A Matching Simulation to Assess Additional Housing Capacity in Auckland

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This version: June 11, 2018

Abstract

The current policy focus to improve housing affordability in New Zealand is reflected in the National Policy Statement on Urban Development Capacity (NPSUDC), which prescribes that local governments must ensure there is sufficient housing capacity to meet demand. Though some households may benefit because of better purchase conditions, additional capacity may not have a significant impact on improving affordability. I explore how additional capacity affects demand behaviour by setting up a matching (housing allocation) model to simulate competition among buyers for every additional unit. I found that rate of take-up differs across scenarios, and households that manage to buy a house have median incomes that are at least 50% higher than the median household income in Auckland ($91,728). Hence, affordability does not improve for medium or low-income households. The model and results then provide insights about the market outcomes of the NPSUDC and support the development of other housing programs.

Keywords: Housing affordability, Mixed Integer Programming, Spatial location, NPSUDC

JEL codes: R15, R21, R31

1. Introduction

Affordable housing has become a sensitive issue in New Zealand. In July 2017 the median house prices for Auckland was $830,000, and for the rest of the country $415,838. (Real Estate Institute of New Zealand, 2017). Prices in Auckland, between 2014 and 2017, increased by 45% (*New Zealand Herald*, 2017) and in December 2012 Auckland was found to suffer a shortfall of new houses ranging between 20,000 to 30,000, and a need for 13,000 new homes each year, for the next 30 years (Auckland Council, 2012). The Auckland Unitary Plan (AUP) estimates that by 2041, 400 thousand extra houses are needed to accommodate an increasing population. Out of the projected growth, 60 to 70 percent are expected to settle within the metropolitan area, and the rest in future urban zones, satellite towns, and rural and coastal areas (IHP, 2015).

In addition to stagnant supply, high migration, low interest rates and stringent land use regulations; sky-rocketing prices have created a complex policy environment to improve housing affordability for renters and to mitigate the social consequences of the housing shortage. One of the most discussed policy options consists on adding housing capacity by removing regulations or constraints that limit development, or by releasing land and changing zoning provisions (Gyourko, Mayer and Sinai, 2013). For this, the National Policy Statement on Urban Development Capacity (NPSUDC) came into force in late 2016 as a mechanism to streamline housing supply. The NPSUDC prescribes that local governments must ensure there is sufficient development capacity to meet demand; and, if unbalances occur then a greater number of opportunities for development should be provided. Those opportunities should be commercially feasible and produce a more competitive housing market (Government of New Zealand, 2016). The policy rationale of the NPSUDC then relies heavily on developing capacity to accommodate additional houses. Capacity may take the form of land releases or rezoning for residential purposes, further intensification of the city or redevelopment of existing residential sites (IHP, 2015).

Additional housing capacity however does not necessarily guarantee that affordability will improve. Housing supply is inelastic in Auckland and there is a large queue of people wanting to settle in the city, in addition to current residents, which cast pressure on prices (Aura and Davidoff, 2008; Grimes and Aitken, 2010; Gyourko, Mayer and Sinai, 2013; Fernandez, 2016). Furthermore, low mortgage rates and high construction costs also contribute to supply not keeping pace with demand (Martin and Norman, 2018). These issues jointly may render the impact of the NPSUDC to be uncertain regarding affordability; the effect may even be small when compared to the size of the housing problem (Metcalf, 2018). Still, in the margin, additional housing may imply welfare changes for households because of better purchase conditions and relocation alternatives across housing submarkets.

Evaluation of housing policies usually focuses on utility maximization or lifecycle analysis to explore substitution patterns between housing and non-housing consumption, as well as the timing for any household to decide housing purchases (Senior and Wilson, 1974; Anas, 1980; Wheaton, 1990; Johnson, 2007). Other studies focus on econometric approaches to explore the determinants for a household deciding between renting or buying, conditional to house typologies, life stage and spatial variables (Barrios García and Rodríguez Hernández, 2008; Chen, Clapp and Tirtiroglu, 2011; Jaén-García and Piedra-Muñoz, 2012; Barrios, Colom and Molés, 2013). To explore the implications of the NPSUDC on affordability and other market outcomes, because of additional housing capacity, in this paper I take a different approach based on simulating the matching between every additional unit and first-home buyers. My goal is to identify the type of households buying the additional housing and to estimate the rate of take-up as a characterisation of market clearance. This is done by simulating the matching between every additional unit and buyers through a mathematical programming model to approach the economic value of additional capacity in Auckland. Value is represented by welfare changes, in the form of consumer surplus for new houses, and changes in household stress (measured as the ratio between mortgage payments and income).

The modelling approach in this paper resembles a matching (housing allocation) problem where n households live in n indivisible objects (houses) and each household has preferences over her and other houses. Preferences are configured as an ordinal ranking of the houses that each household would be willing to buy, the household then selects the house and pays the market price; the difference between the willingness to pay and price is interpreted as the consumer surplus (Miyagawa, 2001). Thus, a house is allocated to the household with the strongest preference, i.e., the largest valuation. This allocation mechanism is implemented through a mixed-integer programming model where the objective function maximizes the consumer surplus of any household given basic characteristics such as: income, household type (e.g., couple with kids), current rent and relocation possibilities across housing submarkets. Because of the allocation mechanism, the model measures the expected take-up of a feasible development, and tracks the spatial outcome of purchases of the additional housing.

For a scenario closely resembling a competitive market, results indicate that strong incompatibility between prevailing household income and housing prices distribution leads to low rates of take-up of additional houses. As developers anticipate to the low take-up, they adjust supply downwards to remain profitable, and thus affordability does not improve. In turn, for scenarios where prices are relatively lower and with different spatial location of houses, take-up is much higher. Nonetheless, the median income of buyers is at least 50% higher than Auckland's median household income, which makes it uncertain that the sole reliance on adding capacity to market will significantly improve overall affordability, as is assumed in the NSPUDC. Thus, results should be interpreted as suggestive of policy insights (Johnson, 2007).

The approach of this paper, based on mathematical programming, can provide analytical tools for housing planning since it allows addressing a number of policy questions: does additional capacity necessarily imply better affordability conditions? Does additional capacity necessarily imply greater take-up given the current distribution of prices and household incomes? What are the policy options to increase take up of housing?

The paper is structured as follows: Section 2 provides a background on housing policy in New Zealand to set up the foundations of the matching model described in Section 3. Section 4 describes data and modelling assumptions. Section 5 presents and discusses the results. Section 6 concludes.

2. Background

The rationale behind the modelling approach of this paper is the NPSUDC, which mandates local governments in New Zealand to play a more significant role on planning for urban environments. Planning should consist on enabling growth in response to communities demand, and providing space through intensification of urban areas or releasing land in greenfield areas. The aim of the NPSUDC is then to ensure that planning decisions enable the supply of housing to meet demand.

The NPSUDC is explicit on the premise that competitive housing and land markets are the main mechanism through which supply will meet demand at lower prices, and leaving aside other demand factors or state-supported options. This premise also appears in other legislation bodies. The Housing Accord and Special Housing Areas Act (HASHA) (enacted in 2013) introduced the Special Housing Areas, consisting on developers setting aside a share of affordable houses in every development project. The Special Housing Areas (SHA) were previously areas zoned for industrial or commercial purposes (brownfield land), or undeveloped areas (greenfield land), that were rezoned for the purpose of residential development. The HASHA fast-tracked the resource consenting process for housing projects based on the premise that faster and higher supply would lead to lower prices (Auckland Council, 2013). By 2017 a total of 154 sites were declared as SHA where 3,105 homes had been built (Ministry of Business Innovation and Employment, 2017), but no records exist to identify which of those houses were actually affordable. Thus, it is not possible to assess the effectiveness of that program on improving affordability.

The NPSUDC requests that (additional) development capacity be supported by infrastructure where local governments should ensure the alignment between resource planning and the functioning of competitive land and housing markets. Thus, Auckland (and other high-growth councils) must carry out an assessment whether projected additional housing meets demand in the short, medium and long-terms, as well as to estimate housing demand by types of dwellings, locations and price points. The assessment is to be carried out on the premise that competitive markets are the driving force on matching households to the additional housing capacity, on a one-to-one basis, and that the capacity is welfare-enhancing to current renters. Hence, the mathematical model presented in the next section seeks to incorporate the premise of the NPSUDC, carry out the matching between demand and supply, and provide inputs to inform policy making, particularly regarding housing affordability.

