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Sensitivity Analysis on Sydney's Urban Structure and House Prices for the 2021 Intergenerational Report

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[1] The views in this paper are those of the authors and do not necessarily reflect those of NSW Treasury.
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NSW GOVERNMENT

Preface

House prices have a critical role in New South Wales' economic and fiscal sustainability. Sydney's median house price[2] grew by almost 290 per cent over the 20 years to June 2020, nearly triple growth in average income[3] of 105 per cent over the same period[4]. This represents demand for Sydney housing (and land) outpacing supply. Low interest rates, high net overseas migration and strong employment growth have contributed to the growth in demand. Meanwhile, geographical constraints, complex housing and land regulations, construction capacity and mixed incentives for local development have constrained growth in supply, particularly in Sydney's inner suburbs[5]. Some unintended consequences of higher house prices for NSW are worsening wealth inequality, poorer educational outcomes through housing insecurity, and a reduced supply of high-skilled migrants.

The COVID-19 global pandemic has resulted in around a third[6] of the NSW workforce working from home during 2020[7]. While some of this is a temporary adjustment, a structural shift in flexible work practices is likely to persist. A recent NSW Innovation and Productivity Council (IPC) survey suggests NSW businesses and employees are anticipating an increase in remote working (up to 30 per cent of the labour market working remotely) relative to prior to the pandemic (where 18 per cent of people surveyed worked remotely)[8]. While this represents whole-of-state expectations, Sydney could see relatively higher levels of remote working than the state average, given it is highly concentrated with "remoteable" knowledge-intensive industries. This shift would lower commuting costs and reduce incentives for households and businesses to locate close to the CBD. This would have implications for urban structure, with a reduced property price premium on proximity to the urban centre and an increased demand for property in the outer suburbs and regions, such as the Central Coast and Illawarra.

This paper discusses two hypothetical scenarios to the Sydney housing market and total welfare. The first scenario represents an increase in remote work, for example, as a structural shift in flexible work arrangements post the COVID-19 pandemic. The second scenario represents greater density in the CBD and inner suburbs, for example, as a result of relaxed building restrictions. These scenarios have been prepared using the model underpinning the peer-reviewed academic paper - *Urban Structure and Housing Prices: Some Evidence from Australian Cities*[9]. This is a variant of the Alonso-Muth-Mills model, calibrated to represent features of a large city. The model has been calibrated further for this paper to represent Sydney prior to the COVID-19 global pandemic.

The preliminary model outputs will be finalised and presented as part of the next NSW Intergenerational Report (IGR), to be released in 2021, and will support a broader discussion on the importance of effective planning regulations to sustainable growth. It will also provide the opportunity to explore some potential structural shifts resulting from the COVID-19 pandemic and associated government and business responses.

JEL Classification Numbers: E24, J11, J21, J23

[2] 12-month average to June, Stratified Median Sales Price, houses, Sydney. Data provided by CoreLogic and seasonally adjusted by NSW Treasury
[3] 4-quarter average to June, Full-time Average Weekly Earnings, NSW. ABS
[4] CoreLogic, ABS. (2020)
[5] Daley, J; Coates, B. (2018)
[6] Defined as: Working from home for *most days* in the past week, persons aged 18 years and over
[7] ABS. (2020)
[8] IPC. (2020). Proportion of work expected to be done remotely, including home and other locations. The proportion of people working from home roughly corresponds to the proportion of work time being done remotely. See Appendix B, NSW Remote Work Insights, NSW IPC.
[9] Kulish, M., Richards, A., and Gillitzer, C. (2012)

Keywords: COVID-19, house prices, transport, urban planning

Acknowledgement

NSW Treasury acknowledges the Traditional Owners of the land on which we live and work, the oldest continuing cultures in human history.

We pay respect to Elders past and present, and the emerging leaders of tomorrow.

We celebrate the continuing connection of Aboriginal and Torres Strait Islander peoples to Country, language and culture and acknowledge the important contributions Aboriginal and Torres Strait Islander peoples make to our communities and economies.

We reflect on the continuing impact of policies of the past and recognise our responsibility to work with and for Aboriginal and Torres Strait Islander peoples, families and communities, towards better economic, social and cultural outcomes.

Note
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Contents

A model of urban structure and housing costs

The Alonso-Muth-Mills model

The model underpinning this paper is a version of the well-established model of Alonso (1964), Muth (1969) and Mills (1967), and formalised by Wheaton (1974). The parameters have been set to reflect the broad features of the greater Sydney. The model description and results are intentionally non-technical and brief. Readers can find a detailed description of the model on the Reserve Bank of Australia website[10]. Information on the model calibration can also be found in Appendix A.

The Alonso-Muth-Mills model is a static model that captures the impact of various determinants of housing costs. This paper focuses on the 'closed-city' version of the model in that there are no migration flows to the city. The population of the city and the level of income of households is taken as given. The city is assumed to be mono-centric in the model: households locate around the central business district (CBD), and each worker travels[11] to the CBD for work[12] during peak hours only. The model assumes that all other things equal, households would choose to live closer to the CBD to reduce the costs associated with commuting and free up income for other uses. For the market to clear, average land and housing costs increase with closer proximity to the CBD, while building density (dwellings per unit of land) increases with proximity to the CBD.

