INFRASTRUCTURE VICTORIA

Technical report

The post-pandemic commute

The effects of more working from home in Victoria

November 2021

Acknowledgements

Infrastructure Victoria acknowledges the traditional owners of country in Victoria and pays respect to their elders past and present, as well as elders of other Aboriginal communities. We recognise that the state's infrastructure is built on land that has been managed by Aboriginal people for millennia.

This paper uses unit record data from Household, Income and Labour Dynamics in Australia Survey (HILDA) conducted by the Australian Government Department of Social Services (DSS). The findings and views reported in this paper, however, are those of the author and should not be attributed to the Australian Government, DSS, or any of DSS' contractors or partners.

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1. Introduction

This technical report provides detail on our modelling of the shift to working from home.

The rapid shift to working from home was one of the most apparent impacts of the COVID-19 pandemic and the subsequent public health response. This report explores the possibility this shift may persist into the medium-term, 10 to 20 years from now. We modelled scenarios illustrating a range of possible outcomes for Victoria's urban form and travel patterns, triggered by a shift to more working from home. Our modelling results, combined with previous analysis and policy development, allow us to explore the implications for policy and make recommendations for the Victorian Government to consider.

Our report *The post-pandemic commute* focusses on the headline modelling results and policy implications. This technical report complements the post-pandemic commute report, setting out the modelling context, method, and results in detail.

The 'Working from home and COVID-19' chapter details the types of work suitable to be done from home, the extent of working from home prior to COVID-19, the digital technologies which enable working from home, and expectations for working from home into the future.

The 'Integrated economic and transport modelling' chapter outlines our chosen model, the Victorian Land Use and Transport Integration (VLUTI) model. We summarise the VLUTI modelling framework, some key parameters and standard outputs, and the base case scenario. This chapter also details how we developed the inputs to shock VLUTI with working from home scenarios.

The 'Working from home changes land use and transport patterns' chapter presents detailed VLUTI modelling outputs. We present modelling results on the impacts on the spatial distribution of employment and population in 2036. We also present the implications for people's transport movements, detailed transport metrics, and the modelled impact on economic indicators such as gross local product and wages.

2. Working from home and COVID-19

This chapter provides background and context on working from home and COVID-19. We cover the types of work suitable to be performed from home, the extent of working from home prior to COVID-19, the digital technologies which enable working from home, and expectations for working from home into the future.

2.1 Working from home is better suited to some types of work

In this report, we characterise 'working from home', or teleworking, as employment which can be feasibly done from a worker's place of residence, enabled by digital technologies, in office-based occupations and industries. This excludes, for example, farmers who may be technically working from a property where their residence is also located, but are not teleworking.

The duties performed in some occupations and industries are better suited to working from home. For instance, an IT professional might easily work from home, as they may only require a desk, chair, computer, and an internet connection, and do not need to work on site. In contrast, a construction worker needs to be physically on site to perform their duties and cannot undertake their work from home. Around a third of jobs in Victoria have the potential to be worked from home.[1]

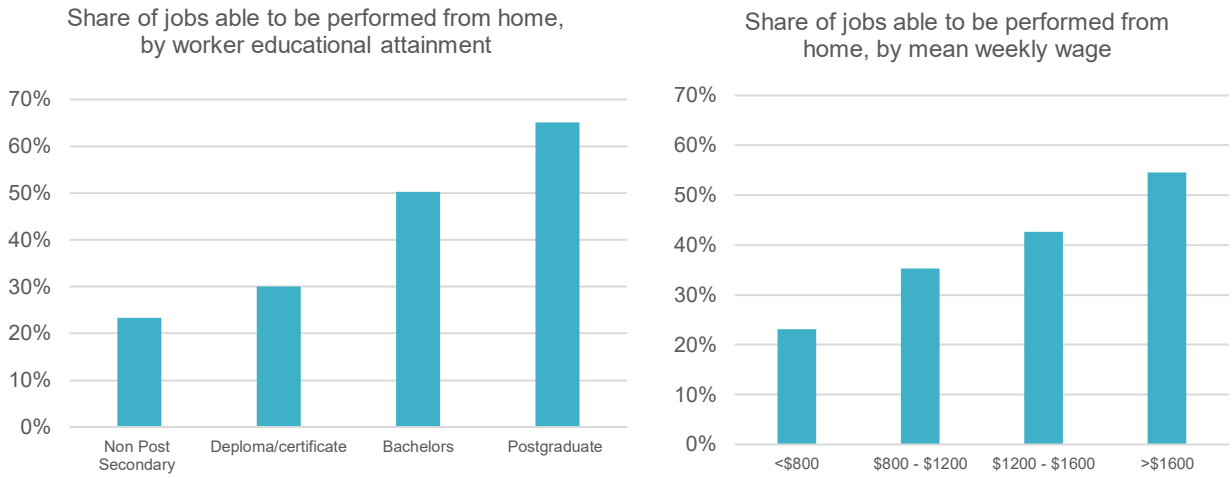
We limited our modelling of greater working from home to occupations that can be feasibly performed from home (defined in section 3.6.1). As shown in Figure 1, these tend to be industries with workers with high educational attainment and high incomes. Typically, 'knowledge-intensive' industries are well suited to working from home because they rely on human capital, rather than physical capital. These industries are commonly located in physical clusters, such as central business districts. Knowledge-intensive industries include: [2]

- information media and telecommunications
- financial and insurance services
- rental, hiring and real estate services
- professional, scientific and technical services
- administrative and support services
- public administration and safety.