3. Matching Model

In this paper the economic appraisal of additional housing capacity resembles a housing allocation problem where n households live in n indivisible houses, and each household has preferences her and other houses. The operation of the housing market implies an allocation or matching of houses to households. In the most simple allocation mechanism, simple serial dictatorships with no money transfers, households are ordered in descending order of preferences with respect to the available houses. The one on the top of the ordering (with the strongest preferences) is assigned her top choice; the one ordered second is assigned her top choice among the remaining objects, and so on (Abdulkadiroğlu and Sönmez, 1998). In real housing markets in turn it is the interaction between housing prices and income (holding other things constant) which determines the ordering (ranking) of the houses for each household as well as the transfer scheme. Each household pays the price of the house they buy, and the difference between willingness to pay and price is interpreted as a welfare measure, the consumer surplus (Miyagawa, 2001).

The matching (housing allocation) model focuses on three characteristics of the housing market: interaction of each household with their preferred houses conditional to prices, income and housing submarkets. The outcome of the model is a Pareto optimal allocation of houses as there is no other matching M such that no household is worse off in M than in the current allocation M_0, and at least one household is better off in M than in M_0 (Coles and Smith, 1998). Still, informing policy making based on mathematical programming requires a careful balance between model verisimilitude, tractability and policy relevance (Johnson, 2011). The rest of this section describes the model and its components.

Indices and sets:

$i = 1,2,\ldots,n$ number of households in the sample

$hb = 1,\ldots,J$ house type (standalone, house, terrace, apartment)

$z = 1,\ldots,13$ number of sections in Auckland (created from the aggregation of 40 housing submarkets)

Data

$Cost_{hb}$ Annualised cost to buy and relocate into the new house

$Bid_{i,z}$ Rent bid of household i that buys a house at section z

$MortgagePayment_{hb}$ Mortgage payments embed the development costs and profit margin for the developer, estimated at a time-horizon of 25 years and 5% discount rate

$Income_{z,i}$ household income

$StressFactorBuyer$ household stress factor

$Deposit_{i,hb}$ housing deposit

Decision Variables

$BUYHOUSE_{i,z,hb}$ dichotomic variable that in the optimal solution takes the value of 1 if a house is bought

Model

$$\text{maximize} \quad Welfare = \sum_{i,z,hb} \left(Bid_{i,z} - \ Cost_{hb}\right) \ * BUYHOUSE_{i,z,hb} \qquad ((1)$$

subject to

$$\sum_{z,hb} MortgagePayment_{hb} * BUYHOUSE_{i,z,hb} \leq Income_{z,i} * StressFactorBuyer \qquad (2)$$

$$Deposit_{i,hb} \ \geq Minimum * Price_{hb} \ * BUYHOUSE_{i,z,hb} \qquad (3)$$

$$\sum_{hb} BUYHOUSE_{i,z,hb} \leq 1, \forall \mathrm{i} \qquad (4)$$

$$\sum_{i} BUYHOUSE_{i,z,hb} \leq 1, \forall hb \qquad (5)$$

$$BUYHOUSE_{i,z,hb} = \{0,1\}, \forall i \in I, \forall hb \in J, \forall z \in Z \qquad (6)$$

Model (1) to (6) is a mixed integer program for the matching (housing allocation) problem. The objective function (Equation 1) maximizes the difference between willingness to pay and market price, where household's valuation is represented as bid rents to keep utility constant regardless the location of the purchased house (Senior and Wilson, 1974), thus the difference between willingness-to-pay and housing price proxies the consumer surplus resulting from the additional housing capacity given the take-up capabilities of demand (Miyagawa, 2001; Ng and Lo, 2015). This approach is appropriate as long as housing demand outstrips supply, the choice spaces of low-income consumers are constrained relative to wealthy consumers (Johnson, 2007), and preferences are quasilinear (income is held constant by the time of the transaction). The willingness of a prospective buyer to pay a given price for a particular house will then depend on the buyer's income as well as her current housing arrangements, relocation deadlines, and the likelihood of finding more desirable properties (Albrecht *et al.*, 2007).

The primal problem consists on maximization of bid rents for different houses at different locations (Alonso, 1960), which is equivalent to the minimization of actual rents paid in the dual (Senior and Wilson, 1974). Similar to the Herbert-Stevens model, the matching model aims to keeping a pre-specified (anticipated) utility level, where housing characteristics are fixed exogenously and do not adjust to consumer demand. The ideal case is that each household to have a bid rent, $Bid_{i,z}$, for each type of house, I bound this variation by constraining the household to move within three housing submarkets (see Section 4).

Constraint (2) limits mortgage payments to 50% of the household income, this limit is set by a stress factor. Mortgage payments embed the development costs and profit margin for the developer, estimated at a time-horizon of 25 years and 5% discount rate. Constraint (3), indicates that the deposit should be at least 20% of the sale price; and, constraints (4) and (5) control that a household will purchase one house only and that a house is purchased only by one household. Thus, every house is occupied by the highest bidder, but the model does not constraint that every household gets allocated a house or that every house is sold in the market (Miron, 2017).

4. Data and Assumptions

The matching model requires estimates of supply and demand for the additional houses. Given the complexity of the housing market, a number of assumptions are needed for tractability. First, only current renters will purchase a house, that is, I focus on first-home buyers. Second, the model is static and assumes only one house is purchased at a particular period. It does not encompass whether the buyer will resell it in the future. Third, as households move to a new house, old houses are left empty and are eventually occupied by other households. This chain of events continues indefinitely and makes the model intractable, thus I focus only on the marginal impact of the additional capacity as households buy any of the new houses. Fourth, households will only buy the new houses corresponding to the additional capacity induced by the NPSUDC.

A core assumption in the model is that the housing market is competitive, that is, no state intervention or state support occurs, additional housing capacity will not alter prices, all households are fully informed about price and spatial distribution, and both developers and households may anticipate the future (forward-looking behaviour).

Demand

The core for the model is to create representative households that mimic the potential demand. Figure 1 is a simplifying display of the process to construct the households' sample.

I generate 100 households by Area Unit (AU) and impute income and rent figures (from the 2013 Census data) based on a regression of rent in terms of income, household type (single person, couple without children, couple with children, and single-parent households) and AU fixed effects. Then I assume that AU figures can be downscaled to meshblocks (the smallest geographic unit for which statistical data is reported, varying in size from part of a city block to large areas of rural land.).

Then, to mimic potential household relocation across Auckland (when buying and moving into a new house), I depart from the conventional definition of submarkets as geographical or neighbouring areas (Bourassa, Hoesli and Peng, 2003). I rely on Auckland Council (2017), which contains a housing demand assessment based on hedonic models, where AU are assumed as adequate proxies for neighbourhoods. Models in Auckland Council (2017) identify the environmental and city amenities that shape housing prices, but also predict prices and implement medians clustering to identify housing submarkets. The advantage of clustering (relative to other submarkets definition) is the explicit combination of numerous variables rather relying on geographic or political boundaries (Ugarte, Goicoa and Militino, 2004). Auckland Council (2017) identifies 40 submarkets, which are intersected with meshblocks to show the potential alternatives of relocation across Auckland (Figure 2).

Households are then mapped to the intersected meshblocks and submarkets, which results in about 130 thousand households. From each intersection those households with the 10 highest incomes are selected and are assumed as those with the greatest likelihood to buy a house (strongest preferences because of income), resulting in 9,017 households.

Some modelling assumptions follow: (i) it is likely that more than one submarket exists at any meshblock, I select the lowest one. For example, if a particular meshblock is matched with submarkets 1, 2 and 10, I select 10 for the purposes of simulation. (ii) one-bedroom houses are bought by single-person households; two-bedroom houses by couples with or without children and single-parent households; and, houses with three or more bedrooms are bought by couples with children or single-parent with children households. Multi-family or non-family households are excluded from the sample. (iii) For single-parent households, income is estimated as the average between couple with children and single person figures. (iv) To control for corner solutions or extreme reallocations (e.g. a household relocating from a wealthy area to a poor one), submarkets are further aggregated into 13 sections, submarkets 1,2 and 3 (wealthy areas) are aggregated into Section 1, and so on. Any household may relocate only within each section, that is, three submarkets.

Figure 2 show the submarkets identified through the hedonics model in Auckland Council (2017). Highest prices concentrate in coastal areas in the North Shore and Eastern Bays. Other high-price submarkets locate in smaller pockets in North and South Auckland. Nonetheless, lower-price submarkets are located in roughly the same areas. Other intermediate and low-price submarkets locate in the central parts of the isthmus as well as South and West Auckland. In the Auckland isthmus, high-price clusters locate in most of the North and Central areas (e.g., Freeman’s Bay and the Eastern bays) where prices are highly determined by the proximity to coastal areas. Submarkets with relatively lower prices appear in the Eastern and South-eastern areas (e.g. Mount Wellington and Tamaki) (Auckland Council, 2017). Figure 3 shows the aggregation of the submarkets into the 13 Sections.

