather than letting them filter down. Social interactions may also result in tipping points, such as where relatively small changes in the social characteristics of areas lead to comparatively large (positive or negative) changes in property values. For instance, the re-centralisation of some types of jobs in Melbourne and Sydney over the past 30 years altered the geography of locational obsolescence in these cities, in turn altering the local housing market context. The subsequent residential re-centralisation led to gentrification in parts of these cities that further accentuated differences in local housing market outcomes. If housing affordability pressures in areas close to jobs concentrations also are the result of social interactions, then market supply mechanisms become less effective in ensuring access to housing for low-income households.

The housing market effects with social interactions needs to be distinguished from housing market effects as a result of proximity to jobs concentrations only (such as might arise due to agglomeration economies (Nygaard, Parkinson et al 2021). Social interactions and neighbourhood effects may work in addition to changing local housing market context resulting in concentrations of both high and lower income neighbourhoods in close proximity to employment centres.

Deliberately disrupting established communities, despite potentially increasing the efficiency of the housing market through cyclical obsolescence of ageing housing, is anathema to many urban policy objectives. An alternative is to promote development patterns that provide diverse housing options matched to specific income profiles. This is often an objective of infill policies that encourage apartment developments. However, in high-demand areas, specific social and affordable housing developments (or mixed tenure developments incorporating such options) will often be necessary to ensure a supply of housing affordable to low-income households.

Such a policy does not rely on filtering dynamics. Rather than relying on some properties being vacated and becoming less attractive to higher income groups, such a policy relies on direct provision of affordable housing options to low-income households in areas close to labour markets or other amenities. Further, provided such a policy does not substantially alter the social dynamics of these areas (that is, substantially change the socio-economic profile), direct provision of social and affordable housing in high-cost locations may be less disruptive to existing dynamics of social interactions. For instance, the results in Chapter 3 suggests that the presence of social housing had no significant effect on the occupancy characteristics of neighbourhoods in the inter quartile and upper quartile ranges (only in the lower quartile range of neighbourhoods).

A final note, on the need for housing market insights in policy setting, relates to the second-order objective of this project: to explore the potential to use existing public data sets to examine housing markets. On this note, the two pieces of analysis offer different lessons. Government datasets from Victoria were sufficient for neighbourhood-scale analysis. Comparison of available data suggest that some details needed (particularly around building age) are not readily available in NSW. Similarly, as outlined in Appendix C, NSW data required significant preparation and cleaning to enable even limited property-scale analysis. While hard to predict without undertaking the work, comparison of data suggests similar challenges would face property-scale analysis of Victorian data. On this basis, one final policy direction is for Australian governments to better collect, maintain and even coordinate (across jurisdictions) property data, needed for analysis to inform housing and urban policy.

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Appendix A: Method and variable descriptives

The modelling framework in Chapter 3 is a General Nesting Spatial (GNS) model that includes a spatial lag (change in occupancy characteristics in neighbouring CDs), spatial lag in some independent variables in neighbouring CDs, as well as a spatial lag in the error term. For comparison Spatial Durbin Model (SDM) results are reported in Appendix B, Table A5 and Table A6. The variable selection follows Rosenthal's (2008) analysis of the role of filtering and social interaction neighbourhood change. By including spatial lags of the dependent variable in particular, but also independent variables (Lesage and Fischer 2008), the modelling additionally controls for spillover effects (such as might arise from social interactions and neighbourhood effects). It also enables adjusting for identification biases that might arise from the use of spatially organised data (such as area-based data) that is based on arbitrary (such as administrative or logistical practicalities) aggregation of social and economic point estimates (modifiable areal unit problem).

The empirical specification in Sections 3.1.2 and 3.1.3 are based on Rosenthal (2008). Rosenthal proposes that under filtering, the relative socio-economic status of neighbourhoods should correlate with the age of properties in the respective neighbourhoods; changes in relative neighbourhood status should consequently also correlate with the age of properties *and* have an effect on the occupancy characteristics of residents independent of social interactions or neighbourhood effects. The main test for change in neighbourhood status is thus:

$$\ln\left(\frac{y_{i,t1}}{y_{i,t0}}\right) = \alpha + b_1 HouseAge_{i,t0} + b_2 \ln\left(y_{i,t0}\right) + b_3 \ln\left(\frac{y_{i,t0}}{y_{i.t-1}}\right) + b_4 SES_{i,t0} + b_5 distance_i + \theta_{LA} + e_i \ (1)$$

In order to include spillover effects and account for modifiable areal unit issues Equation (1) is estimated as a spatial model of the form:

$$\ln\left(\frac{y_{i,t1}}{y_{i,t0}}\right) = (\cdot) + \rho WC\ln\left(y_{i,t1}/y_{i,t0}\right) + \rho WCy_{i,t0} + \rho WCdens_{i,t0} + e_i, \qquad e_i = \lambda WDe_i + v_i \ \ (1')$$

In Equation (1) (the 'Filtering regression') *y* is the relative income in area *i.* Relative income is defined as the median income in year *t* for CD *i,* divided over the median income for all Melbourne in year *t. t* is a time index where t_0=2006, and $t_{+/-1}$ is 10 years before and after. The estimation includes relative income at the start of the period and change in relative income prior to the base period as part of the independent variables. These measure the degree of cyclicality in neighbourhood status. HouseAge is a vector of property age variables, divided into 10-year intervals that measure the proportion of the housing stock in each age interval. The housing age variables are the key indicators of filtering dynamics and is expected to be U-shaped.

SES is vector of socio-economic status variables in 2006 (described further below), and distance is distance to CBD. *k* indexes time; *θ* is a vector of fixed effects for local authorities. *α*, *β* and *θ* are coefficients to be estimated. Following Rosenthal (2008), the SES variables are included as proxies for social interaction effects. For instance, neighbourhood externalities (such as social capital and cost, area status) arising from social interactions and activity that also determine demand for dwellings in specific locations (Ioannides and Zabel 2003; Rosenthal 2008). Social capital can be conceived as both a community-level resource (such as features of neighbourhood social organisation like trust, norms and networks (Putnam 1995)), and an individual level resource arising from membership of specific social networks (Bourdieu 1986). In Australia, as elsewhere, social capital is for instance associated with health outcomes (Ziersch et al. 2005). Homeownership is frequently shown to exert a positive effect on social capital formation (Ruskruge et al. 2013); conversely public housing tenants in Australia exhibit lower levels of interpersonal trust (Donoghue and Tranter 2012).

The discussion in Chapter 2 suggest that filtering as a physical process (depreciation) and filtering as a housing policy (such as affordability, supply, access to labour markets and so on) are additionally conditioned by a complex set of political economy, social interactions and demographic characteristics. These in turn also condition how neighbourhoods change over time. In Equation (1) these determinants are collected under the *SES* vector. Equation (1) is estimated with and without the SES variables. The separate estimations provide an important test for whether the physical processes associated with filtering can be considered independent of the political economy and socio-economic dynamics (Rosenthal 2008).

For instance, political economy (local land use decisions and planning rules) may be a function of residents' social capital. Owner-occupiers, residents with higher education and workers who are likely to experience income growth/career progression may in this respect be expected to bring different capabilities and motivations for maintain desirable neighbourhood characteristics, including physical quality of the housing stock. *SES* therefore captures the owner occupation rate, per cent of residents with bachelor degree or higher, and the average age of residents. Intra-city relocation patters are also determined by neighbourhood effects that in turn may reinforce spatial patterns of income status, such as spatial patterns of ethnicity and race and/or presence of public housing. *SES* therefore also captures the per cent of public housing and Australian-born residents. Finally, *SES* also contains housing density (*dens*) and so provides a measure of land use intensity and urban form, which may additionally condition demand for different locations. *dist* measures the centroid-to-centroid distance from each collection district to the collection district containing the Melbourne (historic) general post office (GPO).

In Equation (1') *W* is a spatial weighing matrix that captures spatial interdependencies ($WD=d_{ij}^{-1}$; inverse distance between CD_i and CD_j centroids; WC=1/s is the weight of *j* where s is the number of CCDs (*j*) that share a boundary with *i*; all other areas have a weight of 0).