[1] *Infrastructure Victoria adaptation of method in Coates, Brendan, Matt Cowgill, Tony Chen and Will Mackey, Shutdown: estimating the COVID-19 employment shock, 2020, Grattan Institute*

[2] *SGS Economics and Planning Pty Ltd, Melbourne Functional Economic Region Report, 2019, prepared for Infrastructure Victoria, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/SGS-Melbourne-Functional-Economic-Region-Report-March-2019.pdf*

Figure 1. Share of jobs able to be performed from home, by worker education and mean wage, Australia

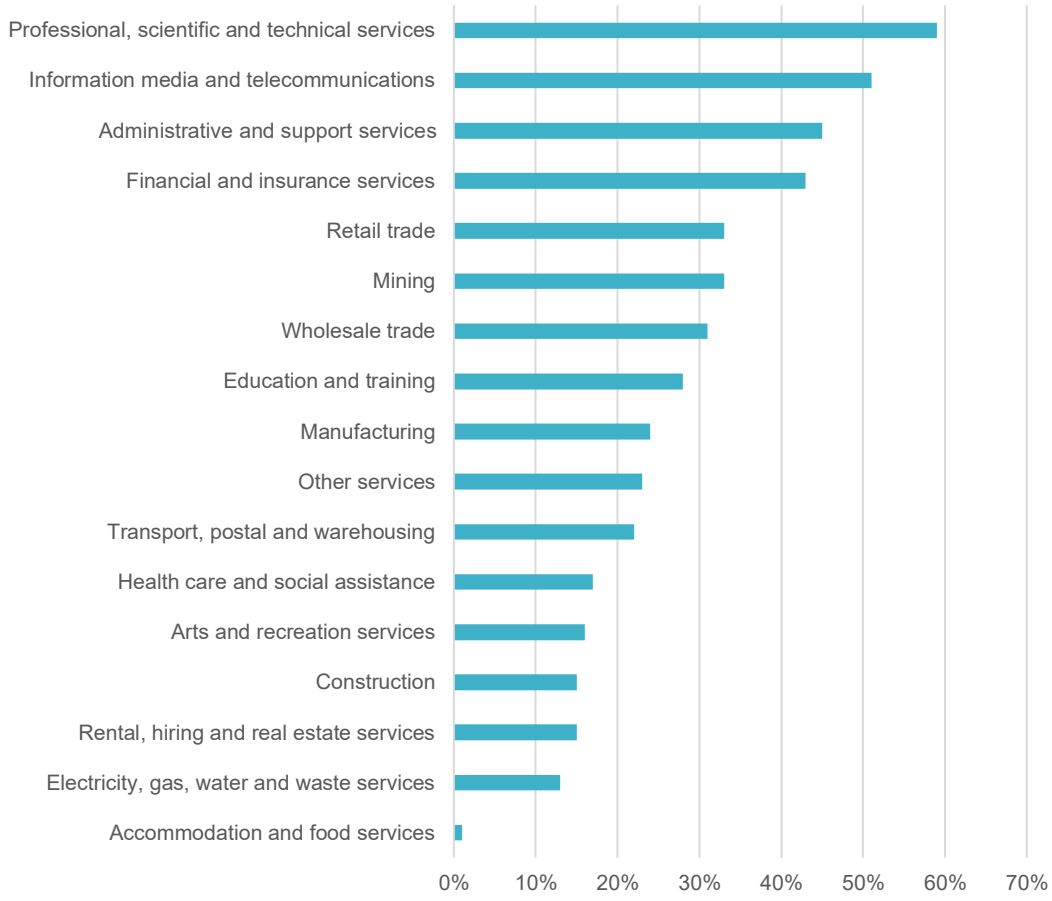


Source: Infrastructure Victoria analysis of Department of Social Services (DSS), Household, Income and Labour Dynamics in Australia Survey, 2021.