The Sydney CBD and surrounding suburbs are generally characterised by taller buildings and greater density, while Sydney's fringes are comprised of larger dwellings and lower density. The model assumes households make trade-offs between living in smaller dwellings closer to the CBD (as the property price per square meter generally increases with proximity to the CBD) and living in larger properties further away from the CBD and with more costly commutes. The model allows for the size and shape of city to change with; the size of the population, the cost of transport; and the value of land in alternative uses, such as agriculture.

Like all economic models, the scenarios in this paper are a simplification of reality. Decisions on where to live are complex and based on a variety of social, personal, economic and environmental factors. Unlike the mono-centric city assumed in the model, Greater Sydney is characterised by three cities – the Western Parkland City, the Central River City and the Eastern Harbour City. While the CBD is the largest commuting destination now, work is increasingly conducted all around Sydney and areas such as Greater Paramatta and the Western Sydney Aerotropolis are becoming increasingly attractive to work and live. Sydney's access to coastline and mountain ranges also mean that the model's proximity to the CBD model does not capture the suburb-specific desirability and local amenities. Similarly, density and housing costs per square meter are generally greater with closer CBD proximity, yet they do vary by suburb and are impacted by factors such as zoning and public transport connections. This simplicity, however, allows for a sharper focus on the key drivers of the urban structure, particularly on the factors of interest in this paper, travel costs and density.

Parameters

Parameter value have been selected in line with the work of Bertaud and Brueckner (2005) and are representative of the close to 2 million households living within the boundary of Greater Sydney. The calibration is based on the latest available data immediately prior to the current economic shock. The baseline model includes parameters for incomes and travel costs. Household's travel costs are assumed to rise as the geographical distance from the CBD increases. This has been calculated by direct costs of public/ private transport and the value of time spent commuting. Household incomes of $115,000 per year have been calculated based on the Household Income and Wealth survey

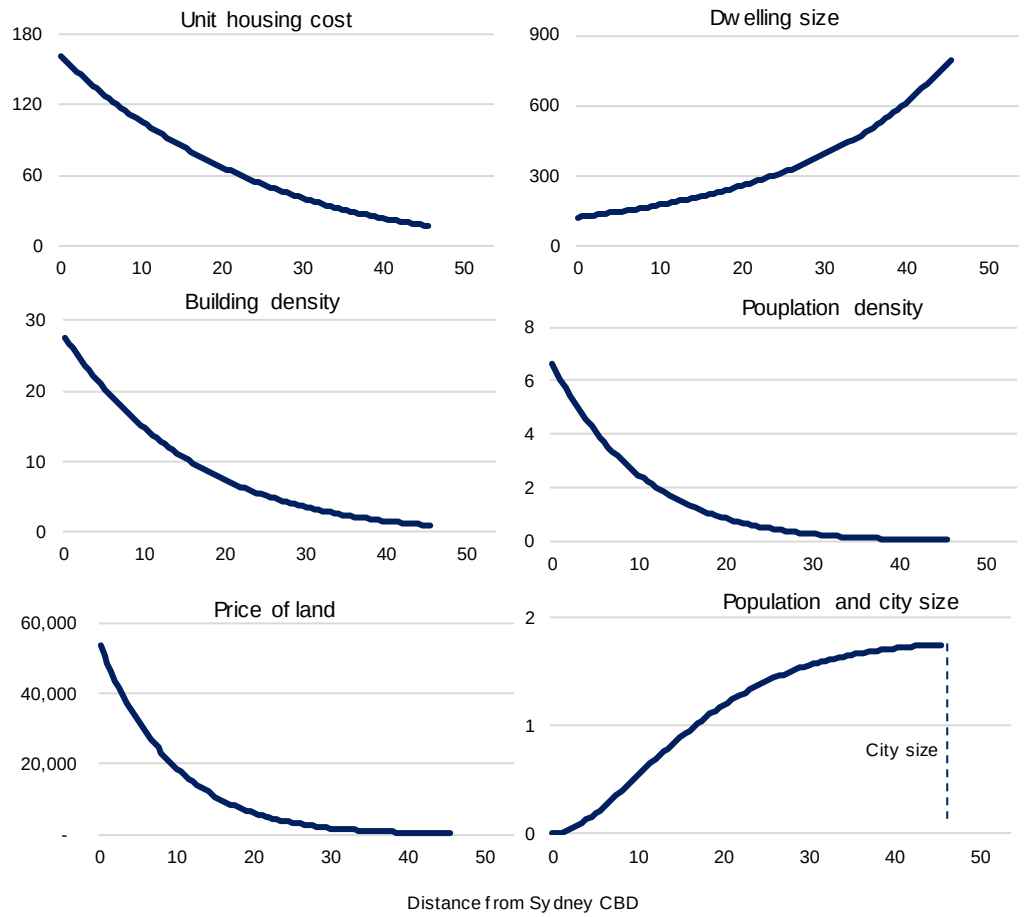
[10] https://www.rba.gov.au/publications/rdp/2011/2011-03/alonso-muth-mills-model.html
[11] Travelling to workplaces is broadly defined to represent using both public transport and private vehicles.
[12] Brueckner, J, K. (1987); Anas, A., Arnott, R., Small, K, A. (1998) for survey articles on the model and various extensions

published by the Australian Bureau of Statistics (ABS). See Appendix A for the full list of parameter values.

Baseline

The baseline results in Chart 1 show key characteristics of the city on the y axis as functions of distance from the CBD in the x axis. Land and housing values increase with closer proximity to the Sydney CBD, along with the average dwelling size decreasing, and building and population density increasing.