The inclusion of a spatial lag of the dependent variable – that is, a measure of whether changes in relative income status in one area affects the rate of relative income change in nearby areas – has two important implications. Firstly, there is a direct effect from what goes on within each neighbourhood, for instance urban renewal interventions, population growth and social interactions. Secondly, there is an indirect effect from what goes on in nearby neighbourhoods. This secondary effect can amplify the direct effect, but it can also reduce the effect of any neighbourhood specific intervention or change (Lesage and Fisher 2008). Income growth in adjacent areas may hasten economic obsolescence in the area of interest.

The results from Equation (1') are reported in Section 3.1.2. In Section 3.1.1 the basic structure of Equation (1) is retained, but with relative income in 2006 ($\ln(y_{i,t0})$) as the dependent variable. This version of Equation (1') thus provides the basic socio-spatial structure from which change takes place.

Finally, under filtering older neighbourhoods should have a higher rate of re-development as obsolete (physically and/or economically) housing is demolished and replaced with new (Rosenthal and Helsley 1994). However, owners of properties in different sub-markets have multiple options open to them, in addition to letting dwellings filter down (such as upgrade and/or convert use). Hence differences in demolition rate may also provide tentative evidence on sub-market specific adjustment dynamics. For Melbourne a testable equation is therefore:

$$DR_i | S_i = \alpha + b_1 HouseAge_{i,t0} + b_2 zoning_{i,t0} + b_3 \ln(hp_{i,t0+k}/hp_{i,t0-k}) + b_4 \ln(hp_{i,t0}) + b_5 \ln\left(y_{i,t0}\right) + \theta_{LA} + e_2 \quad (2)$$

Where *DR* is the number of demolished properties over the period 2005-2014 as a proportion of the 2006 housing stock at CD level. We also use Equation (2) to estimate the price elasticity of supply (2016–19) at SA2 level.[22] *Zoning* is a vector of zoning variables that measure the per cent of a Collection District covered by different zoning classifications (for instance residential, low density residential, mixed land use etc.). *Hp* is the log of average property price; remaining notation is as before. The results of Equation (2) (the 'Demolition regression') are reported in Section 3.1.4.

Table 1 and 2 provide descriptive statistics for the variables in Equation (1) and (2). Due to differences in data availability the estimation samples vary somewhat across the estimations. Table 1 and 2 are based on the respective estimation samples.

22 The difference in spatial unit is a function of the different data sources behind the regressions. Demolition data is based on analysis of DELWP housing development data. Dwelling supply is based on recently available small area estimates data (experimental) from the ABS (ABS 2020). This latter data is only available for the period 2016–19.

Table A1: Descriptive statistics filtering regression

Variable	Obs	Mean	Std.Dev	Min	Max	Source
ln relative income change 2006–16	6,185	0.117	0.301	-2.531	2.405	Authors' calculation from ABS census 2006, 2016
Ln relative income 2006	6,185	-0.154	0.365	-2.810	0.792	Authors' calculation from ABS census 2006
ln relative income change 1996–2006	6,185	0.014	0.295	-2.901	3.743	Authors' calculation from ABS census 1996, 2006
ln distance to GPO (m)	6,185	9.632	0.868	-1.431	11.197	Authors' calculation
ln dwelling density 2006 (ABS)	6,185	2.330	0.801	0.003	6.665	ABS Census 2006
Property age 1996–2005 (%)	6,185	0.266	0.251	0.000	1.000	Victorian Valuer General (valuation)
Property age 1986–95 (%)	6,185	0.125	0.178	0.000	0.998	Victorian Valuer General (valuation)
Property age 1976-–85 (%)	6,185	0.120	0.175	0.000	0.990	Victorian Valuer General (valuation)
Property age 1966–75 (%)	6,185	0.175	0.201	0.000	1.000	Victorian Valuer General (valuation)
Property age 1956-–65 (%)	6,185	0.120	0.163	0.000	1.000	Victorian Valuer General (valuation)
Property age 1946–55 (%)	6,185	0.068	0.129	0.000	1.000	Victorian Valuer General (valuation)
Property age 1936–45 (%)	6,185	0.024	0.058	0.000	0.972	Victorian Valuer General (valuation)
Property age 1926–35 (%)	6,185	0.024	0.056	0.000	0.717	Victorian Valuer General (valuation)
Property age 1916–25 (%)	6,185	0.025	0.062	0.000	0.676	Victorian Valuer General (valuation)
Property age 1906–16 (%)	6,185	0.016	0.053	0.000	0.671	Victorian Valuer General (valuation)
Home ownership 2006 (%)	6,185	0.623	0.187	0.000	1.000	ABS Census 2006
Graduate education 2006 (%)	6,185	0.046	0.037	0.000	0.250	ABS Census 2006
Aged 30-49 2006 (%)	6,185	0.300	0.065	0.000	0.615	ABS Census 2006
Married 2006 (%)	6,185	0.417	0.073	0.000	0.805	ABS Census 2006
Australian born 2006 (%)	6,185	0.642	0.134	0.079	0.913	ABS Census 2006
Social housing 2006 (%)	6,185	0.029	0.084	0.000	0.920	ABS Census 2006

Table A2: Descriptive statistics demolition regression

Variable	Obs	Mean	Std.Dev.	Min	Max	Source
Demolition rate (ABS base)	5,362	0.041	0.047	0.000	0.571	DELWP HDD and ABS Census 2006
Property age 1996-2005 (%)	5,362	0.229	0.198	0.000	1.000	Victorian Valuer General (valuation)
Property age 1986–95 (%)	5,362	0.130	0.178	0.000	0.996	Victorian Valuer General (valuation)
Property age 1976–85 (%)	5,362	0.127	0.180	0.000	0.990	Victorian Valuer General (valuation)
Property age 1966–75 (%)	5,362	0.183	0.199	0.000	1.000	Victorian Valuer General (valuation)
Property age 1956–65 (%)	5,362	0.128	0.165	0.000	0.964	Victorian Valuer General (valuation)
Property age 1946–55 (%)	5,362	0.074	0.133	0.000	1.000	Victorian Valuer General (valuation)
Property age 1936–45 (%)	5,362	0.025	0.057	0.000	0.784	Victorian Valuer General (valuation)
Property age 1926–35 (%)	5,362	0.026	0.057	0.000	0.584	Victorian Valuer General (valuation)
Property age 1916–25 (%)	5,362	0.027	0.064	0.000	0.676	Victorian Valuer General (valuation)
Property age 1906–16 (%)	5,362	0.017	0.053	0.000	0.671	Victorian Valuer General (valuation)
Zoning (low density residential) (%)	5,362	0.013	0.087	0.000	0.989	DELWP, vicmap-planning
Zoning (mixed use) (%)	5,362	0.005	0.048	0.000	1.000	DELWP, vicmap-planning
Zoning (industrial) (%)	5,362	0.012	0.065	0.000	0.900	DELWP, vicmap-planning
Zoning (park) (%)	5,362	0.035	0.082	0.000	0.849	DELWP, vicmap-planning
Zoning (commercial) (%)	5,362	0.021	0.064	0.000	0.790	DELWP, vicmap-planning
Zoning capital city/activity centre (%)	5,362	0.011	0.087	0.000	1.000	DELWP, vicmap-planning
Zoning (other) (%)	5,362	0.256	0.309	0.000	1.000	DELWP, vicmap-planning
Heritage overlay (%)	5,362	0.096	0.221	0.000	1.000	DELWP, vicmap-planning
ln change in HP $/sqm 1995–2005	5,362	0.709	0.322	-2.007	1.871	Victorian Valuer General (sales), median sqm after trimming at 5th and 95th percentile
ln HP $/sqm 2006	5,362	7.891	0.353	6.277	8.558	Victorian Valuer General (sales), median sqm after trimming at 5th and 95th percentile
ln number of sales 1995–2006	5,362	1.868	2.289	0.000	6.917	Victorian Valuer General (sales)
ln dwelling density 2006 (ABS)	5,362	2.336	0.720	0.003	5.622	ABS Census 2006
ln distance to GPO (m)	5,362	9.645	0.811	-1.431	11.187	Author's calculation
Ln relative income 2006	5,362	-0.159	0.343	-2.810	0.792	Authors calculation from ABS census 2006