Figure 1: Construction of the Households Sample

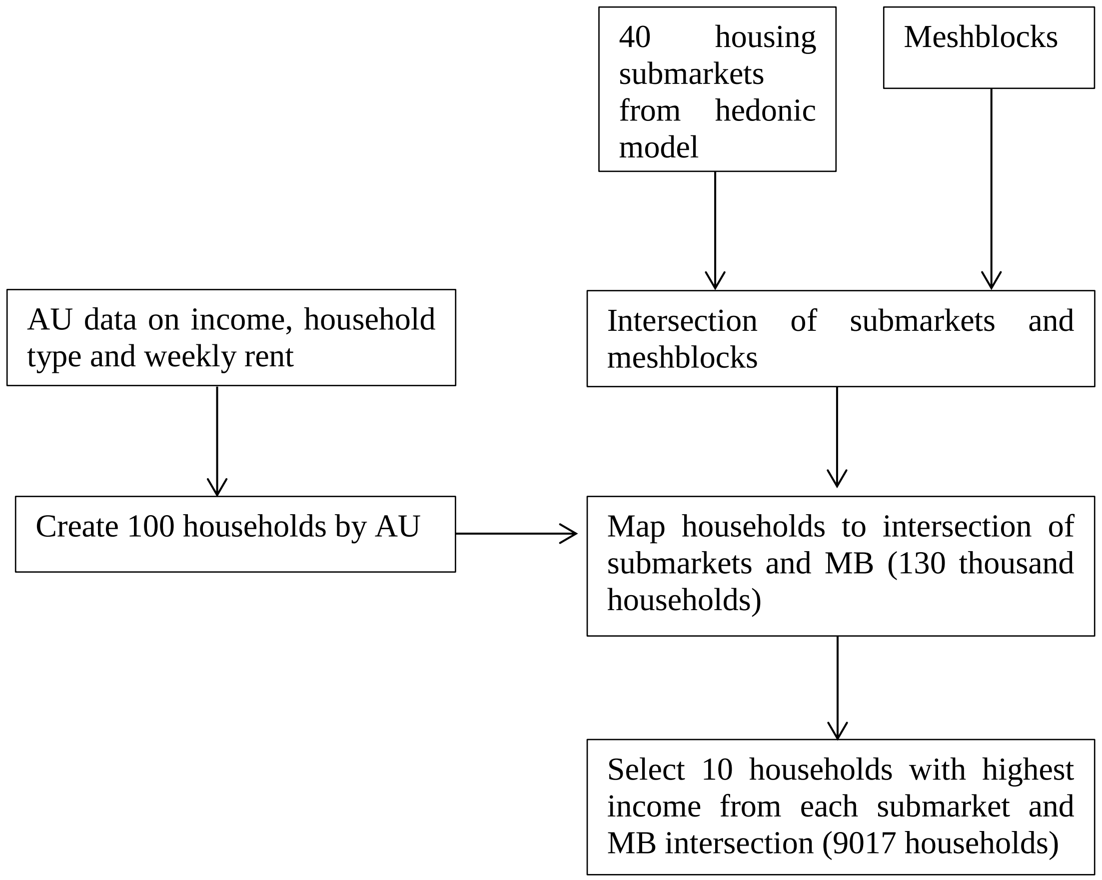


Figure 2: Housing Submarkets – Auckland and Auckland Isthmus

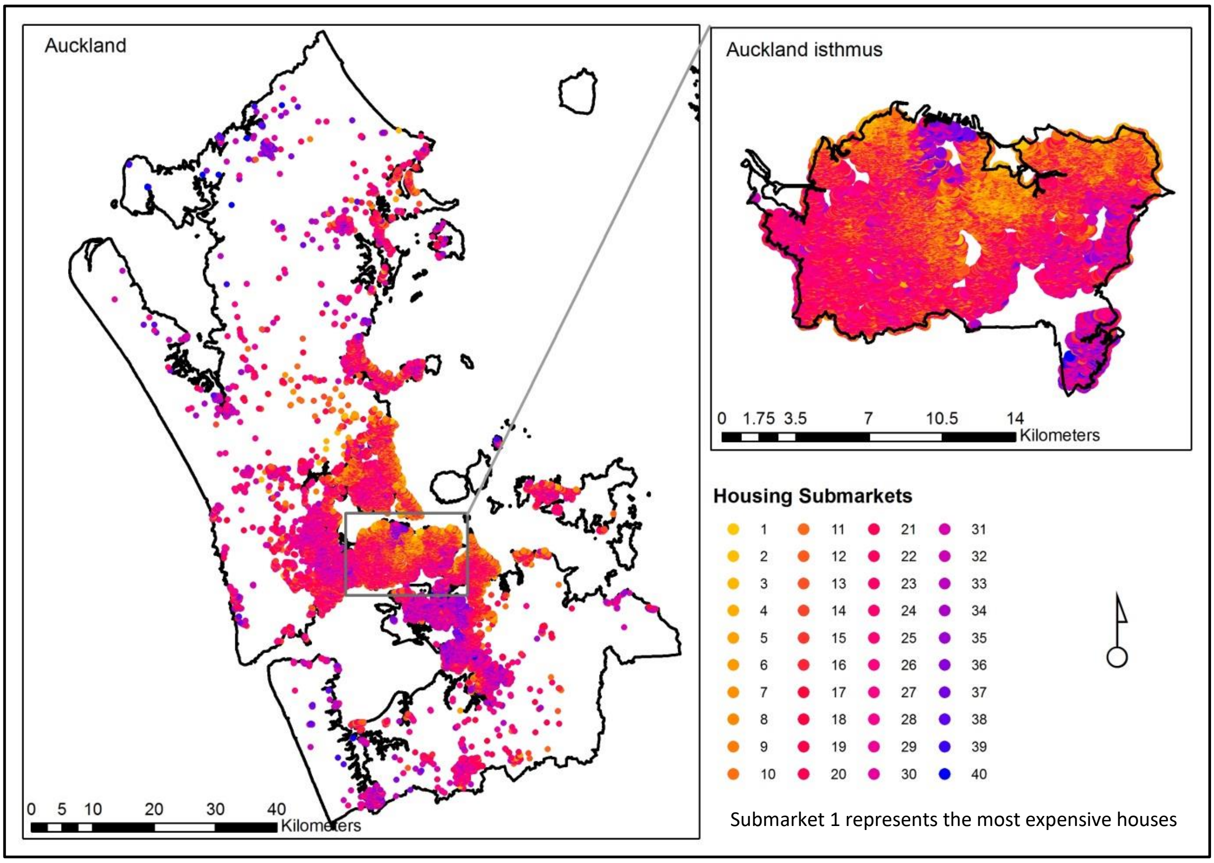

Auckland
Auckland isthmus
0 1.75 3.5 7 10.5 14
Kilometers
0 5 10 20 30 40
Kilometers
Housing Submarkets
1 2 3 4 5 6 7 8 9 10
11 12 13 14 15 16 17 18 19 20
21 22 23 24 25 26 27 28 29 30
31 32 33 34 35 36 37 38 39 40
Submarket 1 represents the most expensive houses

Figure 3: Aggregation of Submarkets into Sections – Auckland and Auckland Isthmus