In Australia, the industries with the highest proportion of businesses with at least one employee teleworking immediately prior to the pandemic were all office-based and knowledge-intensive, including professional, scientific and technical services, and information media and telecommunications. Industries which are not well suited to working from home typically require physical interactions between people and/or specialised equipment. As shown in Figure 2, the industries with the lowest teleworking shares of businesses were accommodation and food services, and electricity, and gas, water and waste services.[3]

[3] *Australian Bureau of Statistics (ABS), Business Indicators, Business Impacts of COVID-19, September 2020, ABS, 2020, https://www.abs.gov.au/statistics/economy/business-indicators/business-conditions-and-sentiments/sep-2020#teleworking-and-expected-changes-to-working-hours'*

Figure 2. Proportion of businesses with any employees teleworking, prior to COVID-19, Australia



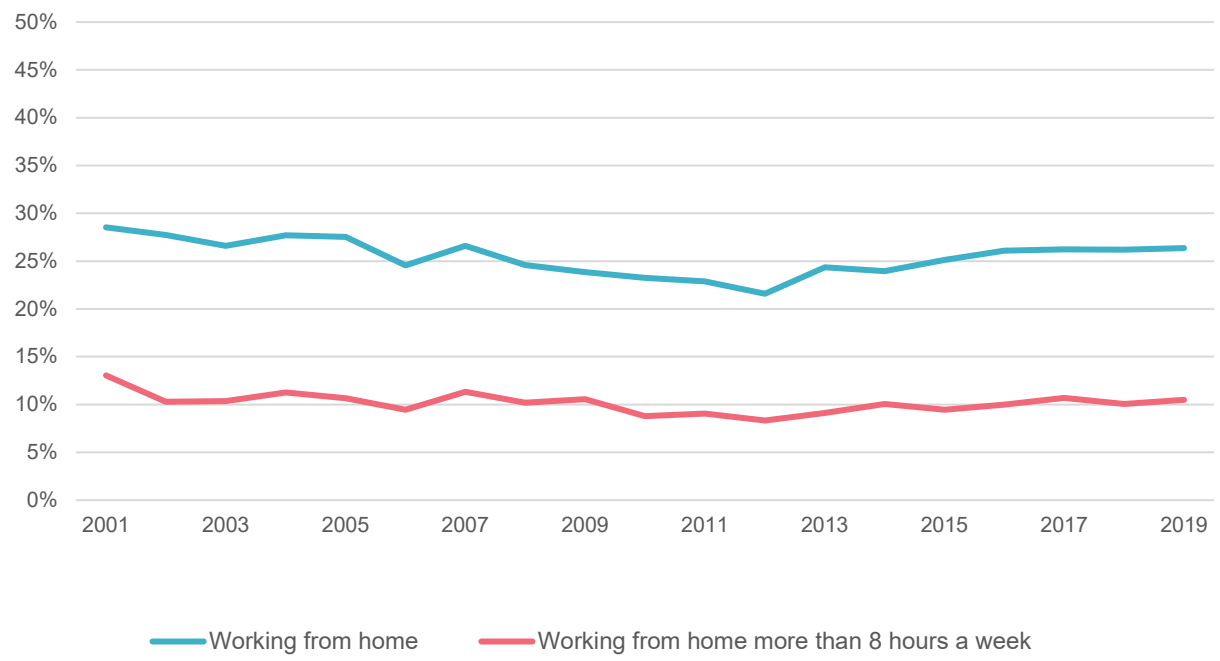
Source: ABS, Business Indicators, Business Impacts of COVID-19, September 2020

Further detail on the method we used to determine the suitability of jobs to working from home for modelling purposes is at section 3.6.1.

2.2 Working from home was stable prior to COVID-19

Prior to COVID-19, the proportion of Victorians regularly working from home had been relatively stable for the past two decades. Around 25% of Victorian workers did at least some work from home in a typical work week, and around 10% worked at least eight hours from home in a typical work week. This is illustrated in Figure 3.

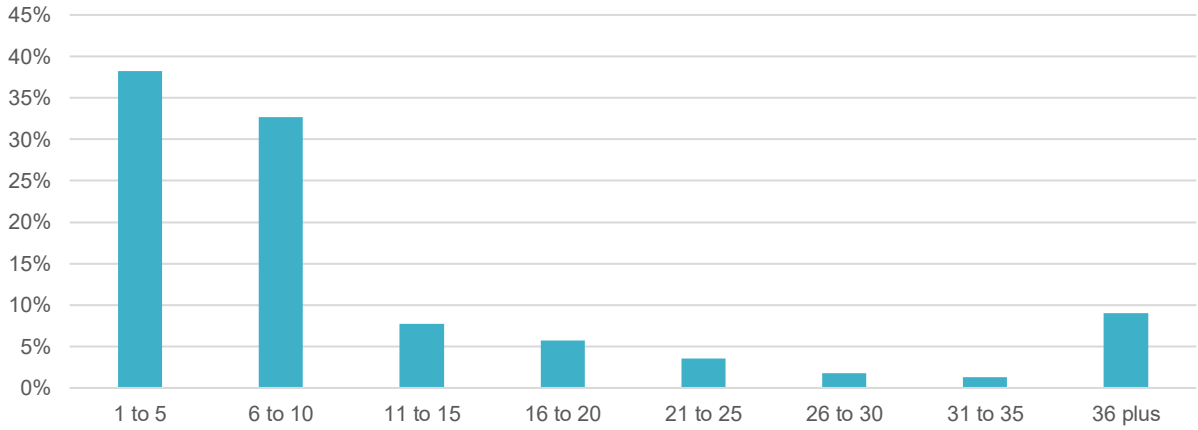
Figure 3. Proportion of Victorian workers working from home



Source: Infrastructure Victoria analysis of Department of Social Services (DSS), Household, Income and Labour Dynamics in Australia (HILDA) Survey, 2021.
Note: Working from home classified as working at least one hour from home in a typical work week.