Table A3: Descriptive supply regression

	Obs	Mean	Std.Dev.	Min	Max	Source
Ln dwelling supply	297	5.963	1.161	2.480	9.111	ABS (2020a)
In HP	297	13.187	0.385	12.487	14.683	Australian Property Monitors, AURIN
In HP change 2013–16	297	0.292	0.134	-0.512	1.017	Australian Property Monitors, AURIN
In dwelling density 2016(ABS)	297	6.204	1.309	1.684	8.998	ABS Census 2016
Property age 1996–2005 (%)	297	0.190	0.149	0.000	1.000	Victorian Valuer General (valuation)
Property age 1986–95 (%)	297	0.125	0.107	0.000	0.604	Victorian Valuer General (valuation)
Property age 1976–85 (%)	297	0.114	0.104	0.000	0.506	Victorian Valuer General (valuation)
Property age 1966–75 (%)	297	0.152	0.117	0.000	0.571	Victorian Valuer General (valuation)
Property age 1956–65 (%)	297	0.099	0.100	0.000	0.459	Victorian Valuer General (valuation)
Property age 1946–55 (%)	297	0.054	0.078	0.000	0.434	Victorian Valuer General (valuation)
Property age 1936–45 (%)	297	0.019	0.033	0.000	0.196	Victorian Valuer General (valuation)
Property age 1926–35 (%)	297	0.018	0.033	0.000	0.231	Victorian Valuer General (valuation)
Property age 1916–25 (%)	297	0.018	0.037	0.000	0.283	Victorian Valuer General (valuation)
Property age 1924 plus (%)	297	0.039	0.093	0.000	0.608	Victorian Valuer General (valuation)
Zoning (park) (%)	297	0.069	0.069	0.000	0.479	DELWP, vicmap-planning
Zoning (commercial) (%)	297	0.028	0.050	0.000	0.426	DELWP, vicmap-planning
Zoning capital city/activity centre (%)	297	0.010	0.060	0.000	0.909	DELWP, vicmap-planning
Zoning (industrial) (%)	297	0.043	0.092	0.000	0.587	DELWP, vicmap-planning
Zoning (low density residential) (%)	297	0.014	0.061	0.000	0.639	DELWP, vicmap-planning
Zoning (mixed use) (%)	297	0.008	0.030	0.000	0.400	DELWP, vicmap-planning
Zoning (other) (%)	297	0.335	0.299	0.007	1.000	DELWP, vicmap-planning
Heritage overlay (%)	297	0.091	0.170	0.000	0.978	DELWP, vicmap-planning

Appendix B: Supplementary estimates

Table A4: Quasi-quartile regression

	Change in relative income status, 2006–16		
	'Lower quartile'	'Inter-quartile range'	'Upper quartile'
ln Relative income 2006	-0.340 (0.132)**	-0.121 (0.147)	-0.270 (0.116)*
ln Relative income change 1996–2006	-0.074 (0.078)	-0.176 (0.057)**	-0.059 (0.034)
ln Distance to GPO (m)	0.041 (0.022)	0.047 (0.022)*	0.024 (0.033)
ln Dwelling density (ABS)	0.182 (0.054)***	0.107 (0.025)***	0.094 (0.023)***
Property age 1996–2005 (%)	-0.376 (0.317)	-0.359 (0.099)***	-0.145 (0.084)
Property age 1986–95 (%)	-0.572 (0.324)	-0.562 (0.108)***	-0.217 (0.099)*
Property age 1976–85 (%)	-0.317 (0.304)	-0.543 (0.110)***	-0.226 (0.097)*
Property age 1966–75 (%)	-0.474 (0.307)	-0.548 (0.109)***	-0.375 (0.134)**
Property age 1956–65 (%)	-0.152 (0.297)	-0.504 (0.109)***	-0.216 (0.140)
Property age 1946–55 (%)	-0.011 (0.292)	-0.151 (0.099)	-0.220 (0.147)
Property age 1936–45 (%)	0.064 (0.352)	-0.007 (0.143)	-0.007 (0.169)
Property age 1926–35 (%)	0.734 (0.520)	-0.050 (0.138)	-0.204 (0.143)
Property age 1916–25 (%)	0.491 (0.570)	-0.152 (0.125)	0.010 (0.126)
Property age 1906–16 (%)	0.823 (1.014)	-0.171 (0.177)	-0.105 (0.145)
Home ownership (%)	0.083 (0.140)	0.331 (0.100)***	0.266 (0.102)**
Graduate education (%)	0.882 (0.702)	2.263 (0.530)***	0.609 (0.442)
Aged 30-49 (%)	0.564 (0.331)	0.394 (0.174)*	-0.449 (0.196)*
Married (%)	0.078 (0.236)	0.455 (0.215)*	0.239 (0.309)
Australian born (%)	0.288 (0.113)*	0.554 (0.102)***	0.688 (0.138)***
Social housing 2006 (%)	-0.646 (0.158)***	-0.241 (0.251)	-0.144 (0.504)
Spatial lag, contiguous			
ln dwelling density 2006 (ABS)	0.106 (0.032)***	-0.037 (0.010)***	-0.082 (0.028)**
ln relative income 2006	0.762 (0.110)***	0.417 (0.103)***	0.734 (0.126)***
ln relative income change 2006–16 (ld)	0.518 (0.150)***	0.643 (0.076)***	0.494 (0.168)**
ln relative income change 2006–16 (ld) (error)	-0.397 (0.181)**	-0.345 (0.103)***	-0.220 (0.175)
Pseudo-R2	0.305	0.217	0.241
Number of CDs	1,182	3,697	1,306

*Note: GNS model, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. ln=natural log; ld=lagged variable.*

Source: Author's calculation from Victorian Valuer General data (valuation), ABS Census 1996, 2006, 2016.

Table A5: Spatial regression coefficients alternative spatial weight regressions and modelling methods