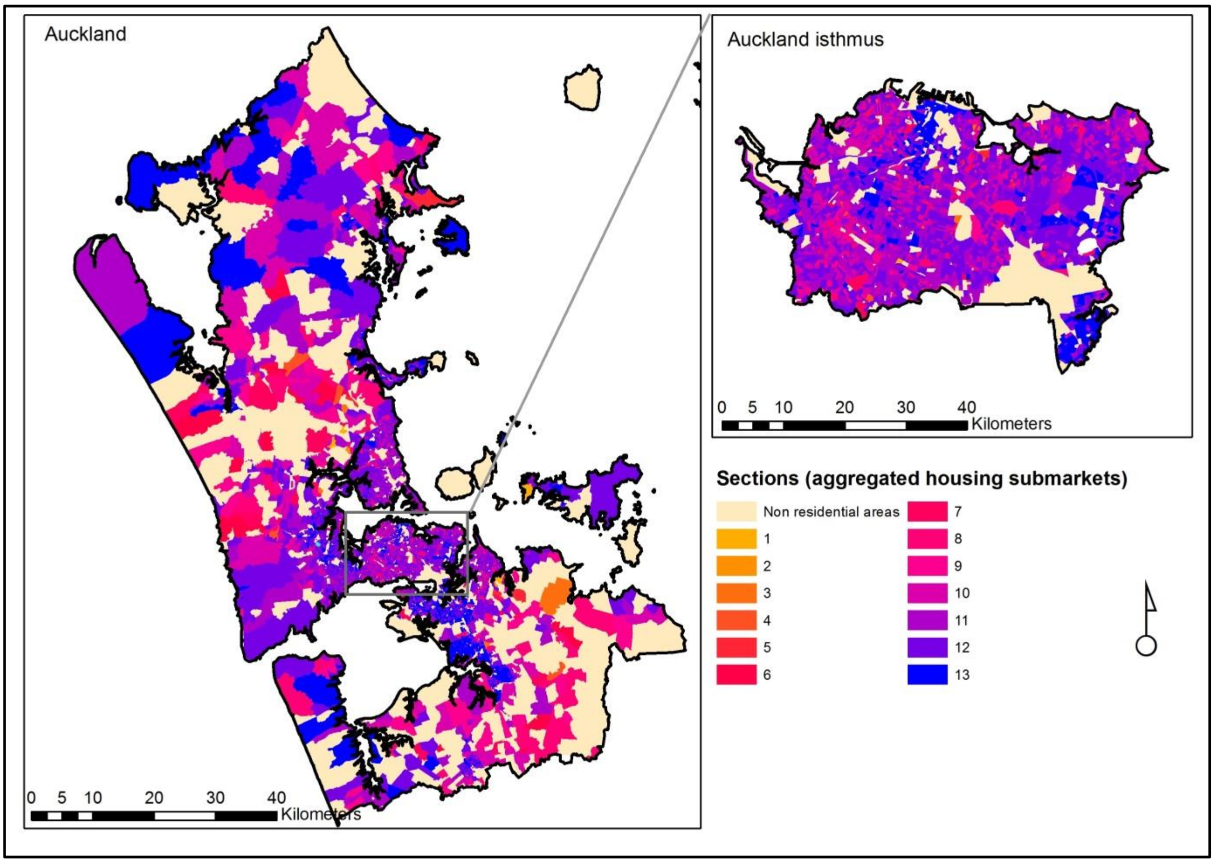


Table 1 compares households in the entire Auckland region and the sample. Dispersion rates and the shares of household types differ because the sample includes households with the ten highest incomes from the mapping between meshblocks and housing submarkets. This assumption represents those households that are more likely to buy a house given market conditions. Though the sample could be expanded to include lower-income households, this would be immaterial as they will still be outbid from the competitive market setting of the model. Nonetheless, for future research simulations of subsidized or other state-supported programs, or housing directed to a specific target population could be incorporated in the model.

Average income figures in Table 2 are also higher than Auckland's household median income ($98,621)[1]. As no wealth or assets information can be extracted from Census data, deposit is proxied by an annualised figure in the objective function that should be at least 20% of the sale price of the house. Other assumptions on the demand side are that no demographic or economic shocks alter household formation and composition, and no income effects occur.

[1] https://www.stuff.co.nz/business/98016625/auckland-tops-income-table-as-households-earn-more

The sample amounts 9,017 households, where more than 90% concentrates between Sections 9 and 13. Household composition is 27% and 28% for couples and couples with kids, respectively, and 22% for single-parent and single-person households (Table 3).

Table 1: Descriptive Statistics for Auckland and the Sample of Households

		Annual Income[1]		Weekly Rent[12]	
	Share (%)	Mean	SD	Mean	SD
Auckland: 392,052 households					
Couple with children	36.6	176,080	121,770	588	120
Couple	25.9	195,603	116,649	549	121
Single person	23.1	64,335	71,910	449	316
Single parent (with children)	14.4	120,208	96,840	588	120
Sample: 9,017 households					
Couple with children	28.2	177,496	42,016	603	58
Couple	27.2	196,446	37,183	558	52
Single person	22.8	73,661	39,314	427	53
Single parent (with children)	21.8	134,354	34,350	593	48

Notes: [1]Values updated to 2017. [2]Rent estimates based on 154,347 renting households.

Table 2: Average Income by Household Type and Section – Sample

Section	Couple (no kids)	Couple with kids	Single parent	Single person
1	179,612	242,361	140,310	60,467
2	228,613	205,796	123,043	89,100
3	224,570	169,231	143,397	148,309
4	230,620	203,844	125,881	82,561
5	239,423	218,844	152,934	92,498
6	214,786	210,062	136,937	69,882
7	220,557	200,217	137,356	78,480
8	223,036	194,262	142,524	77,979
9	212,812	198,364	135,182	76,950
10	206,541	192,941	128,653	69,595
11	203,338	184,095	127,994	74,907
12	196,470	175,930	122,132	67,996
13	165,520	144,099	113,455	83,332

Table 3: Number of Households by Type and Section - Sample

Section	Couple (no kids)	Couple with kids	Single parent	Single person	Total
1	1	2	3	2	8
2	1	1	3	1	5
3	2	3	2	5	12
4	9	13	6	6	34
5	9	8	10	6	33
6	17	11	8	14	50
7	41	50	29	37	157
8	56	59	52	52	219
9	143	160	103	104	510
10	267	301	219	226	1013
11	563	584	449	458	2054
12	940	943	730	777	3390
13	404	408	355	365	1532
Total	2453	2543	1969	2053	9017

Supply

Supply is represented by the additional capacity or the net increase in house development facilitated by changing rules or regulations, i.e., the NPSUDC. The analysis then adheres to the rationale of the NPSUDC, which indicates that significant releases of land will directly translate into additional housing capacity and improvements on housing affordability (Government of New Zealand, 2016). To increase the degree of realism, the supply scenarios also incorporate the incorporation of the Future Urban Land Zones and changes on the densification rules prescribed by the Auckland Unitary Plan (IHP, 2015).

The additional house capacity is extracted from simulation runs of the Auckland Council Development Capacity (ACDC) model. The model simulates profit-maximizing developers buying land and looking up on development alternatives at parcel-level (standalone houses, terraces, apartments), where alternatives are conditional to the zoning constraints. The model calculates the development costs for that parcel and built form typology (e.g. how many houses are possible on the parcel). The model incorporates wide input data on costs of land, construction and site development, professional fees, development contributions, service connections, finance, and costs of sale. Data comes from a variety of sources such as construction budgets, consultants and interviews with developers and builders. Costs are then used to estimate the net return from the sale of new houses, price data come from imputations of sales in neighbouring dwellings obtained from the Valuation and Rates Dataset of the Auckland Council. Hence, the model assesses the commercial feasibility of development decisions based on market prices as well as the likelihood of achieving a return for the cost, effort and risk involved.

The model categorises the AU into 10 sale price bands, with for example Otara and Clendon in Category 1 and Parnell and Herne Bay in Category 10. This categorisation drives the selection of the floorspace, price and other cost assumptions, and guarantees consistency between the costing of the house and its location. The comparison of prices and costs provides a margin result on a total dollar and percentage basis. Thus, developments with a gross positive margin greater than 20% are considered as economically feasible. The Model then tallies up all of the capacity that is economically feasible. Conversely, if a development provides insufficient financial return, then the developer will not build the project or, alternatively, the funding source (e.g. a bank) will not fund such development.

The feasibility assessment is on a parcel-by-parcel basis (350,000+ parcels). The base dataset has a large amount of information on every property parcel in Auckland, including site size, parcel dimensions, frontages, existing house number(s), existing building size and areas, existing use, the existing zone, improvement value (IV), land value (LV), capital value (CV), year built, zonification, maximum heights and other key planning parameters. Data is obtained from a number of sources: Property Council of NZ, Auckland Council, and property development experts group.

Output is displayed in several spatial levels such as meshblocks, AUs, Local Board area, and Precinct. Data also exists for Publically Owned Land, Special Housing Areas, existing Watercare Moratoria Areas, and intersection with a set of pre-collated physical constraints are also provided. The components of housing are defined as Terraces, Apartments and Houses. A housing unit is characterized by tenure type, number of bedrooms between 1 and 5, and geographic location by meshblock. Buyers are allowed to allocate up to 50% of income as a "choke" allocation in order to calculate the valuations (bid rents).

Further details on the ACDC model may be found in Auckland Council (2017) and IHP (2015).

The scenarios for additional housing capacity are described as follows:

- The Maximum-return or Profit-Descending (PD) scenario represents profit-maximizing developers. For example, if there are two possible feasible developments, returning 25% and 22% gross return on costs input, the developer will choose the 25% return option. This may be considered the 'yield seeking capital preferred' option. Relative to the other scenarios, the PD mimics competitive markets and consists mainly of large and expensive houses.

- The Minimum-price or Price-Ascending (PA) Scenario represents a developer selecting the feasible development option whose house retail price is the lowest. This would be the option that shows the lowest possible house price that a profit motivated development community can deliver, and would be the "affordable housing advocates option". For example, if two feasible development options are available where house prices are $800,000 and $900,000, the developer will choose the lowest price. This scenario consists of smaller houses as the ACDC model assumes floorspace and price are strongly linked.