Figure 4 shows the distribution of hours worked from home in a typical work week for a full-time worker. The most common number of hours worked from home is between one and five hours a week. This suggests that prior to the pandemic, working from home may not mean avoiding a commute to an office. For example, people may have finished off work at home in the evening, after having worked in the office during the day. On average, in occupations suited to teleworking, HILDA and Census data shows people worked around 8% of total hours from home during a week, or almost half a day per week on average for a full-time worker.[4]

Figure 4. Distribution of hours worked from home in a typical work week for a full-time worker, 2019, Victoria



Source: Infrastructure Victoria analysis of Department of Social Services (DSS), Household, Income and Labour Dynamics in Australia Survey, 2021.
Note: Limited to occupations that are well suited to working from home as defined in in section 3.6.1. Non-zero hours only. Working 38 hours or more a week.

[4] *Infrastructure Victoria analysis of Melbourne Institute of Applied Economic & Social Research, Household, Income and Labour Dynamics in Australia (HILDA), 2021, prepared for Department of Social Services (DSS), Australian Government; Australian Bureau of Statistics, Census of Population and Housing: Method of Travel to Work, 2016 (data for Victorians)*

By analysing HILDA data, we also found that before COVID-19, people working from home were more likely to live in dispersed locations, farther from the central city. This implies that working from home can influence the location people choose to live, and that historically people working from home have chosen to live in more dispersed locations. This finding supports our modelling framework and the results of our modelling. Further detail on this analysis is in the Appendix of this report.

2.3 COVID-19 resulted in rapid uptake of working from home and the associated technology

The proportion of people working from home in Victoria increased from an historically stable 10% to 15% of workers prior to the pandemic to around 50% of workers in September 2020.[5]

While the proportion of people working from home was stable over previous decades, digital technology has advanced materially. Enabling infrastructure, such as reliable fast internet, and tools for online collaboration and communication, mean many routine office tasks could have been performed remotely for some time.[6]

Despite the available enabling technology existing prior to COVID-19, organisations faced substantial barriers to implementing working from home. These include the direct upfront costs of adopting new technology and its accompanying disruption and resistance. Incumbent organisational practices can have substantial inertia, and management and staff can both resist change, even if better options theoretically exist.[7]

The global pandemic and public health response, comprising stay at home orders and mandatory working from home (for those who can), as well as the availability of necessary digital tools, suddenly meant working from home became widespread in 2020.[8] Employers rapidly took up remote work technologies across the globe. For example, in December 2019, video conferencing software Zoom had an average 10 million daily meeting participants. This rose to more than 300 million in April 2020, a 30-fold increase.[9] Similarly, users of Microsoft's collaboration software, Teams, increased from 20 million in 2019, to 75 million in 2020, to 145 million by mid-2021.[10] Microsoft reported that two years of digital transformation occurred in just two months.[11]

2.4 Working from home could persist in the medium-term

Disruption and adaption have accelerated the shift to working from home in the short-term. Elements of this shift could persist into the medium-term, but there may be differences in the way employers implement it.

Employers are already starting to change their approach to work location following the pandemic. Some have decided to leave office-based work behind. For example, Australian software company Atlassian has embraced working from home for its 5,700 global staff. Atlassian already had permissive remote working policies prior to COVID-19, and the pandemic spurred their new 'TeamAnywhere' policy. This permits staff to work anywhere in the world, and only require them to attend an office around four times a year for workshop events. Acknowledging that some employees nevertheless benefit from working and collaborating in the office, Atlassian will still maintain physical offices.[12] Other large employers, such as Deloitte Australia and Telstra, are shifting to more remote working by allowing staff to choose their location and approach to work.[13]

[5] *Australian Bureau of Statistics (ABS) Household Impacts of COVID-19 Survey, September 2020, ABS*

[6] *Davis, Morris A., Andra C. Ghent, and Jesse M. Gregory, The Work-from-Home Technology Boon and its Consequences. No. W28461., 2021, National Bureau of Economic Research, https://www.nber.org/system/files/working_papers/w28461/w28461.pdf*

[7] *Vilhelmson, Bertil, and Eva Thulin, Who and where are the flexible workers? Exploring the current diffusion of telework in Sweden, 2016, New Technology, Work and Employment 31, no. 1, https://www.gu.se/sites/default/files/2020-05/Vilhelmson%20%26%20Thulin%202016.pdf*