Chart 1: The unconstrained urban equilibrium in Sydney



Units are as outline in Footnote[13]

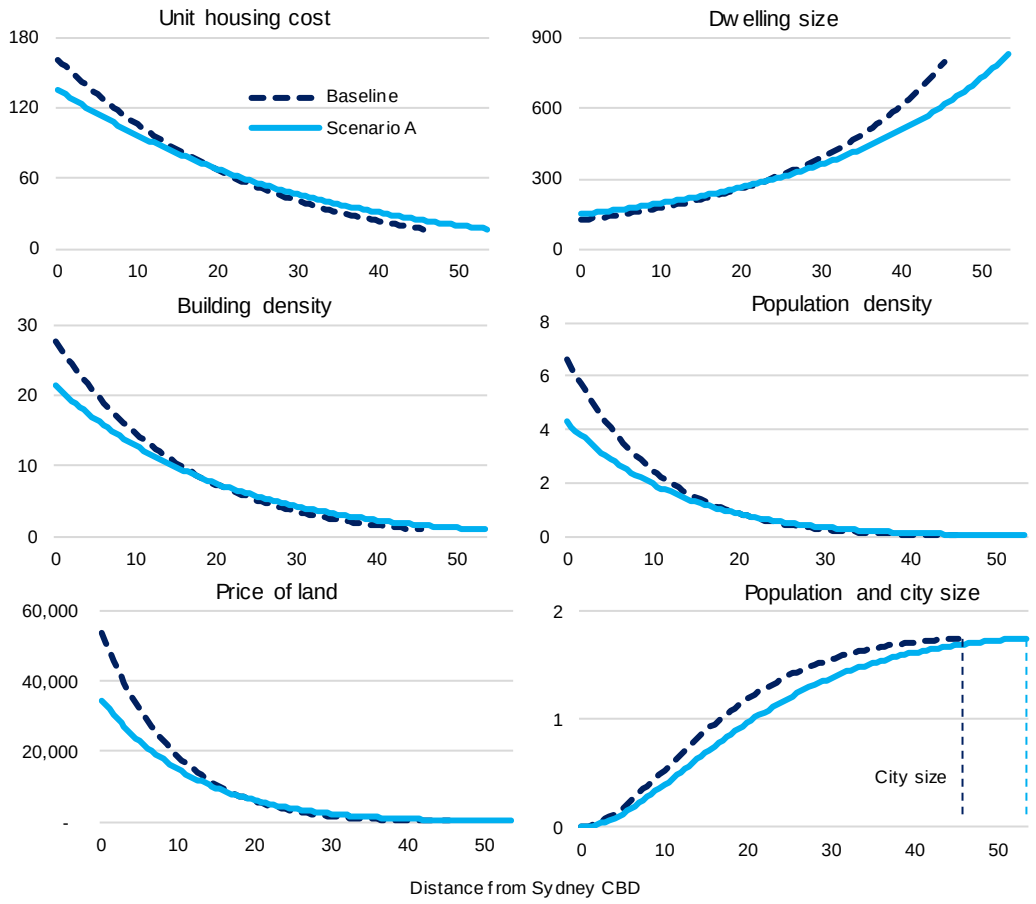
[13] (Rental) unit house prices in dollars per square metre of living space per year; dwelling size in square metres of living space; building density in housing floor space per unit of land (Floor Space Ratio); population density in thousands of persons per square kilometre; (rental) price of land in thousands of dollars per hectare per year; and population in millions of households. The model refers to the rental prices of housing and land, which is equivalent to purchase prices assuming a constant interest rate. For example, in Chart 1 a dwelling with 300 square meter of living space at CBD costs around $160 in rent per square metre per year. Assuming an interest rate of 2 per cent, it is equivalent to a purchase price of around $2.4 million($\frac{\$160*300m^2}{2\%}$). To incorporate both the rents and purchase prices, the rest of the paper will refer them as housing and land costs.

Sensitivity analysis

This section discusses the housing costs and total State welfare implications of (i) a reduction in average household transport costs - through more time spent working from home, (ii) applying a density restriction to areas in close proximity to the CBD, (iii) allowing a relaxation of that density restriction – for example, as a result of more flexible housing regulations, and (iv) a combination of (i) and (ii). They can be interpreted as comparing the long-run equilibrium of two cities that differ only on that one dimension. These are hypothetical static scenarios for the purposes of adding data and analysis to public debates about the role of changing drivers of the urban structure. They cannot capture the full complexity of these hypothetical changes and are not NSW Treasury forecasts.

Scenario A – Reduced transport costs scenario

Chart 2: Effects of lower commuting costs



The first scenario considers a general reduction in household commuting cost into the CBD, as working from home arrangements become more commonplace post the COVID-19 pandemic. In this scenario, all employees are assumed to work from home one day a week on average. This is equivalent to a reduction of 20 per cent of total household commuting cost (see box 1). Alternatively, it can be viewed as half of the workforce work from home two days a week, with the other half representing those jobs which cannot practically be performed from home, such as construction work and cleaning. This scenario assumes transport costs will consistently reduce across all locations. For

example, those living closer to the CBD will reduce their travel costs with the same propensity as those living further away.

Box 1: Working remotely and work-related transport costs

To contain the spread of the COVID-19 virus, many countries, including Australia, practiced social distancing. In addition, a large number of businesses scaled back or suspended operations because of government-mandated closures, concerns for employee health, or reduced demand. According to the NSW IPC remote working survey, the proportion of work done remotely in NSW rose from 18 per cent in 2019 to 43 per cent during the pandemic (NSW IPC, 2020). Other surveys found similar proportions of employees practicing remote working (ABS, 2020).