- The Minimum Project Cost (CD) scenario chooses the feasible development option whose aggregate input cost is the lowest in dollar terms. This option is developed as the maximum return scenario may require both significant capital inputs and are typically more complex projects, and may be beyond the reach of the 'average developer', particularly where the developers own house is used as collateral. This would be the option with lowest input costs that a profit-motivated development community can deliver, and would be the 'small developers' option. That is, the selected development alternative choice would be the one that requires, say, $1 million of inputs, rather than one that generates higher percentage profits but requires $10M to generate. Even if it is at a lower percentage return, the first option will be chosen. This option tends to provide a mix of house sizes and prices somewhere between the other two 'extremes' described by the PA and PD scenarios.

For the purposes of generating inputs to the demand model, supply is composed of 6000 new houses, roughly equivalent to the number of new houses sold annually in Auckland. The most profitable, cheapest or lowest input cost developments are chosen from a combined outputs of both the Urban and Greenfields ACDC models. A restricted set of house criteria are carried forwards including a stratified house retail price (modelled house price plus a random number between 0 and 1), typology (house terrace, apartment), locational information and the number of bedrooms.

The feasibility scenarios represent the potential spatial and price distributions of housing in Auckland. This analysis at unit-level allows a one-to-one matching between housing supply and household demand, conditional to the mobility determined by the market segments. For computational purposes, the 40 market segments are aggregated into 13 sections. The distribution of houses by sections (Table 4) shows that for the PD scenario, no houses are deemed profitable by developers in Section 13, i.e., relatively poor areas. But a bulk of houses (67%) is developed in intermediate-price sections 6 to 10. Terraces only account to 4.5% of the feasible houses which are feasible in Sections 2 to 9. On the contrary, for the PA and CD scenarios, 83% and 88% of the feasible houses (houses and terraces), respectively, concentrate in Sections 10 to 13. It should be noticed that terraces become feasible for the PA and CD scenarios and account to 20% and 28% of all feasible houses.

Accordingly, for the PD scenario, average house prices tend to be higher in sections 1 to 6, compared to the rest of sections (Table 5). The PA scenario does not show a clear decreasing pattern on prices which is explained by the high variability of prices even in neighbouring locations. Overall, average prices of houses in the PD scenario are 29% and 25% higher than for the PA and CD. Likewise, prices of terraces in the PD are 64% and 36% higher than for the PA and CD.

Table 4**: Number of Houses by Section**

Scenarios

	Profit Descending			Price Ascending			Project Cost Descending		
Section	Houses	Terraces	Total	Houses	Terraces	Total	Houses	Terraces	Total
1	133		133						
2	254	6	260						
3	386	11	397	2	2	4	1		1
4	23	39	62	30	1	31	1		1
5	505	18	523	3	1	4	1	1	2
6	604	61	665	76	2	78	1	10	11
7	682	12	694	21	10	31	27	43	70
8	593	114	707	285	29	314	80	31	111
9	951	11	962	491	91	582	415	94	509
10	988		988	591	102	693	624	162	786
11	234		234	583	438	1021	640	494	1134
12	375		375	1428	515	1943	1560	819	2379
13				1275	24	1299	972	24	996
Total	5728	272	6000	4785	1215	6000	4322	1678	6000

Table 5**: Average Price by House Type and Section**

	Scenarios					
	Profit Descending		Price Ascending		Project Cost Descending	
Section	Houses	Terraces	Houses	Terraces	Houses	Terraces
1	1,669,500					
2	1,170,001	1,809,601				
3	1,160,355	1,776,568	1,144,500	973,081	1,296,001	
4	1,294,310	2,373,120	766,174	1,259,281	1,296,001	
5	1,472,834	1,735,068	1,444,500	1,259,281	1,296,001	1,501,500
6	1,490,412	1,675,154	970,251	973,081	1,296,001	1,331,454
7	1,036,534	1,742,645	1,052,343	973,081	962,791	1,238,061
8	1,122,494	1,754,979	821,414	1,150,722	684,006	1,357,973
9	1,023,713	1,809,601	702,964	1,152,349	651,148	1,295,844
10	1,079,232		722,885	1,166,687	796,143	1,358,177
11	985,513		1,027,565	1,110,953	857,929	1,302,041
12	1,093,753		1,000,521	1,080,020	841,857	1,292,093
13			721,663	1,187,731	721,159	1,501,500

5. Results

The purpose of the simulations is to identify the type of households that may buy a new house given income, household type and current rent. Households search a house within three housing submarkets and compete with other households within a competitive market setting. Search is conditional to the prices distribution across scenarios and the spatial location of houses. Housing supply is extracted from the ACDC model and is taken as given in the context of this paper. The paper then assesses whether the additional housing capacity (induced by the NPSUDC) is consistent with the purchase capabilities of the households sample. This consistency is represented by the rate of take-up of the additional houses, welfare changes and housing stress.

Take-up of the additional capacity

Take-up is measured as the ratio between the number of houses actually sold and those becoming available because of the NPSUDC. The ideal case would be a ratio equal to 1, all houses are sold (no excess supply). Take-up is then the starting point to predict residential-selection patterns in Auckland.

Results in Table 6 reveal that the relatively high prices under the PD scenarios imply that a large share of households cannot afford buying any house, even if housing stress is allowed to be up to 50% of income. Out of the 6,000 new houses becoming available, only 1,844 (30.7%) would be sold. As the model assumes that developers are fully informed, supply may be adjusted downwards to be consistent with this low rate of take-up. Thus, housing shortage may actually worsen and housing affordability does not improve. On the contrary, prices on the PA and CD scenarios are comparatively lower which implies greater rates of take-up (73% and 71%, respectively), more than double the take-up on the PD scenario.

Table 6 also shows that for all scenarios, couples with or without children buy about 90% of houses. Terraces are a very small share of all sales under the PD scenario, whereas under the PA and CD scenarios couples buy 785 and 614, respectively. Nonetheless, sales of terraces are less than 19% of all sales in the PA, and less than 15% in the CD scenario. Furthermore, though single-parent households buy less than half of houses than couples, the number of houses bought by single-parent households under the PA and CD scenarios more than doubles those on the PD.

At this point it should be mentioned that the output of ACDC model did not find it feasible to develop apartments or any houses with less than two bedrooms, which implies that no single-person household is buying any house across the scenarios.

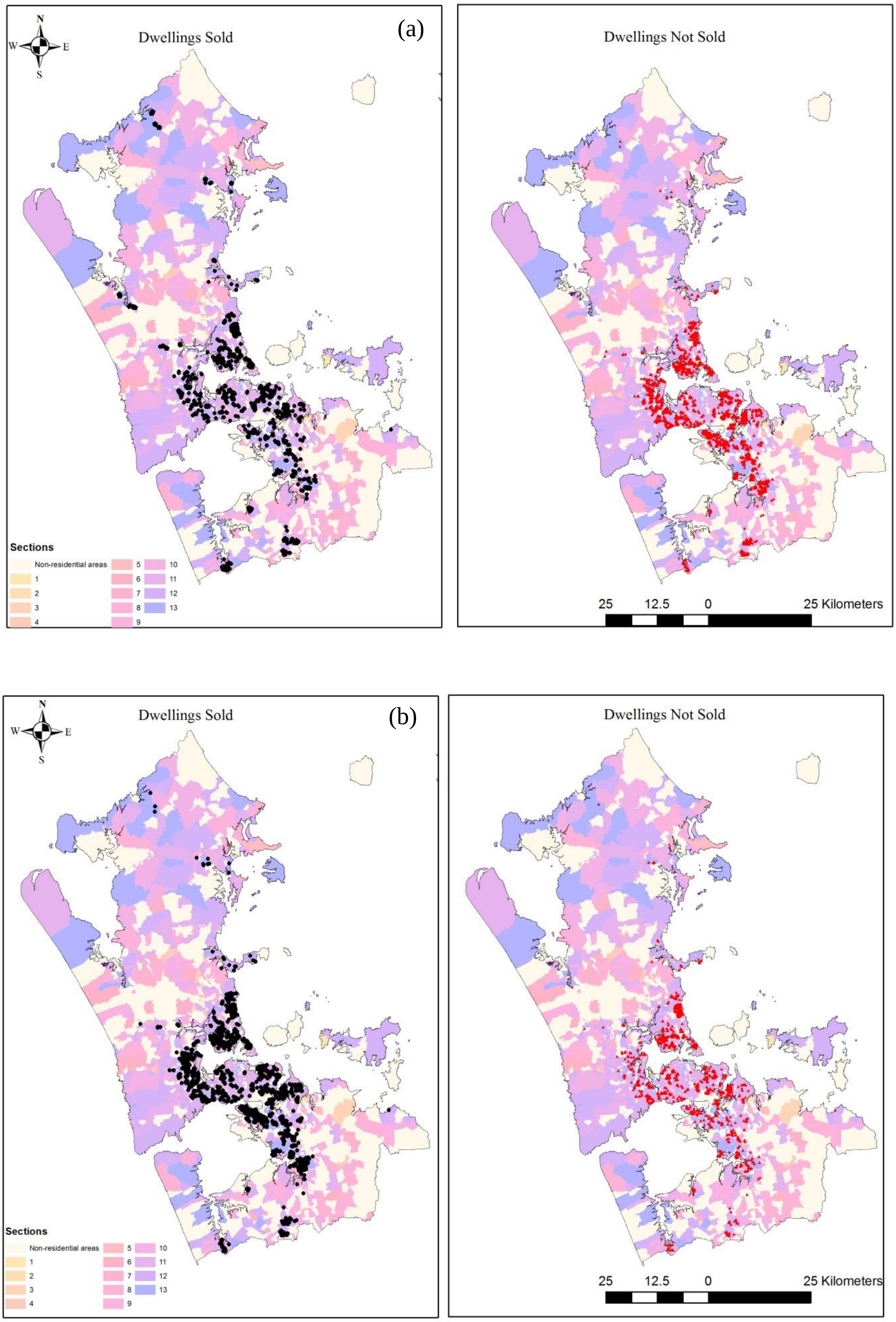
Table 6: Number of Houses Sold by Household Type