[8] *McKinsey & Company, How COVID-19 has pushed companies over the technology tipping point—and transformed business forever, 2020, McKinsey & Company, https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever*

[9] *Shannon Bond, A Pandemic Winner: How Zoom Beat Tech Giants To Dominate Video Chat, 2020, NPR, https://www.npr.org/2021/03/19/978393310/a-pandemic-winner-how-zoom-beat-tech-giants-to-dominate-video-chat*

[10] *David Curry, Microsoft Teams Revenue and Usage Statistics, 2021, Business of Apps, https://www.businessofapps.com/data/microsoft-teams-statistics/*

[11] *Jared Spataro, 2 years of digital transformation in 2 months, 2020, Microsoft 365, https://www.microsoft.com/en-us/microsoft-365/blog/2020/04/30/2-years-digital-transformation-2-months/*

[12] *Bianca Healey, Atlassian says staff can limit days in the office to only four a year, 2021, Australian Financial Review, https://www.afr.com/work-and-careers/workplace/atlassian-says-staff-can-come-into-the-office-only-four-times-a-year-20210430-p57npd*

[13] *Tess Bennett, Deloitte to allow all staff to decide where and when they work, 2021, Australian Financial Review, https://www.afr.com/work-and-careers/careers/deloitte-to-allow-all-staff-to-decide-where-and-when-they-work-20210629-p5859t*

In other cases, employers have vowed to require staff to return to the office full time. For example, the City of Melbourne, has committed to requiring 100% of its 1600-strong workforce return to on-site work.[14] US banks JPMorgan and Goldman Sachs are also requiring staff to return to offices.[15]

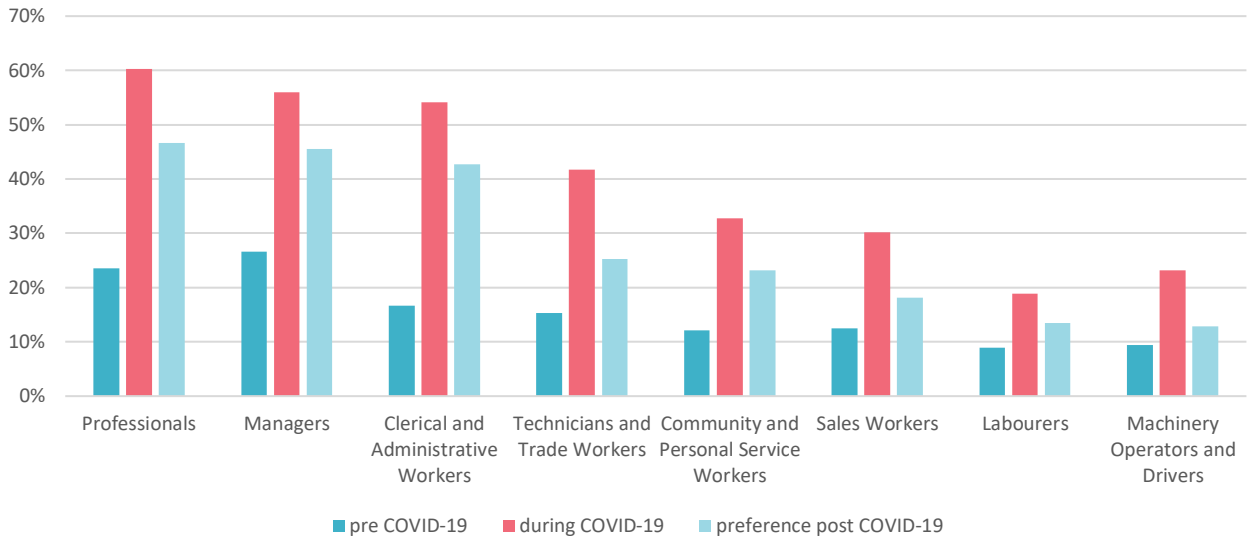
Despite this range of approaches, businesses generally expect more working from home once restrictions ease. Four in five Australian businesses which had staff teleworking during the pandemic expect to continue to have staff teleworking long-term.[16] Similarly, around 76% of Australian managers responding to one survey expected their staff would work from home more often after COVID-19, compared to before the pandemic.[17]

From an employee perspective, a global study (including Australia) from early 2021 found that 70% of employees want flexible remote work options to continue, while 65% are also craving more in-person time with their teams.[18] This signals a desire for the hybrid approach of shared work from home and the office.

In Victoria, of respondents to a 2020 survey who had worked remotely since COVID-19, 70% reported that remote working has benefitted their lifestyle outside work, and 71% said that it benefitted their work life.[19] Consequently, most workers had a preference for more working from home following the pandemic. Figure 5 shows this breakdown of work from home intentions by occupation. It shows that professionals, managers, and clerical and administrative workers prefer higher rates of working from home, compared to pre-COVID-19.