Assuming COVID-19 social distancing restrictions eventually subside, the experience and technological investments made during the pandemic will likely support even greater flexible work practices in the future. However, there remains value in a centralised workplace, including greater physical collaboration and knowledge sharing, and social benefits of face-to-face interactions. Accordingly, many observers expect that the most likely post—COVID-19 work practice scenario will be a hybrid model of remote and in-person work (Boddy, 2020; NSW IPC, 2020; Thompson, 2020).

An NSW IPC *business and employee survey* found that remote working for 2-3 days a week is the most desired outcome post the COVID-19 pandemic (Chart 3). The NSW IPC estimated the share of work performed in organisational workplaces is expected to be 70 per cent post-COVID-19, compared to 82 per cent pre-COVID-19, and 57 per cent during the pandemic (Chart 4). This suggests workers incurred a 30 per cent reduction in transport costs[14] during the pandemic, and will incur a 15 per cent reduction post-COVID-19, compared to the pre-COVID scenario. Sydney could also be expected to have higher levels of remote working than the NSW average as it is a center for highly 'remoteable' knowledge-intensive industries. Therefore, a slightly higher transport cost reduction of 20 percent is used in the scenario analysis for Greater Sydney.

A research paper by the Federal Reserve Bank of Dallas also estimated similar reductions in transport costs. The paper found that, pre-COVID, 75 per cent of workers in the US commuted to workplaces every day, 16 per cent worked commuted "on some days" and 9 per cent worked from home every day (Bick, 2020). During the pandemic, these figures have been recorded at around 51 per cent of workers commuting every day, 14 per cent commuting "on some days" and 35 per cent working from home every day. Assuming an average 2.5 days in workplaces for those commuting "on some days", these figures represent a reduction of 31 per cent in commuting during the pandemic, comparing to pre-COVID, a very similar result to those in the NSW IPC survey.

Chart 3: Preferred days to work remotely

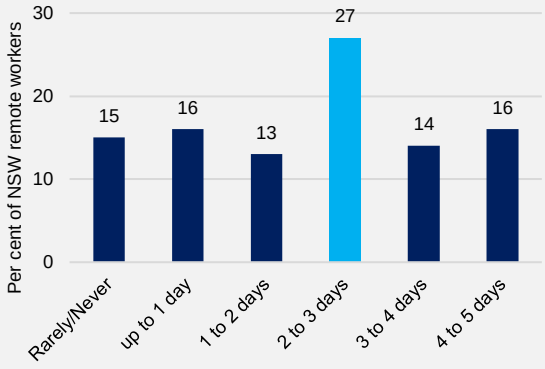
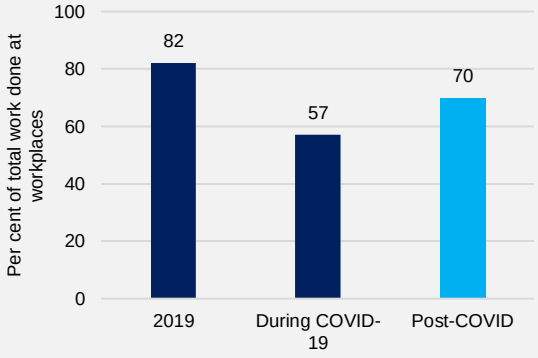


Chart 4: Share of work done at workplaces



Source: NSW Innovation and Productivity Council 2020 Remote Working Survey, NSW Treasury

The effect of a reduction in transport costs is shown in Chart 2. As commuting becomes less costly, living further away from the CBD becomes more desirable for households. This results in an increase in the Sydney city radius from 45km to 54km. With households moving further away from the CBD, relative building density decreases closer to the CBD, but increases towards the city boundary.

Developers adjust to households' changing preferences for housing and build more dwellings further away from the CBD. Relative to the baseline, unit housing costs decrease, and dwelling sizes increase for properties closer to the CBD, while the inverse occurs for properties outside a 20km radius from the CBD. This is not to say that some households further away from the CBD would be worse off. Indeed, if all households are ranked by distance from the CBD, then households at any given distance percentile would live in larger dwellings and face lower unit housing costs than households at the same percentile under the baseline scenario.