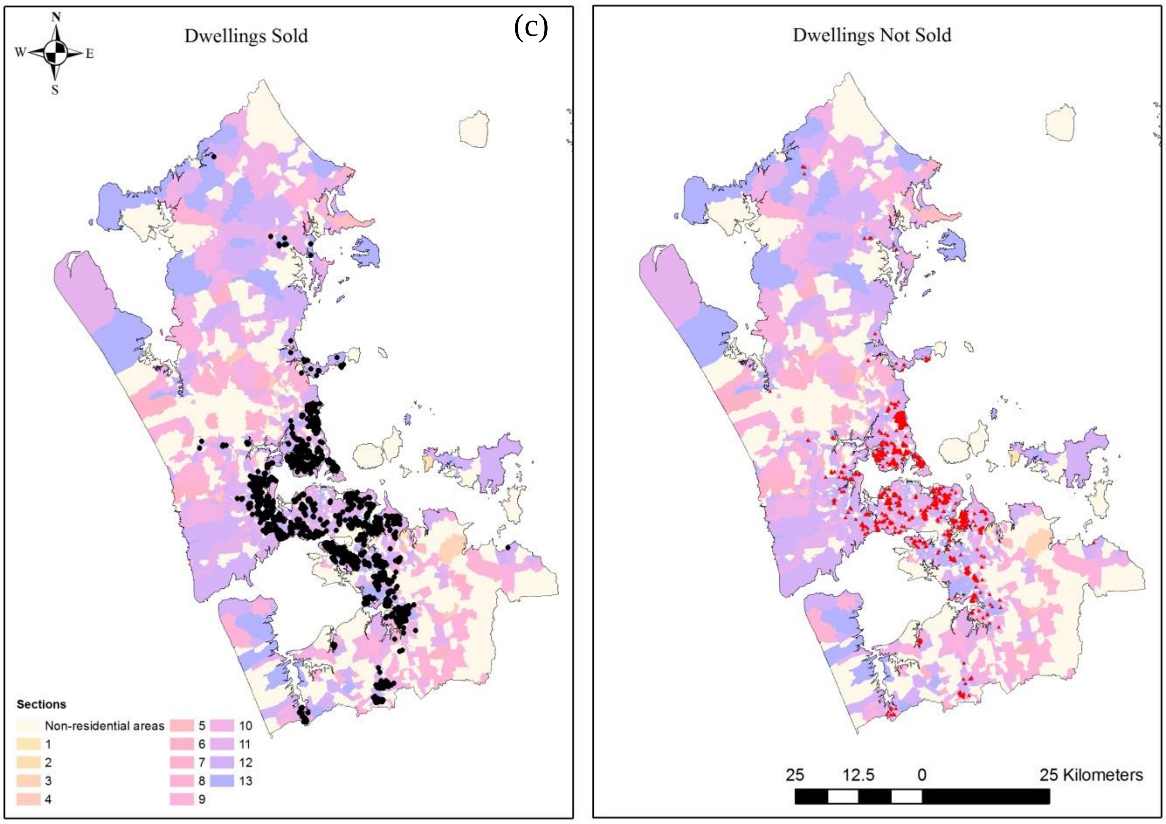
	Scenarios								
	Profit Descending			Price Ascending			Project Cost Descending		
Household type	Houses	Terraces	Total	Houses	Terraces	Total	Houses	Terraces	Total
Couple (no kids)	912	2	914	1688	446	2134	1817	347	2164
Couple with kids	771	1	158	1435	339	1774	1490	267	1757
Single parent	158		772	434	45	479	337	36	373
Total	1841	3	1844	3557	830	4387	3644	650	4294

Figure 4 shows the effect of the spatial location of the additional capacity. In the PD scenario, the rate of take-up is low, which coincide with houses located in areas of the North Shore and Eastern Bays, as well as other scattered areas in the city. Houses actually sold are not concentrated in any particular region but mostly appear in the southern and western areas of the city. In the isthmus the only available houses are in and around the CBD and Eastern Bays, which are not sold.

In the PA and CD scenarios, in turn, the rate of take-up is much higher where sold houses scatter across the city, mostly in South Auckland. Interestingly, houses that are not sold locate in roughly the same areas as houses sold which confirms the existence of several submarkets in relatively small areas (meshblocks). Likewise, houses sold in the PA and CD scenarios also locate in roughly the same areas as houses not sold in the PD, which is explained by its higher prices.

Figure 4: Spatial Distribution of Houses: (a) Profit Descending, (b) Price Ascending, (c) Cost Descending





Market Outcomes

Market outcomes are represented by the price distribution of the houses actually sold and the annual income of households that become first-home buyers.

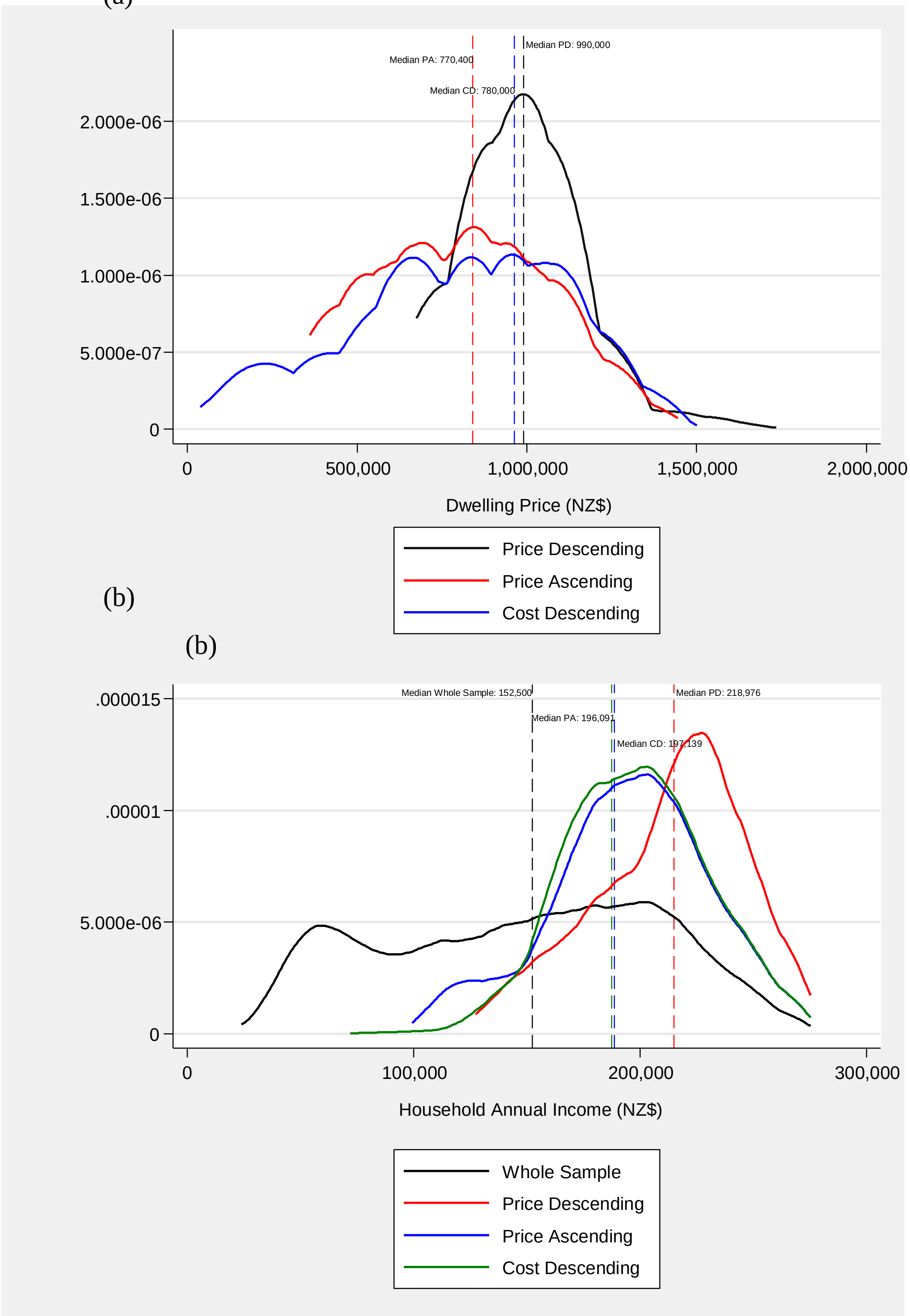
Panel a of Figure 5 shows that house prices in the PD scenario concentrate around their median ($990,000) and the lower end of the distribution truncates at $675,000. In the PA and CD scenarios, the median prices are not distant, but the CD there is greater dispersion where the lower end of the distribution includes houses sold for $100,000 or less, the price distribution for the PA truncates at $360,000.