These findings indicate many people would like to continue working from home to some degree following the pandemic and the easing of restrictions, and that employers expect more staff to work from home more often.

Figure 5. Percent of work days worked from home by occupation, Victoria 2020



Source: Nitish Kumar, and Pugh, Nigel for Department of Jobs, Precincts and Regions, Victoria work from home survey, 2020

[14] *City of Melbourne, City of Melbourne staff to return to CBD workplaces, Media release, Wednesday 24 February 2021, https://www.melbourne.vic.gov.au/news-and-media/Pages/City-of-Melbourne-staff-to-return-to-CBD-workplaces.aspx*

[15] *Jack Kelly, Wall Street Banks That Demanded Workers To Return To Their Offices May Have To Change Their Plans Due To Delta Variant, 2021, Forbes, https://www.forbes.com/sites/jackkelly/2021/08/04/wall-street-banks-that-demanded-workers-to-return-to-their-offices-may-have-to-change-their-plans-due-to-delta-variant/?sh=577888c37356*

[16] *Australian Bureau of Statistics (ABS), Business Conditions and Sentiments, April 2021, ABS, https://www.abs.gov.au/statistics/economy/business-indicators/business-conditions-and-sentiments/apr-2021#teleworking*

[17] *John Hopkins and Bardoel, Anne, Key working from home trends emerging from COVID-19, A report to the Fair Work Commission, 2020, Commonwealth of Australia, https://www.fwc.gov.au/documents/sites/clerks-work-from-home/research/am202098-research-reference-list-su-241120.pdf*

[18] *Microsoft Work Trend Index, The Next Great Disruption Is Hybrid Work—Are We Ready?, 2021, Microsoft 365, https://www.microsoft.com/en-us/worklab/work-trend-index/hybrid-work*

[19] *Nitish Kumar, and Pugh, Nigel, Victoria work from home survey, 2020, Conducted on behalf of the Department of Jobs, Precincts and Regions by Venture Insights*

3. Integrated economic and transport modelling

This chapter outlines our chosen model, the Victorian Land Use and Transport Integration (VLUTI) model. VLUTI is an innovative model which integrates transport and economic modelling and allows us to account for some of the complexities of a shift to working from home. This chapter also details the modelling base case and our method of producing the inputs to shock VLUTI with working from home scenarios.

3.1 This modelling builds on our previous work

A shift to working from home over the medium-term is of particular interest to us as it has implications for how Victorian cities are structured and how people use the transport network. We developed scenarios to model and understand the medium-term impacts of more working from home on the economy, transport, and land use outcomes. This modelling subsequently provides insight into future infrastructure use and has implications for policy.

This report builds on our previous modelling. Our previous modelling includes the *Major Transport Program Strategic Assessment*[20] report which accompanied *Victoria's Infrastructure Strategy 2021–2051*.[21] The *Major transport program* report, released in August 2021, provided our strategic assessment of six major transport projects to support recommendations in Victoria's infrastructure strategy.

In our *Major transport program* report we tested several potential future scenarios to understand the resilience of major transport projects to future uncertainty. One of these scenarios was a permanent shift to working from home for part of the week, for some workers. That scenario is replicated in this report as the medium working from home scenario. In this research, we further explore the broader implications of working from home, beyond its impact on major transport projects.

This report also follows our *Transporting Melbourne's recovery*[22] research, released in January 2021. *Transporting Melbourne's recovery* detailed short-term policy options which aimed to optimise the safety and performance of Melbourne's transport system and support economic recovery from the COVID-19 pandemic. It focused on how the transport network can handle returning travel demand and provides options to overcome crowding and congestion effects, and the health risks posed by potential local transmission of the virus.

Transporting Melbourne's recovery used the Melbourne Activity and Agent Based Model to explore the short-term transport effects of the pandemic. The timeframe considered in *Transporting Melbourne's recovery* is 2021 to 2022. This report is a natural extension, as it considers the lasting impacts of greater working from home over the medium-term.

3.2 VLUTI is well suited to modelling working from home

VLUTI is an integrated economic and transport demand model which we used to investigate the potential medium-term infrastructure and land use implications of greater working from home.

VLUTI is well suited to testing the impacts of working from home. Working from home changes the extent of commuting certain workers do, which has consequences for household and firm location decisions. These are captured by VLUTI's integration of land use and transport impacts.

VLUTI simulates interactions between land use and transport systems. The model is a composite of two established models:

[20] *Infrastructure Victoria, Major transport program strategic assessment report, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/08/Major-transport-program-strategic-assessment-report.pdf*

[21] *Infrastructure Victoria, Victoria's Infrastructure Strategy 2021-2051, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/08/1.-Victorias-infrastructure-strategy-2021-2051-Vol-1.pdf*

[22] *Infrastructure Victoria, Transporting Melbourne's Recovery, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/01/Transporting-Melbournes-Recovery-January-2021-FINAL.pdf*

1) a spatial computable general equilibrium economic (SCGE) model that incorporates land use, developed by Victoria University in collaboration with Infrastructure Victoria; and

2) the Victorian Integrated Transport Model (VITM) developed by Victorian Department of Transport.