	Change in ln relative income statues, 2006–16									
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.).	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
ln relative income 2006	0.411 (0.0235)***	0.5857 (0.0266)***	-0.4178 (0.0227)***	-0.2375 (0.0232) ***	-0.5674 (0.0265) ***	-0.4482 (0.0302) ***	-0.4162 (0.0229) ***	-0.2023 (0.0194) ***	-0.5684 (0.0265) ***	-0.4062 (0.0262) ***
ln relative income change 1996–2006	-0.0856 (0.0209)***	-0.0337 (0.0198)	-0.0690 (0.0189) ***	-0.2027 (0.0249) ***	-0.0287 (0.0204)	-0.1382 (0.0238) ***	-0.0759 (0.0202) ***	-0.1968 (0.0224) ***	-0.0279 (0.0204)	-0.1274 (0.0221) ***
ln distance to GPO (m)	0.0393 (.0102)***	0.0142 (.0081)	0.0333 (0.0074) ***	-0.0406 (0.0172)**	0.0205 (0.0085)**	-0.0241 (0.0118)**	0.0376 (0.0083) ***	0.0087 (0.0117)	0.0210 (0.0086)**	-0.0016 (0.0114)
ln dwelling density (ABS)	0.0650 (0.0110)***	0.0693 (0.0102)***	0.0558 (0.0090) ***	0.1100 (0.0140) ***	0.0709 (0.0105) ***	0.1110 (0.0134) ***	0.0593 (0.0098) ***	0.0911 (0.0120) ***	0.0711 (0.0105) ***	0.0973 (0.0123) ***
Property age 1996–2005 (%)	-0.2310 (0.0433)***	-.1600 (0.0377)***	-0.2181 (0.0366) ***	-0.2469 (0.0539) ***	-0.1510 (0.0392) ***	-0.1725 (0.0528) ***	-0.2303 (0.0399) ***	-0.2375 (0.0398) ***	-0.1532 (0.0394) ***	-0.1426 (0.0409) ***
Property age 1986–95 (%)	-0.3129 (0.0423)***	-0.2622 (0.0421)***	-0.2940 (0.0410) ***	-0.3450 (0.0567) ***	-0.2622 (0.0437) ***	-0.3033 (0.0549) ***	-0.3100 (0.0442) ***	-0.3342 (0.0439) ***	-0.2654 (0.0439) ***	-0.2673 (0.0446) ***
Property age 1976–85 (%)	-0.3021 (0.0465)***	-0.2439 (0.0420)***	-0.2810 (0.0402) ***	-0.3349 (0.0563) ***	-0.2421 (0.0435) ***	-0.2878 (0.0545) ***	-0.2987 (0.0434) ***	-0.3002 (0.0431) ***	-0.2457 (0.0437) ***	-0.2286 (0.0445) ***
Property age 1966–75 (%)	-0.3212 (0.0458)***	-0.2694 (0.0420)***	-0.3023 (0.0396) ***	-0.3715 (0.0557) ***	-0.2711 (0.0434) ***	-0.3262 (0.0537) ***	-0.3173 (0.0429) ***	-0.3365 (0.0411) ***	-0.2740 (0.0436) ***	-0.2786 (0.0435) ***
Property age 1956–65 (%)	-0.1831 (0.0453)***	-0.1717 (0.0410)***	-0.1719 (0.0377) ***	-0.2060 (0.0563) ***	-0.1578 (0.0426) ***	-0.2044 (0.0548) ***	-0.1820 (0.0413) ***	-0.1602 (0.0413) ***	-0.1593 (0.0428) ***	-0.1396 (0.0435) ***
Property age 1946–55 (%)	-0.0605 (.0468)	-0.0393 (.0415)	-0.0413 (0.0373)	-0.0718 (0.0596)	-0.0520 (0.0436)	-0.1250 (0.0562)**	-0.0431 (0.0413)	-0.0474 (0.0416)	-0.0504 (0.0439)	-0.0566 (0.0440)
Property age 1936–45 (%)	0.0336 (.0646)	0.0277 (.0605)	0.0524 (0.0585)	0.0169 (0.0752)	0.0507 (0.0627)	-0.0165 (0.0763)	0.0520 (0.0626)	0.0516 (0.0627)	0.0533 (0.0632)	0.0466 (0.0635)
Property age 1926–35 (%)	-0.0412 (0.0651)	-0.0269 (0.0582)	-0.0547 (0.0594)	-0.0615 (0.0801)	-0.0106 (0.0599)	-0.0809 (0.0783)	-0.0423 (0.0626)	-0.0668 (0.0678)	-0.0095 (0.0601)	-0.0296 (0.0649)
Property age 1916–25 (%)	0.0189 (0.0577)	0.0051 (0.0538)	0.0446 (0.0497)	-0.0554 (0.0752)	0.0167 (0.0556)	-0.0891 (0.0769)	0.0475 (0.0538)	-0.0815 (0.0558)	0.0209 (0.0557)	-0.1079 (0.0577)

	Change in ln relative income statues, 2006–16									
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.).	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
Property age 1906–16 (%)	-0.0451 (0.0733)	-0.0295 (0.0652)	-0.0093 (0.0637)	-0.1327 (0.0935)	-0.0183 (0.0680)	-0.1482 (0.0993)	-0.0069 (0.0688)	-0.1329 (0.0737)	-0.0153 (0.0685)	-0.1293 (0.0725)
Socio-economic controls	NO	YES	NO	NO	YES	YES	NO	NO	YES	YES
Constant	-0.1697 (0.1074)***	-0.3693 (0.1004)***	-0.1088 (0.0782)	0.8869 (0.2067) ***	-0.4908 (0.1034) ***	0.0285 (0.1527)	-0.1490 (0.0887)	0.2381 (0.1362)	-0.4996 (0.1041) ***	-0.2340 (0.1448)
Spatial lag, contiguous										
ln relative income 2006	0.5137 (0.0366)***	0.4650 (0.0355)***	0.4941 (0.0326) ***		0.4370 (0.0362) ***		0.4931 (0.0343) ***		0.4321 (0.0367) ***	
ln dwelling density 2006 (ABS)	-0.0370 (.0091)***	-0.0333 (.0086)***	-0.0419 (0.0085) ***		-0.0313 (0.0087) ***		-0.0385 (0.0091) ***		-0.0302 (0.0090) ***	
ln relative income change 2006–16 (ld)	0.5780 (0.0836)***	0.4560 (0.0847)***	0.5754 (0.0847) ***		0.4006 (0.0885) ***		0.5144 (0.0940) ***		0.3714 (0.0934) ***	
ln relative income change 2006–16 (ld) (error)		-0.2147 (0.1009)***	-0.3616 (0.0981) ***		-0.1285 (0.1032)					
Spatial lag, inverse distance										
ln relative income 2006	1.2336 (0.4040)**			1.9657 (0.1912) ***		1.5833 (0.1496) ***		1.5670 (0.1248) ***		1.4486 (0.1453) ***
ln dwelling density 2006 (ABS)				-0.3034 (0.0398) ***		-0.2100 (0.0264) ***		-0.2779 (0.0254) ***		-0.2258 (0.0254) ***
ln relative income change 2006–16 (ld)				4.2748 (0.7529) ***		3.4535 (0.4296) ***		5.0930 (0.4002) ***		4.2648 (0.3914) ***
ln relative income change 2006–16 (ld) (error)				6.2288 (1.3941) ***		10.3675 (1.0283) ***				
Number of CDs	6,185	6,185	6,185	6,185	6,185	6,185	6,185	6,185	6,185	6,185
Pseudo-R2	0.2512	0.2841	0.2572	0.0424	0.2805	0.2010	0.2571	0.0460	0.2809	0.0411
Estimation method	GNS	GNS	GNS	GNS	GNS	GNS	SDM	SDM	SDM	SDM

*Note: GNS and SDM models, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. ln-natural log, ld=lagged variable. Columns in light grey are the GNS regression coefficients corresponding to the results in Table 3 (column 2 and 3).*

Source: Author's calculation from Victorian Valuer General data (valuation), ABS Census 1996, 2006, 2016.

Table A6: Total marginal effect following spatial regression (Table A5), alternative spatial weights and modelling methods

	Change in ln relative income statues, 2006–16							
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
ln relative income 2006	-0.016 (0.034)	-0.558 (0.488)	-0.314 (0.039)***	-0.447 (0.100)***	-0.018 (0.035)	-0.389 (0.319)	-0.312 (0.038)***	-0.309 (0.067)***
ln relative income change 1996–2006	-0.132 (0.045)**	0.089 (0.368)	-0.043 (0.032)	-0.154 (1.261)	-0.132 (0.044)**	0.152 (0.552)	-0.040 (0.030)	0.059 (0.135)
ln distance to GPO (m)	0.064 (0.015)***	0.018 (0.077)	0.030 (0.013)*	-0.027 (0.219)	0.065 (0.016)***	-0.007 (0.026)	0.030 (0.012)*	0.001 (0.006)
ln dwelling density (ABS)	0.040 (0.015)**	0.054 (0.064)	0.067 (0.015)***	0.117 (0.457)	0.048 (0.016)**	0.026 (0.101)	0.067 (0.015)***	0.032 (0.046)
Property age 1996–2005 (%)	-0.417 (0.075)***	0.109 (0.453)	-0.224 (0.059)***	-0.192 (1.575)	-0.400 (0.074)***	0.183 (0.675)	-0.219 (0.057)***	0.067 (0.153)
Property age 1986–95 (%)	-0.562 (0.087)***	0.152 (0.633)	-0.389 (0.068)***	-0.338 (2.761)	-0.538 (0.086)***	0.257 (0.950)	-0.380 (0.066)***	0.125 (0.287)
Property age 1976–85 (%)	-0.537 (0.088)***	0.148 (0.614)	-0.359 (0.070)***	-0.321 (2.621)	-0.518 (0.087)***	0.231 (0.854)	-0.352 (0.068)***	0.107 (0.246)
Property age 1966–75 (%)	-0.578 (0.088)***	0.164 (0.681)	-0.402 (0.070)***	-0.363 (2.972)	-0.550 (0.086)***	0.259 (0.956)	-0.392 (0.068)***	0.130 (0.299)
Property age 1956–65 (%)	-0.329 (0.076)***	0.091 (0.379)	-0.234 (0.066)***	-0.228 (1.864)	-0.316 (0.076)***	0.123 (0.459)	-0.228 (0.065)***	0.065 (0.152)
Property age 1946–55 (%)	-0.079 (0.073)	0.032 (0.132)	-0.077 (0.066)	-0.139 (1.155)	-0.075 (0.073)	0.036 (0.137)	-0.072 (0.064)	0.026 (0.062)
Property age 1936–45 (%)	0.100 (0.112)	-0.007 (0.045)	0.075 (0.093)	-0.018 (0.183)	0.090 (0.109)	-0.040 (0.158)	0.076 (0.090)	-0.022 (0.061)
Property age 1926–35 (%)	-0.105 (0.115)	0.027 (0.114)	-0.016 (0.089)	-0.090 (0.761)	-0.073 (0.110)	0.051 (0.190)	-0.014 (0.086)	0.014 (0.041)