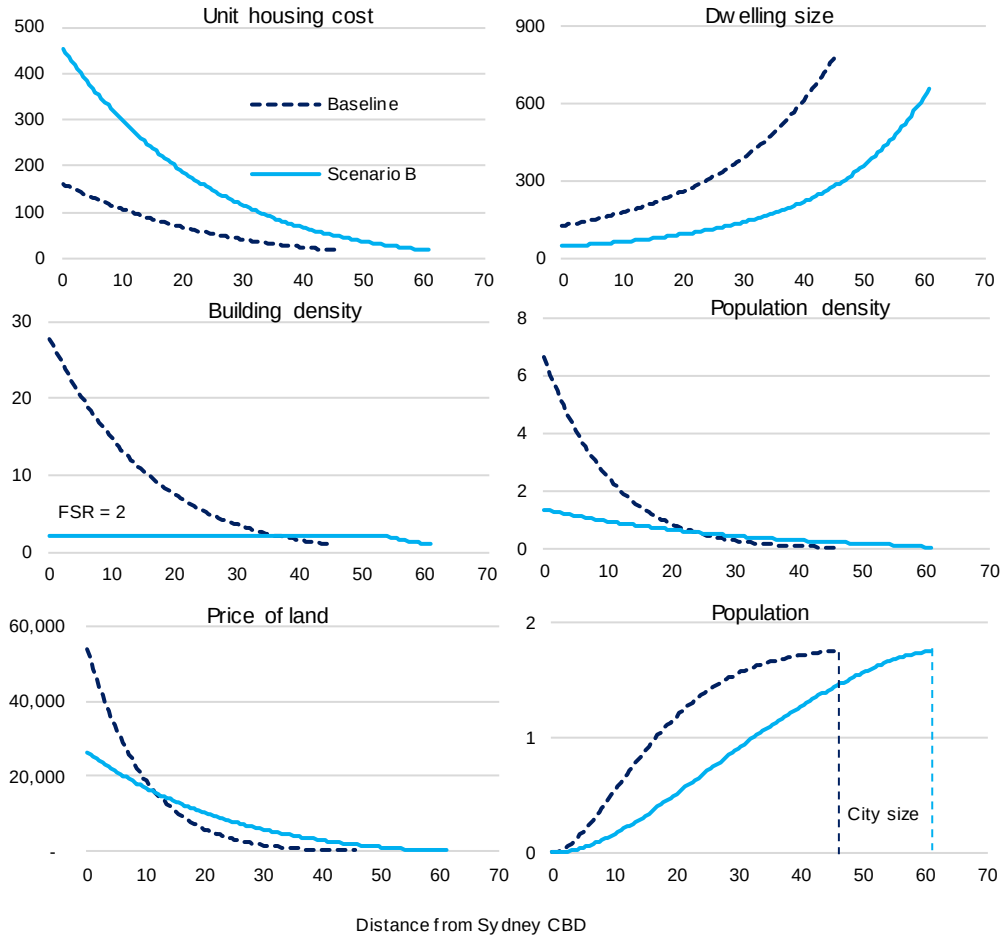
Under this scenario, the average[15] household in NSW incurs less transport costs (-5 per cent), lives in larger dwellings (+10 per cent), and faces lower average housing (-11 per cent) and land costs (-29 per cent) than the baseline scenario. Those who choose to live close to the CBD benefit mostly from larger dwelling sizes and reduced housing costs. Those who live closer to the city boundary predominantly benefit from the lower transport costs.

[14] For modelling purpose, this paper assumes a liner relationship between the amount of work done at workplaces and the need to travel to workplaces/transport costs. It is possible that the link between the two is not linear in reality. For example, a slight reduction of work done at workplaces might not be enough to trigger a change in travel patterns for some workers. On the other hand, some workers might elect to "cram" more work into longer days for those days at workplaces, so they can have more time to do personal tasks on days working remotely during the week, and therefore reducing their travel needs disproportionally more than the change in the amount of work done remotely.

15 These average measures are all weighed by number of households

Scenario's B - Restricted floor space ratio (FSRs) scenarios

Chart 5: Effects an FSR restriction



The baseline scenario assumes residential building density[16] is unconstrained and determined through a market price equilibrium. An exogenous limit on density can be introduced to the model to reflect a wide range of more realistic zoning restrictions placed on the usage of Sydney's land.[17] This paper applies a Floor Space Ratio (FSR) restriction of 2, which is roughly the weighted average FSR of SA2s within a 5km radius to the CBD and corresponds approximately to a limit of two to three stories[18] on average in an area (an example being Redfern-Chippendale[19]). While significantly lower than the FSR value generated under the unconstrained scenario, this FSR value is a reasonable representation of housing dwelling density cap in Greater Sydney (Box 2).

The impact of an FSR restriction on the unconstrained equilibrium is shown in Chart 5. With a higher proportion of Greater Sydney's population unable to live in higher-density housing close to the CBD relative to the unconstrained baseline scenario, more households move closer to the city boundary.

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16 This paper considers density to be presented by a uniform measure for the purpose of modelling. Floor-to-space ratios or FSRs, being the most common zoning restriction used in Greater Sydney, is chosen to be the measure of building density. In reality there are a range of building density measures in Greater Sydney including FSRs, building heights and setbacks, and measures are often combined concurrently to form a suite of planning guidelines.

17 See Kulish, Richards and Gillitzer (2012) for details of how the model is solved under an FSR restriction.

18 There are a range of building envelopes or typologies that could be represent of an FSR value of 2. For example, in an area where the entire block of land can be utilised, as FSR of 2 would allow buildings with 2 storeys. In areas with significant setbacks and only a third of the land blocks can be built on, an FSR value could allow buildings with 6 storeys or more.

19 Statistical Area level 2, for a more detailed definition see Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas, July 2016, ABS

Under this scenario, the Greater Sydney city size increases from a radius of 46km to 61km. Resulting from a reduction in supply of housing close to the CBD, unit housing costs are higher at all distances from the CBD and dwelling sizes are smaller at all distances. Land costs are significantly reduced, compared to the baseline for properties close to the CBD as developers cannot maximise the building heights to match demand. Land then gradually becomes more expensive in the middle and outer suburbs relative to the baseline, as there is increased demand in these areas from people who would have otherwise been living closer to the CBD.