Panel b of Figure 5 shows that, for the PD scenario, the annual income of buyers concentrates in the upper end of the distribution, which contrasts to the distribution of all potential buyers (whole sample). That is, only wealthier households enter the market to buy a house from the additional capacity induced by the NPSUDC. In turn, for the PA and CD scenarios, the median income is relatively low. Nonetheless, the median incomes of the three scenarios are substantially higher than the median household income in Auckland ($91,728); and, no overlap occurs with the lower end of the whole sample distribution. That is, as households compete for the new houses, relatively low income households are outbid of the market. Therefore, though the PA and CD scenarios represent more advantageous purchase conditions, they do not necessarily improve housing affordability for poor households.

Results are consistent with Gyourko, Mayer and Sinai (2013) because, in a land-scarce setting such as Auckland's, high income households crowd out low income households, which adds further pressure on land prices and induces a shift to the right in the income distribution of first-home buyers.

Figure 5: Market Outcomes by Scenario: Distribution of Prices of Houses Sold (a) and Annual Income of Buyers (b)

(a)



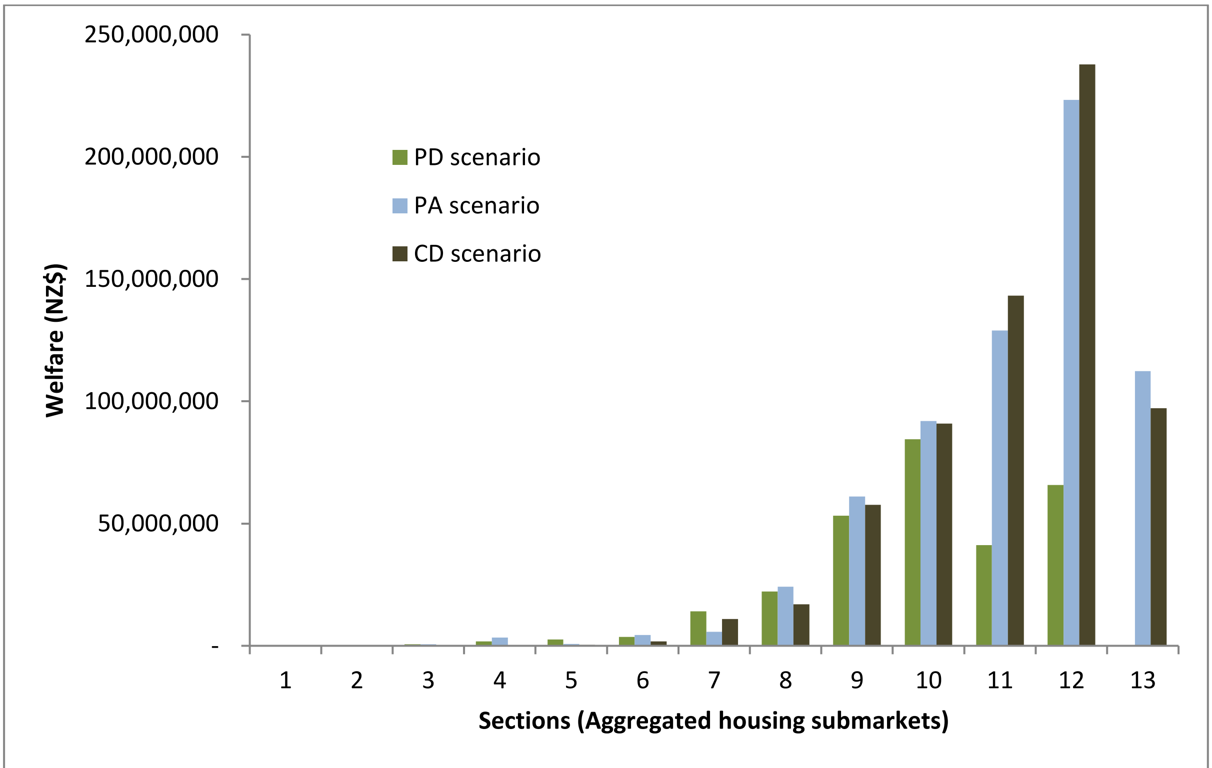
Welfare and Housing Stress

Equation (1) sets the objective of the model on maximising the difference between willingness-to-pay and price -the consumer surplus (Ng and Lo, 2015). Consumer surplus is a direct measure of households' welfare resulting from the additional housing capacity. Results in this subsection show that relaxing housing regulations through NPSUDC-type policies (and thus increasing land supply) appears to be welfare-enhancing (Glaeser and Gyourko, 2017). Nonetheless, results differ across scenarios and affordability implications apply only to households that can cope with deposit and mortgage payments.

Figure 6 shows that additional housing in the PD scenario increases welfare by $303 million; whereas in the PA and CD welfare increases by 717 and 732 million, respectively. Welfare in sections 11 and 12 are significantly higher in the PA and CD scenarios, compared to the PD, because of the lower prices and a larger share of relatively low-income households entering the market.

Welfare in scenarios 10 and below are not very dissimilar between the scenarios as the same buyers in the PD scenario will still outbid lower-income households.