The VLUTI process involves passing information between the two models through iterations which allows the integration of land-use and transport demand modelling elements.

3.2.1 The economic and land use model allows for spatial analysis of population and employment

Victoria University's spatial computable general equilibrium model—the *Spatial Interactions within and between Regions and Cities in Victoria* (SIRCV) model—is used to make a preliminary assessment of the impacts of working from home. SIRCV simulates two core sets of economic agents (households and firms) and two additional agents (government and foreign market) that interact with the core sets of economic agents.

The spatial resolution of the SIRCV model is at Statistical Area Level 2 (SA2) of the Australian Bureau of Statistics' (ABS) Australian Statistical Geography Standard 2016, throughout Victoria. Each SA2 region represents a community that interacts together socially and economically.

3.2.2 The transport model estimates changes in travel patterns

The Victorian Integrated Transport Model (VITM) is a multi-period, multi-purpose and multi-modal strategic level transport model which consists of car, public transport, and active transport modes. VITM uses population and employment projections to examine future impacts of changes to the road and public transport networks in Victoria.

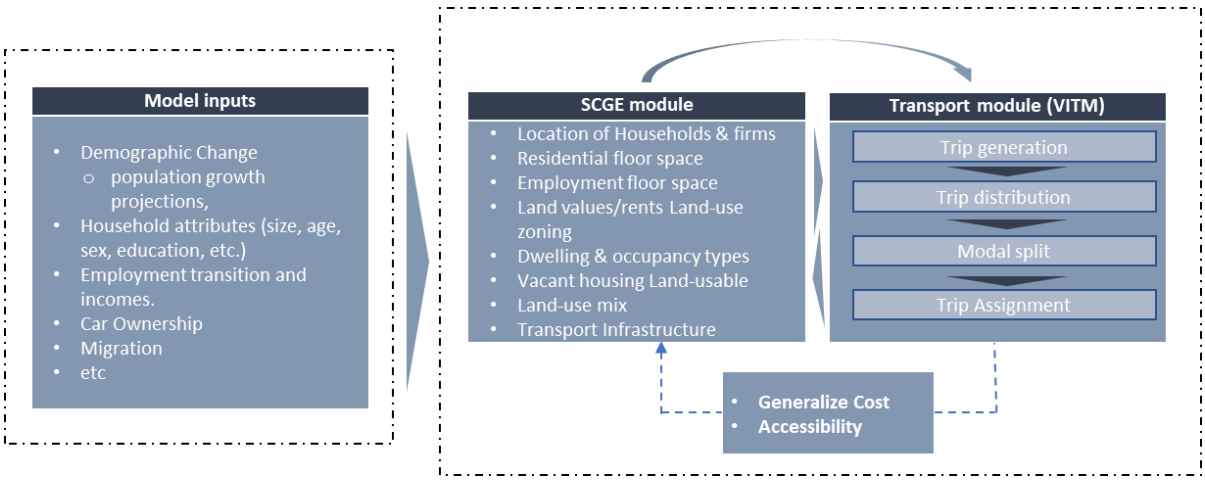
The primary inputs to VITM include model parameters, road and public transport networks, and zonal population and employment data. VITM is calibrated using data from the Victorian Integrated Survey of Travel and Activity (VISTA). VISTA is an ongoing cross-sectional household travel and activity survey conducted on behalf of the state government to understand the complex travel behaviour of individuals. In addition to VISTA data, the 2016 ABS Census data (population and employment levels and distribution) together with other demographic, economic, future land use change, and travel data (such as school enrolments; car ownership levels; household income; public transport usage; and traffic counts) were also used in the development of the VITM.

3.2.3 The economic and transport models are integrated through an iterative process

Combining the economic/land use model (SIRCV) and transport model (VITM) into a single, integrated process, and running both in sequence, provides a more realistic assessment than modelling economic and transport impacts in isolation. The integrated model provides iterative modelling of land use and transport impacts to understand the feedback mechanisms between transport changes and land use changes.

Figure 6 shows the internal structure of VLUTI. Employment and consumption of goods in the SCGE module generate workers place of residence and work data sets which form inputs for the transport module. The transport module then determines mode split and assigns trips to the transport network, returning expected travel costs to the SCGE module.