The overall impacts of this scenario include higher average household transport costs (+43 per cent), smaller dwellings sizes due to less high rises (-30 per cent), higher unit housing costs (+58 per cent), and lower land costs (-15 per cent). As explained in Box 2, an unconstrained scenario in the baseline is unlikely to reflect reality due to a variety of factors. Scenario B seems more representative of Greater Sydney given the reality of supply constraints. Scenario B will be used as the comparison benchmark for the next two scenarios.

Box 2: Dwelling densities in Greater Sydney

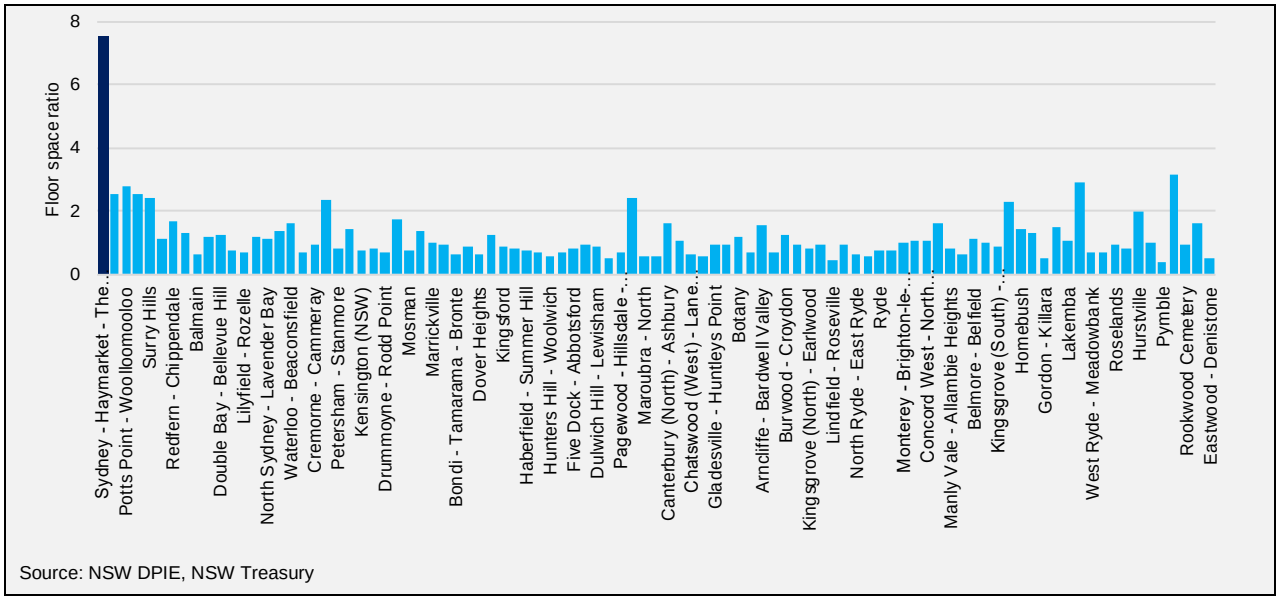
The Alonso-Muth-Mills model is a stylized model that focuses on households adjusting to varying urban structures to maximize their welfare. The model assumes a single center for employment and only residential buildings in the rings surrounding that center. The large discrepancy between modelled FSR output and the actual FSR data used in this paper is likely to reflect several factors.

This paper examined the combined zone FSR by SA2 areas provided by the NSW Department of Planning, Industry and Environment rather than residential zone FSR. This more accurately reflects the increasing popularity of mix-use buildings in recent years, which often include commercial floors at the bottom of the building and residential units on top. Therefore, a strictly defined residential zone FSR no longer effectively accounts for housing dwelling density in an area. A combined zone FSR also includes other commercial and non-residential building types, such as; low-rise shops, warehouses, schools and hospitals. These buildings generally have very low FSR values (<1), and therefore lower the average FSR in an area. It can also be viewed that those commercial and community amenity zones are a necessity for surrounding residential buildings and are therefore part of a “total package” in an area.

Greater Sydney also has many suburban centers which serve as “mini-CBDs” to surrounding suburbs, acting as hubs for commercial activity and employment (Chart 6). Subsequently, these suburban centers attract households to live close to them and divert the pressure away from living close to the Sydney CBD. The FSR data used in this paper also excludes so called “spot rezoning” buildings, where a site is approved for increased building heights beyond what is allowed for that zone in the local environmental plan. As a result, the actual building density- particularly in those areas that are close to the CBD and suburban centers-could be much higher than represented by the FSR data.

The model used in this paper assumes households maximize welfare through homogenous housing and a bundle of other non-housing consumption goods. In reality, households value additional factors outside of those modelled in determining their welfare. These factors include proximity to the natural environment, population density of the area they live in and other community characteristics.