Figure 6: Welfare Measures by Section and Scenario

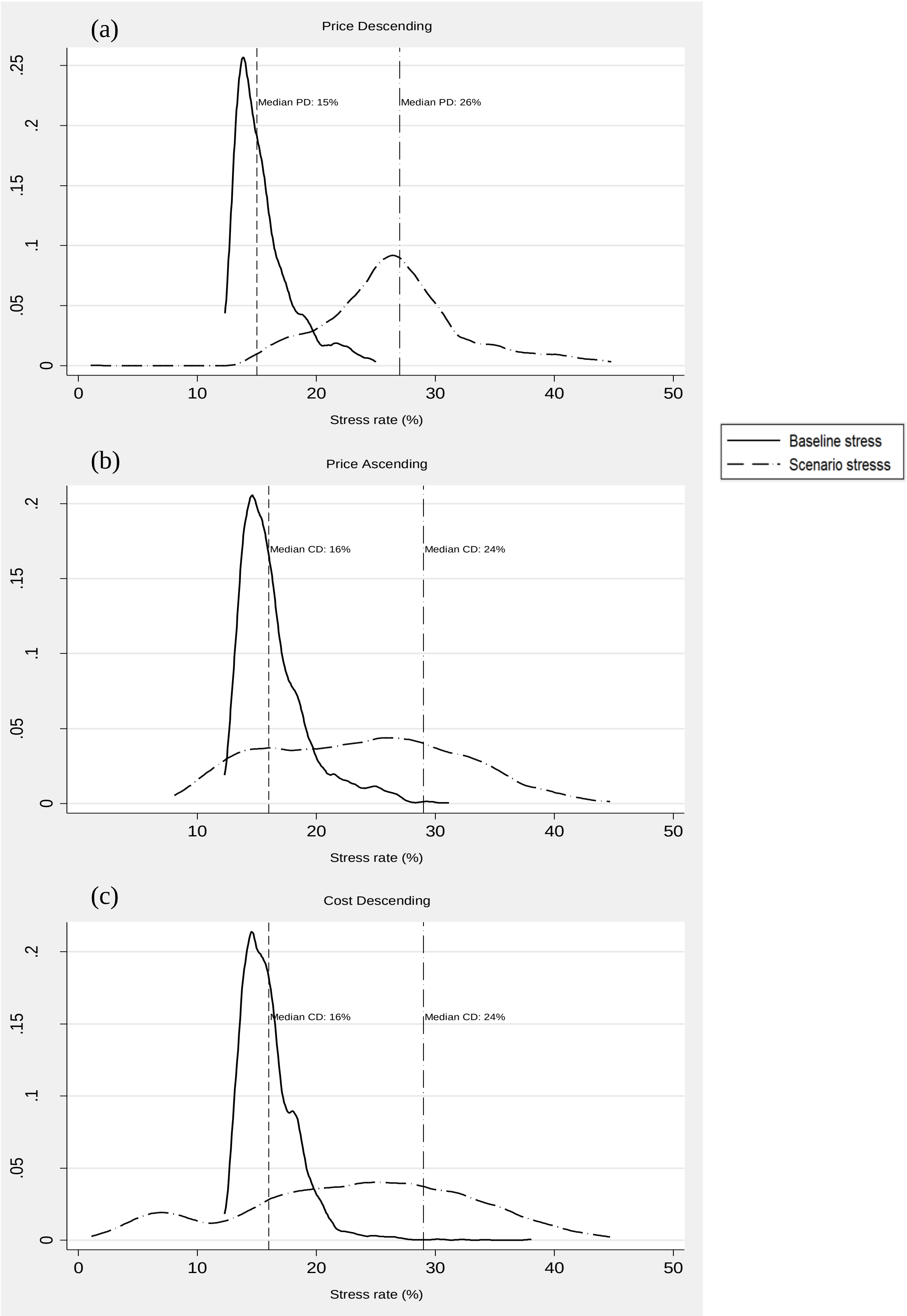


The purpose of the NPSUDC is to stimulate supply on bringing affordable housing into the market. Though it does not incorporate any affordability criteria or requirements to developers, it seeks to address housing stress by mitigating pressures on the economic and social life of individuals and communities (Rowley, Ong and Haffner, 2015; Mulliner, Malys and Maliene, 2016; Akbar, Rolfe and Hossain, 2017). In this paper, household stress is measured as the ratio between mortgage payments and income. As mortgage repayments can leave households precariously positioned on the margins of home ownership (Wood and Ong, 2017), the models allows households to allocate up to 50% of income to mortgage payments. Stress is calculated with respect to those households that manage to buy a house, that is, 1,844, 4,387 and 4,294 households for the PD, PA and CD scenarios respectively. Thus, the baseline stress (the ratio between rent payments and income) changes across scenarios.

Figure 7 shows that baseline stress is between 15% and 16% for all scenarios. Because households buy a house, the median stress across scenarios is now between 27% and 29%. In the PD scenario, (baseline) median rent is at 32,257 and mortgage payments reach 56,981; in the CD, median rent is 31,212 and mortgage 44,894; and, in the PA rent is 31,196 and mortgage 44,341.

Nonetheless, Panel a shows that the distribution of stress for the PD scenario is concentrated around the median, and the truncation of the lower end of the distribution implies that none of the buyers will have stress levels lower than the baseline. For the PA and CD scenarios, stress distribution is more disperse and no concentration around a point estimate is identified. The lower-end of the distributions even reveal that a share of the households will have stress levels that are actually lower than the baseline. Furthermore, though stress levels overall increase for the PA and CD scenarios, only in a few cases mortgage payments exceed the 40% of income. Still, these results are because of the higher median income in the three scenarios relative to the median household income in Auckland.

Figure 7: Housing Stress by Scenario



6. Discussion and Policy Implications

The policy scope in New Zealand regarding housing shortage and unaffordability has a strong inclination toward augmenting housing capacity by means of land releases, densification or similar actions. The National Policy Statement on Urban Development Capacity (NPSUDC) released in late 2016 prescribes that local governments must ensure there is sufficient development capacity to meet demand, and if unbalance occurs then a greater number of opportunities for development should be provided. Those opportunities should be commercially feasible and produce a more competitive housing market. The rationale of the NPSUDC is that housing shortage and unaffordability (and other associated social consequences) will be mitigated through additional housing capacity. It is not a recent policy prescription in New Zealand that releasing tracts of greenfield and brownfield land to the market will improve affordability (New Zealand Productivity Commission, 2012).

This rationale entails that, apart from land use, many things about the housing market are beyond the control of the Auckland Council, such as the structure of the economy and the mix of employment opportunities, the distribution of wealth, and housing assistance programs (Metcalf, 2018). Thus, though overall affordability may not significantly improve with additional and expensive houses coming into the market, in the margin some households may still benefit. To measure those benefits and estimate the market effects of the additional capacity, I construct a matching model based on mixed integer programming to identify the type of households buying the new houses. Housing market is complex, to simplify simulations but still gaining valuable policy inputs, demand is represented by 9,000 artificial households created from 2013 Census data. These households bid for houses that enter the market induced by the effects of the NPSUDC. A number of assumptions are necessary, and I heavily rely on the competitiveness of the market and the forward-looking behaviour of the economic agents.

The model and results provide insights about the market outcomes of three potential scenarios of additional housing capacity. Though the rate of take-up is positively affected by lower housing prices, different characterization of houses and spatial locations, affordability overall may not improve as the artificial households used in the simulations have substantially higher incomes than the median income in Auckland. Moreover, even under the more advantageous conditions of PA and CD scenarios, there is still a share of houses (29%-27% of the total) that remain unsold. Hence, it remains as an open question the sort of scenarios that needs to developed in order to guarantee that low-income households can afford a house where stress does not surpass the 50% threshold, and still the market remains competitive. We hypothesize that state intervention, e.g. subsidisation of deposits or mortgage payments, would induce a different profile of buyers and improve affordability. Nonetheless, additional model results, whose results are not presented, showed that the fiscal cost of subsidisation is high because the state would need to absorb around 50% of the house price (under current conditions) to produce non-negligible benefits on low-income households.

The degrees of realism and generalizability of mathematical programming models (Johnson, 2007) are always subject to scrutiny. I have relied on a simple form of the bid rent for the objective function, and assumed that all externalities and amenities effects are embedded in the price. Model results are not far from reality when signalling that incompatibility between housing prices and household income distributions, in addition to spatial mismatch in the submarkets, produce low rates of take-up. Developers are aware of this incompatibility and they will adjust supply downwards and maximise profits by keeping prices high. This is reflected on the features of Auckland housing market, that is, speculation and low supply inelasticity led to high capitalisation of land into housing prices, increasing construction costs and, consequently, supply not keeping pace with demand pressure (Grimes and Aitken, 2010; NZIER, 2015; Martin and Norman, 2018). Therefore, the simulation model provides insights that may be unavailable using other (econometric) methods. This paper would then fall under a prospective analysis as it includes simulations of various scenarios to anticipate future states (Johnson Jr, 2011).

This paper contributes on improving the understanding the dynamics of the housing market under unaffordability conditions (i.e., high prevailing prices and low household incomes) and resulting market outcomes. These are major ongoing focus of both research and policy (Baker, Mason and Bentley, 2015). A better understanding of the compatibility between supply and demand could then contribute to central and local government policy and spatial planning, as well as to wider community debates on the issue (Mattingly and Morrissey, 2014). I am confident that the implications of the paper agree with Metcalf (2018) as the impact of affordable housing policies (e.g. NPSUDC and Special Housing Areas) in Auckland are small compared to the size of the problem. A broader scope and mix of policies including land use regulations and supplementary measures to housing markets need to be explored.

Future work based on model's refinements relate to a multidimensional approach to explore aspects such as social and environmental issues that affect welfare of buyers relative to those households that do not manage to enter the market (Mulliner, Malys and Maliene, 2016). Also, the effects of housing assistance (e.g. public housing, vouchers, and subsidisation of deposits or mortgage instalments) on welfare and housing stress could be incorporated in the model. It has been demonstrated that welfare may be improved through reducing the share of household income used to pay for housing (Collinson, Ellen and Ludwig, 2015). However, policy benefits should be weighed relative to the fiscal costs and sustainability of likely subsidisation. Finally, supply data based on the ACDC model consist on the most likely supply scenarios based on competitive market settings, where households compete for housing. Thus, more complex rules of behaviour may be added, though I am confident the results an accurate representation of market outcomes.

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