	Change in ln relative income statues, 2006–16							
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
Property age 1916–25 (%)	0.085 (0.093)	0.024 (0.106)	0.025 (0.082)	-0.099 (0.843)	0.082 (0.092)	0.063 (0.222)	0.030 (0.079)	0.050 (0.110)
Property age 1906–16 (%)	-0.018 (0.122)	0.059 (0.243)	-0.027 (0.101)	-0.165 (1.388)	-0.012 (0.120)	0.102 (0.365)	-0.022 (0.098)	0.060 (0.133)
SES	NO	NO	YES	YES	NO	NO	YES	YES
Spatial weight	Contiguous	Inverse distance	Contiguous	Inverse distance	Contiguous	Inverse distance	Contiguous	Inverse distance
Modelling	GNS	GNS	GNS	GNS	SDM	SDM	SDM	SDM

*Note: GNS and SDM models, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. ln=natural log, ld=lagged variable. No columns shaded grey in this table. Table 3 (main text) and Table A7 reports the marginal effects.*

Source: Author's calculation from Victorian Valuer General data (valuation), ABS Census 1996, 2006, 2016.

Table A7: Direct, indirect and total marginal effects following spatial regression (Table 3)

	Change in ln relative income statues, 2006–16			
	All stock		Sold stock	
	dy/dx (Std. Err.)	dy/dx (Std. Err.)	dy/dx (Std. Err.)	dy/dx (Std. Err.)
Direct effect				
ln relative income 2006	-0.388 (0.023)***	-0.575 (0.026)***	-0.366 (0.025)***	-0.563 (0.027)***
ln relative income change 1996–2006	-0.089 (0.022)***	-0.035 (0.020)	-0.115 (0.025)***	-0.041 (0.023)**
ln distance to GPO (m)	0.041 (0.011)***	0.015 (0.008)	0.046 (0.010)***	0.023 (0.009)***
ln dwelling density (ABS)	0.065 (0.011)***	0.069 (0.010)***	0.076 (0.012)***	0.087 (0.012)***
Property age 1996–2005 (%)	-0.241 (0.045)***	-0.164 (0.038)***	-0.127 (0.040)**	-0.144 (0.038)***
Property age 1986–95 (%)	-0.327 (0.048)***	-0.269 (0.043)***	-0.199 (0.037)***	-0.233 (0.036)***
Property age 1976–85 (%)	-0.316 (0.048)***	-0.250 (0.043)***	-0.191 (0.037)***	-0.236 (0.036)***
Property age 1966–75 (%)	-0.336 (0.047)***	-0.276 (0.042)***	-0.208 (0.036)***	-0.268 (0.036)***
Property age 1956–65 (%)	-0.191 (0.047)***	-0.176 (0.042)***	-0.114 (0.037)**	-0.179 (0.035)***
Property age 1946–55 (%)	-0.063 (0.049)	-0.040 (0.043)	-0.002 (0.035)	-0.052 (0.033)
Property age 1936–45 (%)	0.035 (0.068)	0.029 (0.062)	0.010 (0.056)	-0.028 (0.049)
Property age 1926–35 (%)	-0.043 (0.068)	-0.028 (0.060)	0.069 (0.052)	0.016 (0.047)
Property age 1916–25 (%)	0.020 (0.060)	0.005 (0.055)	0.020 (0.039)	-0.007 (0.034)
Property age 1906–16 (%)	-0.047 (0.077)	-0.030 (0.067)	-0.047 (0.051)	-0.078 (0.044)
Home ownership (%)		0.213 (0.036)***		0.248 (0.038)***
Graduate education (%)		0.846 (0.184)***		0.792 (0.193)***
Aged 30-49 (%)		0.166 (0.070)**		0.019 (0.071)
Married (%)		0.035 (0.090)		0.169 (0.094)
Australian born (%)		0.203 (0.036)***		0.220 (0.038)***
Social housing 2006 (%)		-0.291 (0.063)***		-0.220 (0.096)*

	Change in ln relative income statues, 2006–16			
	All stock		Sold stock	
	dy/dx (Std. Err.)	dy/dx (Std. Err.)	dy/dx (Std. Err.)	dy/dx (Std. Err.)
Indirect effect				
lnrely06	0.419 (0.048) ***	0.247 (0.041)***	0.419 (0.067)***	0.182 (0.043)***
ln relative income 2006	-0.075 (0.031)**	-0.019 (0.014)	-0.175 (0.072)*	-0.024 (0.016)
ln relative income change 1996–2006	0.034 (0.012)**	0.008 (0.005)	0.070 (0.025)	0.014 (0.006)*
ln distance to GPO (m)	0.001 (0.014)	-0.002 (0.009)	0.007 (0.020)	0.003 (0.010)**
ln dwelling density (ABS)	-0.202 (0.061)***	-0.091 (0.032)**	-0.192 (0.079)**	-0.085 (0.031)***
Property age 1996–2005 (%)	-0.274 (0.078)***	-0.149 (0.045)***	-0.302 (0.096)**	-0.136 (0.041)***
Property age 1986–95 (%)	-0.264 (0.077)***	-0.139 (0.044)**	-0.289 (0.094)**	-0.138 (0.043)***
Property age 1976–85 (%)	-0.281 (0.080)***	-0.153 (0.047)***	-0.315 (0.099)***	-0.157 (0.047)***
Property age 1966–75 (%)	-0.160 (0.057)**	-0.098 (0.036)**	-0.172 (0.071)**	-0.104 (0.035)**
Property age 1956–65 (%)	-0.053 (0.044)	-0.022 (0.025)	-0.003 (0.053)	-0.030 (0.022)
Property age 1946–55 (%)	0.029 (0.057)	0.016 (0.035)	0.014 (0.085)	-0.016 (0.029)
Property age 1936–45 (%)	-0.036 (0.058)	-0.015 (0.034)	0.105 (0.082)	0.009 (0.027)
Property age 1926–35 (%)	0.017 (0.050)	0.003 (0.030)	0.030 (0.059)	-0.004 (0.020)
Property age 1916–25 (%)	-0.039 (0.066)	-0.017 (0.038)	-0.071 (0.082)	-0.046 (0.031)
Property age 1906–16 (%)		0.118 (0.041)**		0.145 (0.049)**
Home ownership (%)		0.470 (0.166)**		0.464 (0.174)**
Graduate education (%)		0.092 (0.045)*		0.011 (0.042)
Aged 30-49 (%)		0.019 (0.050)		0.099 (0.063)
Married (%)		0.113 (0.035)***		0.129 (0.043)**
Australian born (%)		-0.161 (0.058)**		-0.129 (0.067)