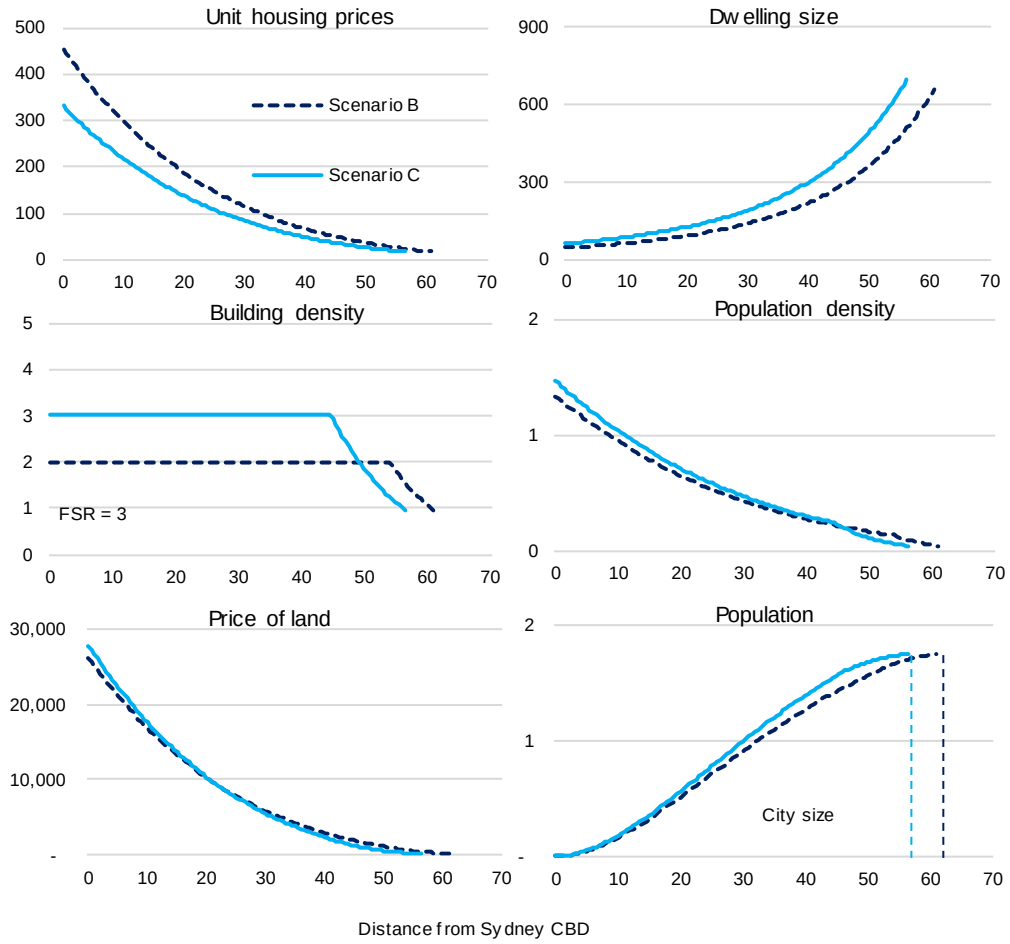
Chart 6: Floor Space Ratio restriction by SA2 within 15km from Sydney CBD