	Change in ln relative income statues, 2006–16			
	All stock		Sold stock	
	dy/dx (Std. Err.)	dy/dx (Std. Err.)	dy/dx (Std. Err.)	dy/dx (Std. Err.)
Total effect				
ln relative income 2006	0.030 (0.049)	-0.327 (0.041)***	0.053 (0.069)	-0.381 (0.044)***
ln relative income change 1996–2006	-0.164 (0.050) ***	-0.054 (0.034)	-0.290 (0.092)**	-0.065 (0.038)
ln distance to GPO (m)	0.075 (0.020)***	0.023 (0.013)	0.116 (0.032)***	0.037 (0.014)**
ln dwelling density (ABS)	0.066 (0.022)**	0.067 (0.016)***	0.083 (0.029)**	0.089 (0.018)***
Property age 1996–2005 (%)	-0.443 (0.090)***	-0.255 (0.062)***	-0.319 (0.111)**	-0.229 (0.061)***
Property age 1986-–95 (%)	-0.601 (0.104)***	-0.418 (0.071)***	-0.501 (0.116)***	-0.369 (0.060)***
Property age 1976–85 (%)	-0.580 (0.104)***	-0.389 (0.073)***	-0.480 (0.115)***	-0.374 (0.062)***
Property age 1966–75 (%)	-0.617 (0.104)***	-0.430 (0.074)***	-0.523 (0.117)***	-0.424 (0.063)***
Property age 1956–65 (%)	-0.352 (0.094)***	-0.274 (0.070)***	-0.286 (0.100)**	-0.283 (0.059)***
Property age 1946–55 (%)	-0.116 (0.092)	-0.063 (0.068)	-0.005 (0.087)	-0.082 (0.053)
Property age 1936–45 (%)	0.064 (0.124)	0.044 (0.096)	0.024 (0.142)	-0.044 (0.078)
Property age 1926–35 (%)	-0.079 (0.126)	-0.043 (0.093)	0.174 (0.131)	0.025 (0.074)
Property age 1916–25 (%)	0.036 (0.110)	0.008 (0.086)	0.050 (0.098)	-0.012 (0.054)
Property age 1906–16 (%)	-0.086 (0.142)	-0.047 (0.105)	-0.118 (0.132)	-0.124 (0.074)
Home ownership (%)		0.331 (0.068)***		0.392 (0.073)***
Graduate education (%)		1.316 (0.309)***		1.256 (0.325)***
Aged 30-49 (%)		0.259 (0.109)**		0.030 (0.113)
Married (%)		0.054 (0.140)		0.267 (0.153)***
Australian born (%)		0.317 (0.060)***		0.349 (0.068)
Social housing 2006 (%)		-0.452 (0.107)***		-0.350 (0.156)*

*Note: GNS model, GS2SLS. Standard errors in brackets. */**/*** significant at 0.05/0.01/0.001 levels. ln=natural log. Appendix B, Table A5 provides regression coefficients and compares estimates based on alternative spatial dependency assumption (inverse distance and contiguity).*

Source: Author's calculation from Victorian Valuer General data (valuation), ABS Census 1996, 2006, 2016.

Table A8: Property price, age of building and full hedonic estimation

	ln Real house price (sales value)			
	Age only		Hedonic specification	
	Coefficient	Robust Std. Err.	Coefficient	Robust Std. Err.
ln Age of building	-0.699	0.005***	-0.210	0.003***
ln Age of building, squared	0.134	0.001***	0.021	0.001***
ln Distance to GPO (m)			-0.151	0.007***
Property sold more than once			0.010	0.001***
ln Distance to Metropolitan Activity Centre			-0.015	0.001***
ln Distance to Other Activity Centre			-0.022	0.001***
ln Distance to Neighbourhood Activity Centre			0.007	0.001***
ln Plot area			-0.049	0.001***
ln Dwelling density			-0.317	0.002***
ln Distance to major road (m)			0.007	0.000***
ln Distance to train station (m)			-0.028	0.001***
ln Distance to tram stop (m)			-0.004	0.001***
ln Distance to primary school (m)			0.002	0.001**
ln Distance to medical centre (m)			-0.005	0.001***
ln Distance to park (m)			0.001	0.000***
Apartment, flat or townhouse (dummy variable)			-0.191	0.002***
ln SEIFA			1.155	0.013***
Heritage overlay (within = 1)			0.077	0.003***
Flooding overlay (within = 1)			-0.010	0.002***
Residential zoning			omitted	
Commercial zoning			0.140	0.007***
Industrial zoning			-0.200	0.015***
Institutional zoning			-0.055	0.017***
Mixed use zoning			0.045	0.004***
Open space zoning			-0.150	0.007***
All other zoning			-0.626	0.016***
Constant	13.609	0.009***	8.899	0.104***
Fixed effect year and quarter	Yes		Yes	
Fixed effect postcode	No		Yes	
Number of observations	419,863		419,863	
Adjusted R2	0.187		0.749	

*Note: robust standard errors in column 2. */**/*** significant at 0.05/0.01/0.001 levels. ln=natural log.*

Source: Authors' calculation from Victoria Valuer General sales data and Victorian Valuer General valuation data.

Appendix C: Rental biographies – data preparation and descriptive statistics

Data preparation

The biographies are compiled from three NSW Government data sources:

1. rental bond data, collected by NSW Fair Trading and administered (as a dataset) by the NSW Department of Communities and Justice (DCJ), for the period 1997 to Q1 2020 (inclusive)
2. property sales data, collected and administered by the NSW Valuer General, for the period 2001–20 (inclusive).
3. development application (DA) data, collected by local councils and administered by the NSW Department of Planning, Industry and Environment (DPIE), for the period 2007–08 to 2018–19 (inclusive).

In each case, the purpose for the data collection sits outside its intended purpose for this analysis: bond data is used by DCJ to generate quartiles for sales and rents across NSW; sales data is used for property valuation and land taxation; development application data is collected for local government performance monitoring. However, there are examples of the data being used for other purposes, both by the government agencies and third parties.

The fact that the data is collected for these specific purposes does, however, mean a significant amount of data preparation is required to assemble it into a property biography database as described here. The data cleaning steps are outlined here briefly.

Bond data includes a text string address for identification, as well as lodgement and (where available) return dates of the bond, the nature of the dwelling (house/flat/etc. and number of bedrooms) and the rent paid at time of lodgement, among other attributes. The address line is parsed for errors and then geocoded against Geocoded National Address File (GNAF), an official Australian address database. This provides point-level coordinates for each address, which are then matched to a property ID on the NSW cadastre (NSW digital cadastre database, or DCDB).

The bond data is manually recorded, particularly for older data, from hand completed bond lodgement forms. As such, there are a number of incorrect and incomplete entries. It also allows for significant variation within a given property – where a lease only covers part of a property for example. As such, it is the most problematic dataset to clean and match accurately to a property ID. Incomplete data is excluded, whether incomplete address or missing rent or missing bedroom number or dwelling type. Non-market rentals (particularly public and not-for-profit community housing) and duplicate entries are also excluded. There are limits – specialist student or seniors housing cannot be extracted, and so is included despite not necessarily representing typical market rental.

Sales data includes an official property address and property ID (at time of settlement) as well as a legal title (lot and plan number) for identification, along with contract and settlement dates, and sale price, among other attributes. Sales are checked against GNAF and the cadastre, like bonds, to ensure it is mapped to the same property IDs as the other datasets. Partial interest sales and non-market sales are excluded, based on attributes included in the public data.

Development application data includes a property address from council databases for identification, as well as the dates of application and determination, development type and application process, among other attributes. It is similarly matched to an address against GNAF and the cadastre. Since a development application often includes subdivision and new properties being created, there were some errors of development applications being attached to current properties when they related to the property that existed before the subdivision.

The samples extracted from these datasets were bonds lodged in Q1 2020 for three-bedroom houses and one-bedroom flats in Greater Sydney. Two dwelling types were analysed to provide a point of comparison and opportunity to examine different market segments. For the properties in these samples, historical data from all three sources that matched to property ID for the samples were also extracted, and compiled into a database that enabled individual property biographies to be analysed.

Once the samples, and associated historical events were extracted, more manual data cleaning was required. This included developing bespoke code to identify and remove duplicates and false positives, such as historical sales or bonds that matched on property ID, but did not match the original address line. For example, a different apartment being rented in the same block, where that block is on a single title. Table 1 and 2 summarises the sample sizes.

Table A9: Counts and scope of property level events

Full 'event' data scope	Counts
Bonds held at Q1 2020	696,090
Bonds lodged from 1997 to 2020	4,265,362
Sales between 2001 and 2019	2,289,370
DAs lodged between 2007 and 2019	668,161

Table A10: Sample size, and attrition from iterative cleaning

Sample extracted	Three-bedroom houses (3bh)	One-bedroom flats (1bf)
Bonds lodged in Q1 2020	6,662	10,693
Historical bonds matched	33,338	93,331
Historical bonds retained (after cleaning)	21,820 (against 5,530 of the sample)	40,182 (against 8,157 of the sample)
Historical sales matched	9,527	62,409
Historical sales retained (after cleaning)	7,731 (against 3,660 of the sample)	22,573 (against 4,889 of the sample)
Historical DAs matched	1,835	6,440
Historical DAs retained (after cleaning)	1,597 (against 1,325 of the sample; excl. amendments to approvals)	2,018 (against 1,916 of the sample, excl. amendments to approvals)

The additional data preparation required highlights two limitations to this process. The first is that, despite a relatively comprehensive database of events, the final sample and matched events will have some remaining problems:

- where the data itself was incomplete. As mentioned, the bond data, in particular, had evident gaps. More broadly though, informal rentals and renovations, and short-term rentals, will be missed by these datasets.
- where the data was mismatched. Again, as mentioned, there were numerous instances of 'false positives' – where a bond, sale or DA matched against the property ID despite being for a different dwelling. The second round of data cleaning employed a bespoke data key, based on the property ID and any identification of part of the property – whether a unit number, or a subscript to the street number (for example, 2B or 2C) or a text descriptor (for example, 'upper floor' or 'flat at rear').

These additional processes were developed iteratively based on evident issues in the sample of, typically, 10,000 to 20,000. And do not always scale up to the full database of many millions. This is the second limitation to the process, at least with these datasets. In the analysis that follows, many additional questions arose that would require extracting a different sample. The concomitant time cleaning any new sample set it outside the scope of the current study. The most desired example was to explore the inverse of the sample here: that is, identify some sample of rentals from an earlier period and then track their trajectories forward. There are numerous questions about what happened to dwellings that were previously, but are no longer, private rental, particularly low-cost rental housing. The potential for additional targeted studies with the biography approach are discussed in the final section.

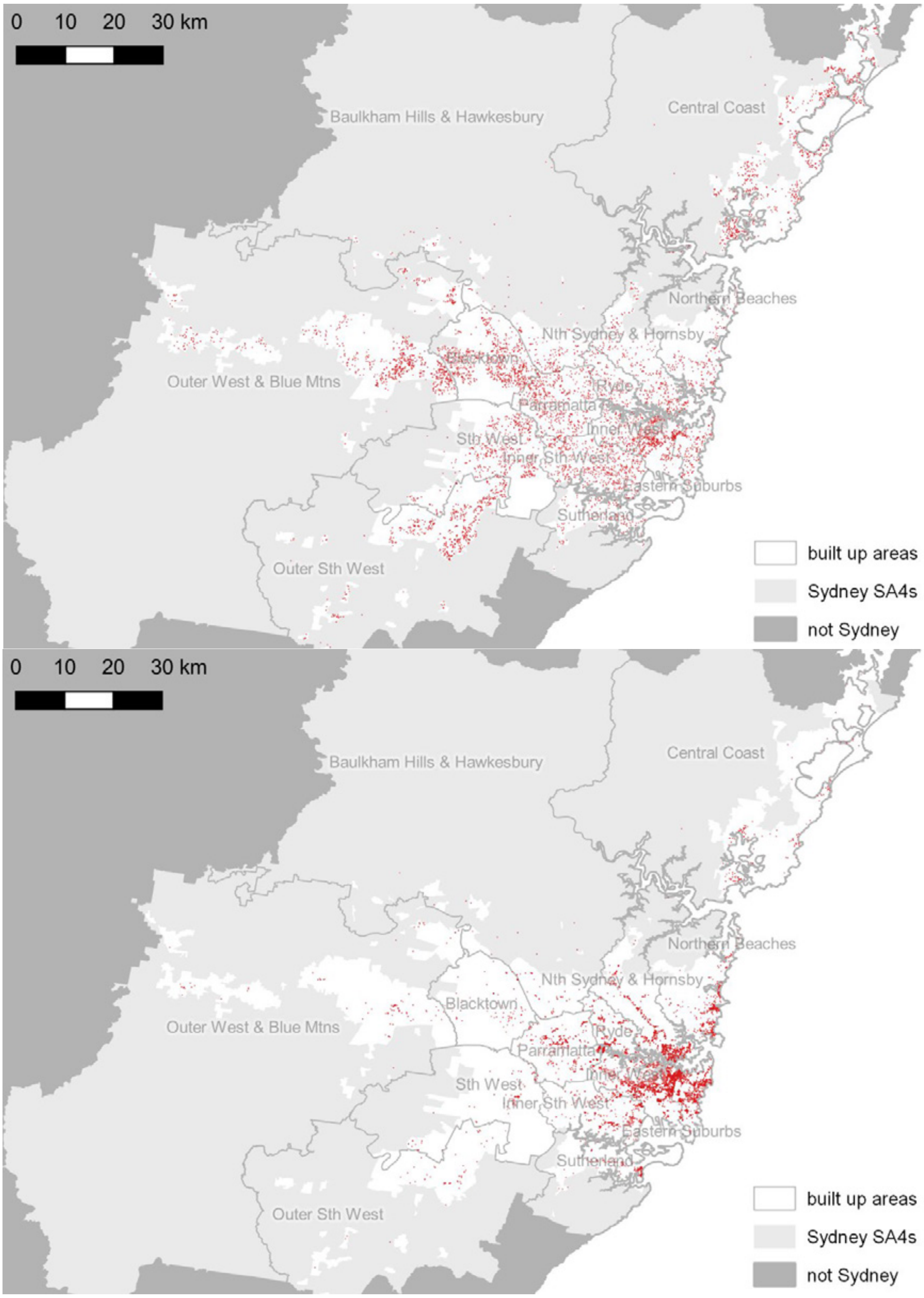
Descriptive statistics

The two samples described above have some notable features in their own right. In both cases, there was a relatively normal distribution of rents paid, although the three-bedroom houses had a significant skew, with rents extending to over 300 per cent of the median, but very few extending to less than 30 per cent of the median (Figure 3). This is partly explained by the much more diverse geography of houses, extending to more extreme parts of Sydney, while apartments were relatively centralised (Figure 2). The geography of the sample is also dictated by the prevalence of rental as a share of tenures. This is discussed in the next section. The sample was grouped into five market segments:

1. up 40 per cent of median
2. 40 to 80 per cent of median
3. 80 to120 per cent of median
4. 120 to 160 per cent of median
5. above 160 per cent of median.