Source: NSW DPIE, NSW Treasury

Scenario C – A relaxed FSR scenario

Chart 7: Effects of relaxing the FSR restriction from 2 to 3

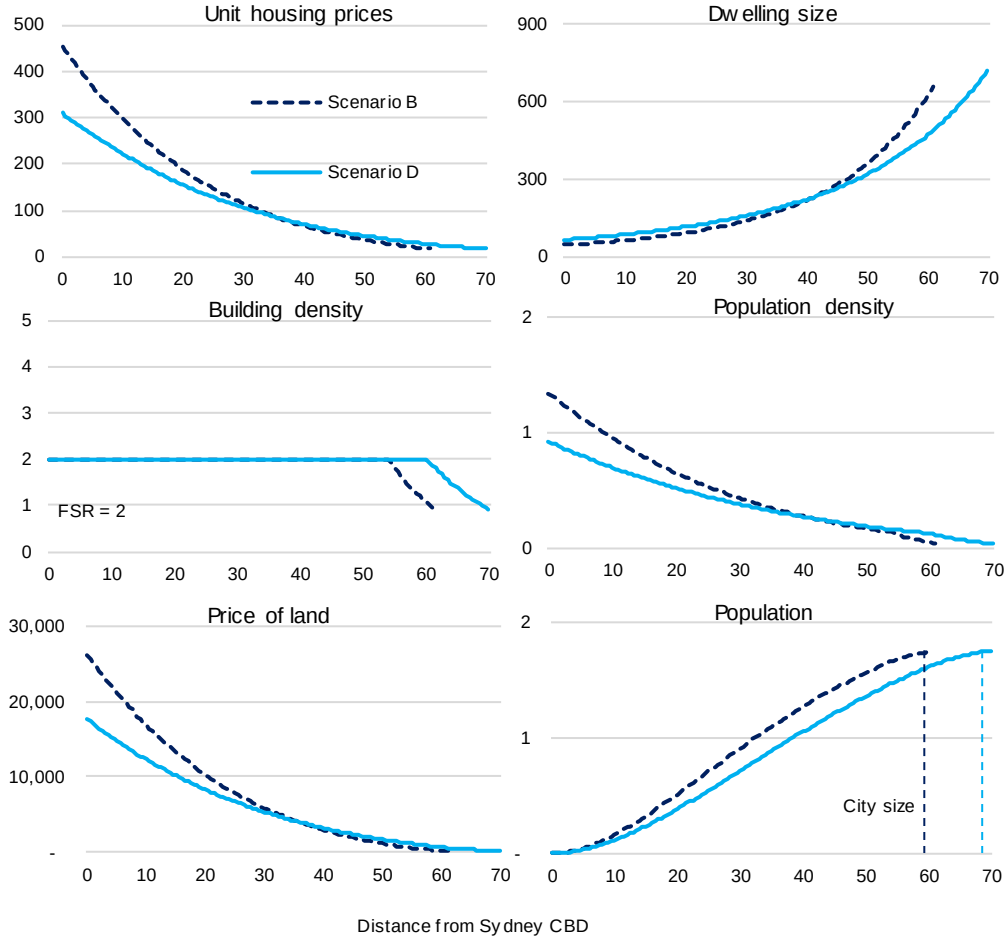


Scenario C examines the impact on the equilibrium of relaxing the current average FSR restrictions from a ratio of 2 to 3 (Chart 7). This corresponds to approximately three to four stories on average in each area of Greater Sydney (for example, Homebush Bay-Silverwater). This increase in building density results in an increase in the number of households living closer to the CBD and a slight increase in the price of land closer to the CBD, as developers can build more apartments per square meter of land. As a result, unit housing costs decrease, and dwelling sizes increase relative to those in Scenario B (measured in percentile distances from the CBD). Compared to Scenario B, households, on average, face lower unit housing costs (-18 per cent), live in larger dwellings (+14 per cent) and incur lower transport costs (-7 per cent). Land costs are 5 per cent higher, with most of the increase occurring close to the CBD. Households also require 4.6 per cent less income to achieve the same level of welfare as in scenario B. In summary, households gain around 5 per cent extra discretionary income with higher density and an equivalent increase in their welfare.

Scenario D – reduced transport costs and higher FSR combined scenario

The final scenario combines Scenario's A and B to model the hypothetical impact of a structural shift towards remote working on Sydney's households using more realistic housing density constraints than the Baseline Scenario (Chart 8). The reduced need for CBD travel results in further incentives for households to live further away from the CBD. The city size is the largest of all scenarios, with Greater Sydney's radius increasing to 70km (roughly the distance between Sydney CBD and Central Coast). The outcomes on the remaining variables are comparable to those discussed in Scenario B. On average, households in this scenario face lower unit housing costs (-22 per cent), live in larger dwellings (+20 per cent), incur lower transport costs (-8 per cent), and lower land costs (- 28 per cent) compared Scenario B. Households require 5.6 per cent less income to achieve the same level of welfare as in scenario B. These shifts are also similar to the results from a recent paper by the Centre of Policy Studies at Victoria University (Lennox 2020).

Chart 8: Effects of combined lower transport costs and FSR restriction



Conclusion

This paper argues that a shift towards remote working, as seen during COVID-19, could result in; a decrease in average household transport costs, an easing of housing cost burdens, an increase in the demand for living further away from the Sydney CBD, and an improvement in the total State welfare. This change in Sydney's urban structure would have implications for the planning of NSW public transport system and social infrastructure over the long term.

The modelling in this paper also suggests that more relaxed urban planning restrictions could lead to greater density, particularly in Sydney's inner suburbs. When modelled with the first scenario of an increase in remote working, the eased planning restrictions partially offset the urban expansion, reduce housing costs and increase total State welfare. For example, an increase in Sydney's average FSR (a measure of building density) from 2 (currently reflective of buildings within a 5km radius to Sydney's CBD) to 3, could reduce average house prices by almost 20 per cent. It could also increase land values (particularly in areas near the CBD) and lower transport costs, resulting in an increase in discretionary household incomes of around 5 per cent.

The analysis in this paper is limited to the inputs modelled in this static Alonso-Muth-Mills model and the associated outcomes. While the model has been specified to represent a model of Sydney, it does not consider several of Sydney's unique characteristics that impact house prices, travel costs and location decisions. Nor does the modelling reflect the complexity of the decision-making process on where people choose to locate. However, the scenarios discussed in this paper reinforce the value of appropriate planning regulations and highlight the potential impact of a structural shift towards remote working on Sydney's urban design and total State welfare.

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Appendix A

Table 1: Calibration

Description	Value
Income ($/year)	115,000
Utility function - Expenditure share on housing	0.176
Housing production function parameter on structures	0.6
Scaling on housing production function	0.0005
Price of capital	0.02
Transport costs ($/year/km)	825
Radians available for construction	3
Agriculture land rent ($/km2/year)	200,000
Population (number of households)	1,750,000

Following (Kulish, Richards & Gillitzer, 2012), table 1 summarises the benchmark calibration. In 2017-18, mean household disposable income per week in Greater Sydney was $2,214 (Household Income and Wealth, Australia 2017-18, ABS). This implies an annual income rounded to $115,000. By June 2018, population in Greater Sydney[20] is estimated to be around 4.9 million (ABS.Stat Estimated Resident Population by SA2 and above, 2001 onwards, ABS). The 2016 Census reported an average people per dwelling of 2.8 in Greater Sydney (2016 Census, ABS). Together they imply around 1.75 million households in Greater Sydney.

Agricultural land rent is calculated by as a weighted average of farmland rental values in those Local Government Areas that are defined as “Metropolitan Fringe" by Revenue NSW.

This paper assumes 1.5 workers per households and 40-hour work per week, so hourly wage is $ 35.89. In line with Kulish et. al. (2012), commute time is valued at 60 per cent of the hourly wage rate, and peak time traffic into/away from Sydney CBD on major roads is 43 km/h (Key roads performance report, June 2019, NSW RMS). The time cost of commuting is $0.49/km per worker. According to the ATO, the reimbursement rate of car operating cost for 2017-18 was $0.66/km. Together, this means the transport cost is $1.15/km per worker. Grossing up by the number of workers per household (1.5) and number of trips per year (240 workdays per year), total commuting cost is $828/km per household per year, which is rounded to $825 in this paper.

[20] Excluding Central coast SA4

Further information and contacts

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