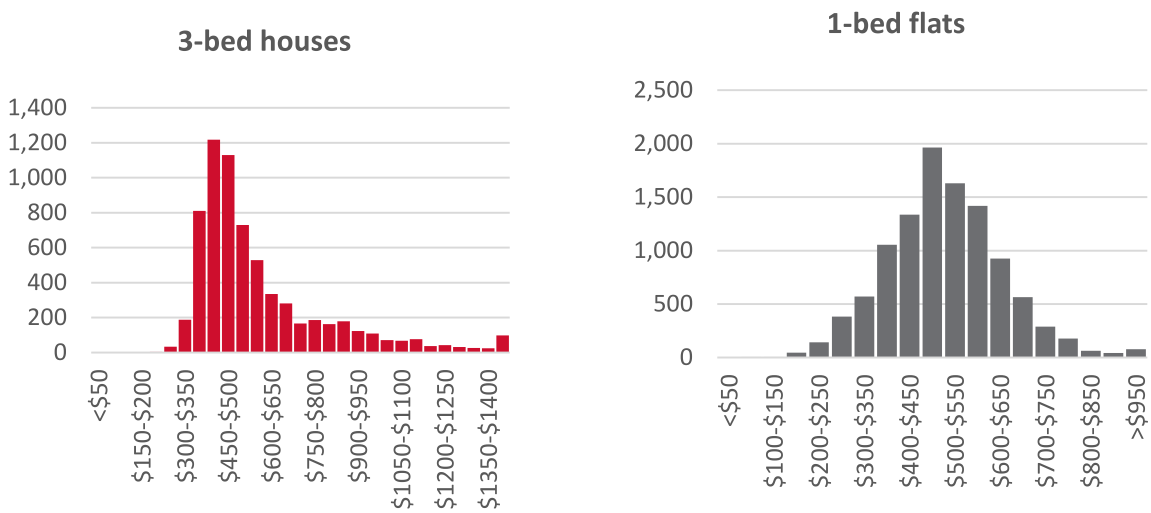
Figure 4 further shows how the volume of rentals quickly dissipates below 40 per cent of median. In fact, there were too few three-bedroom houses in this segment to report (and even then, some data among the seven properties suggested a non-market rent).

Figure A1: : Location of sample dwellings: (t) three-bedroom houses; (b) one-bedroom flats



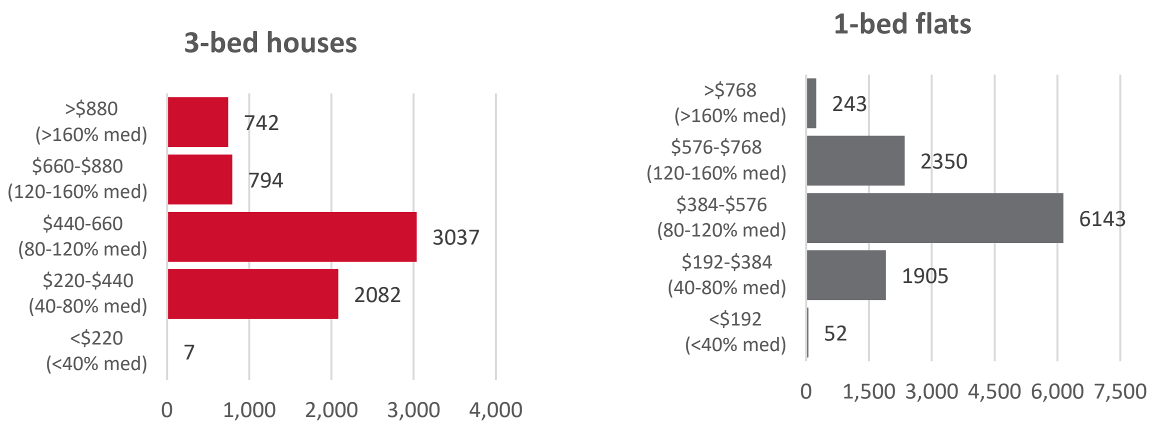
Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described above.

Figure A2: Distribution of rents in sample



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described above.

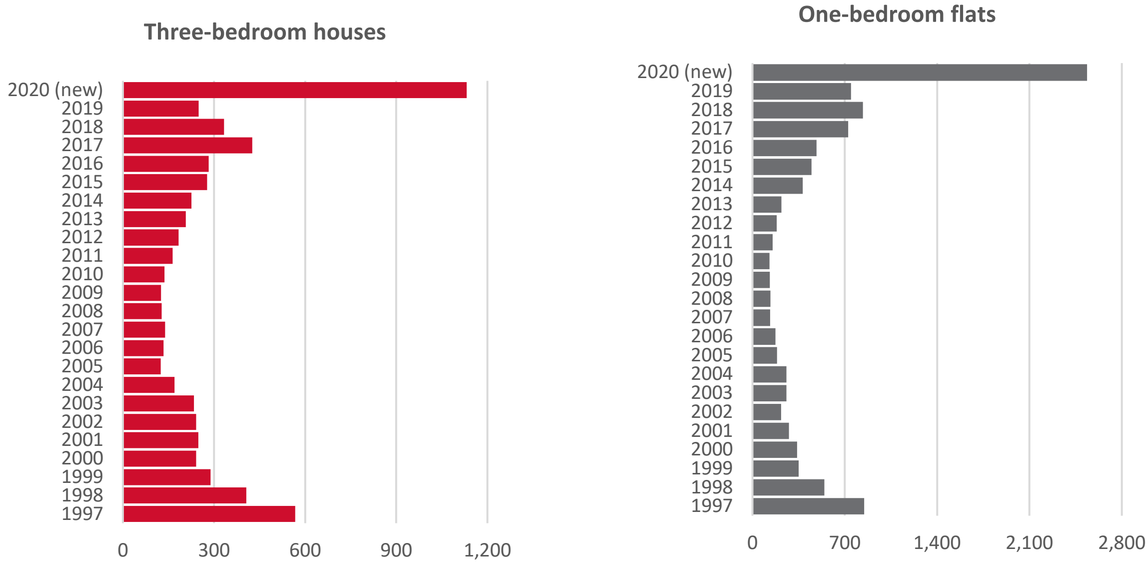
Figure A3: Sample by market segment



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described above.

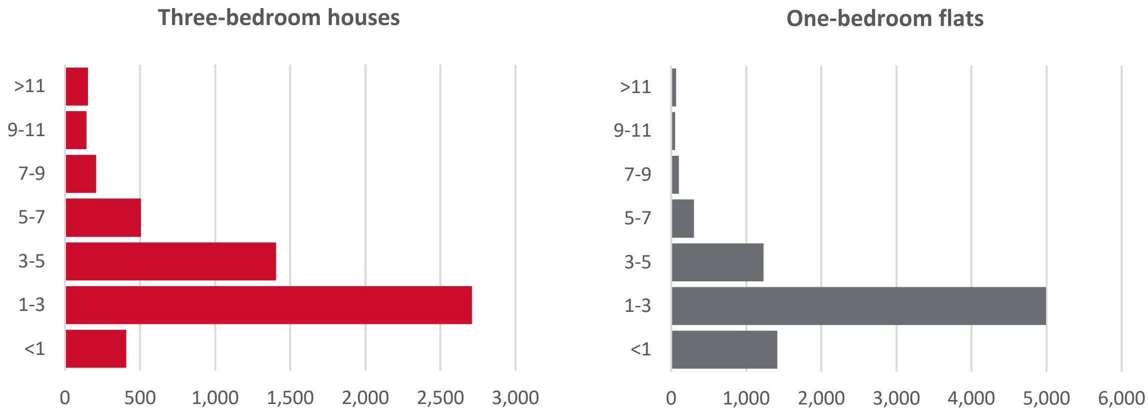
The rental history of the sample also showed some notable patterns. First, there is a clear u-shape in the distribution of the current sample, based on the oldest bond lodged against the property (Figure 4). Some of the first two years in the dataset (1997–98) could reflect even older data that was simply given a 1997 lodgement date as it was added to the database at this time. But the dip in the mid-to-late 2000s is not evidently explained by sampling problems. It could indicate that stock brought into the rental sector in this period has either become owner occupied since, or has steady tenants and so is less likely to be placing a new tenant in Q1 2020. The turnover, as indicated in Figure 5 by the average period between bond lodgements, shows most properties changing tenants every two-to-three years on average, with one-bedroom flats turning over more frequently than three-bedroom houses. When there are large gaps between bonds this could indicate a period outside the rental market, rather than a stable tenant for the entire time. This is examined in the next section.

Figure A4: Sample by year of oldest bond record



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described above.

Figure A5: Sample by 'average tenancy' (year of oldest/ number of bonds)



Source: Authors' analysis of NSW Rental Bond Board; NSW Valuer General; NSW Department of Planning Industry and Environment data sources described above.

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