Figure 6. The internal structure of VLUTI



Source: Infrastructure Victoria, Victorian Land Use and Transport Integration model architecture report, 2021

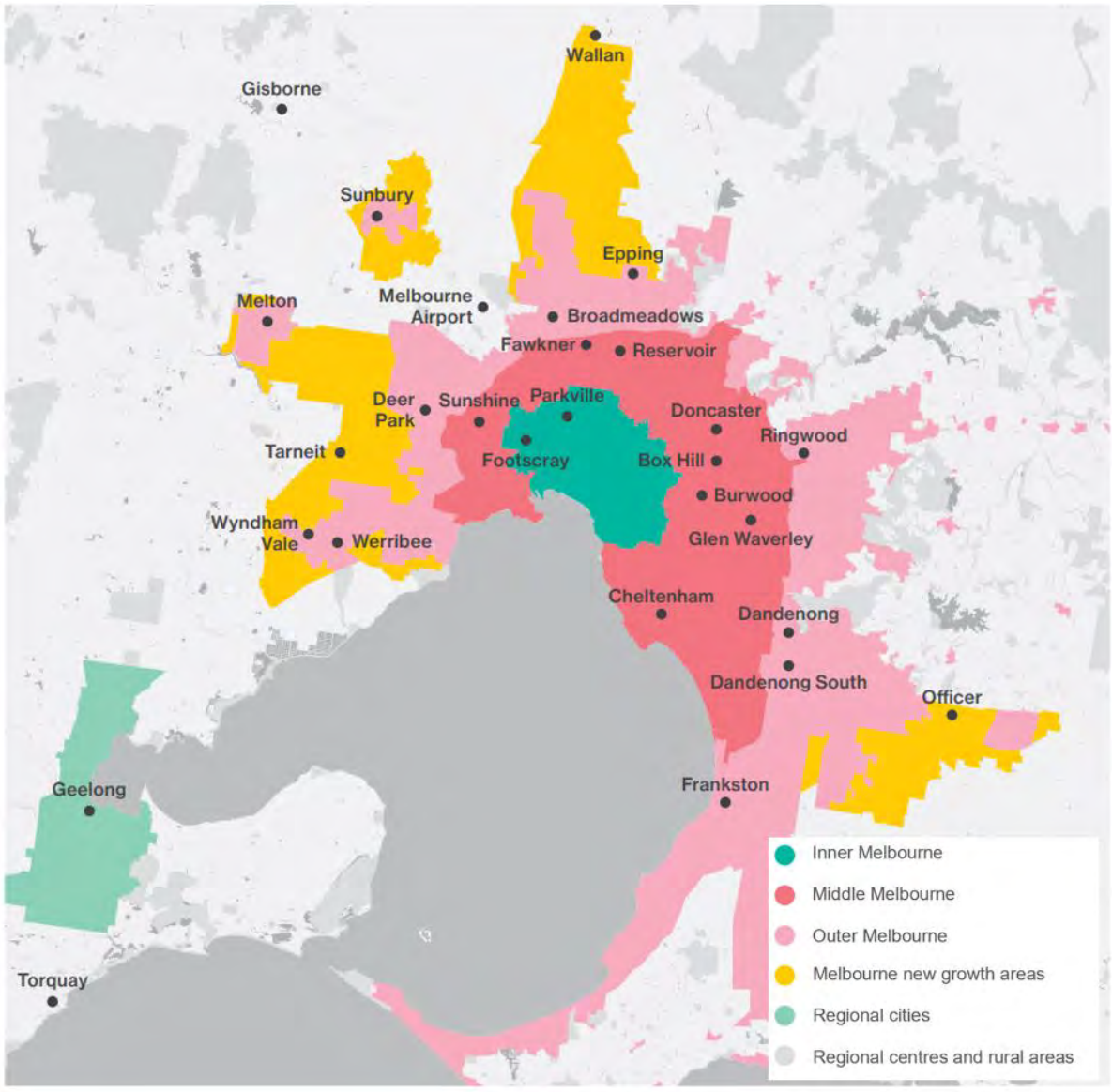
Additional detail on VLUTI is provided in our *Victorian Land Use and Transport Integration (VLUTI) model architecture report*.[23]

3.3 VLUTI has a high spatial resolution

The high spatial resolution of VLUTI allows for detailed or aggregated spatial outputs of population, employment, and transport metrics. In order to present modelling results in a way that is easy to interpret, we typically present results in aggregations: Functional Urban Areas (FUAs) and SA2s. FUAs are used for high level results, and SA2s are used for analysing particular locations.

FUAs split Victoria into six regions, defined by their proximity to Melbourne's central city. This includes inner Melbourne, middle Melbourne, and outer Melbourne. New growth areas account for current and potential areas for greenfield population growth. The regional cities FUA includes 12 cities: Ballarat, Bendigo, Geelong, Horsham, Mildura, Moe, Morwell, Greater Shepparton, Traralgon, Wangaratta, Warrnambool, and Wodonga. The regional centres and rural areas FUA covers all other areas of regional Victoria (that is, excluding the 12 cities in the regional cities FUA).

Figure 7. Functional urban areas



Source: Infrastructure Victoria, Victoria's Infrastructure Strategy 2021–2051, 2021

[23] *Infrastructure Victoria, Victorian Land Use and Transport Integration (VLUTI) model architecture report, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/08/Victorian-Land-Use-and-Tran_tion-model-architecture-report.pdf*

3.4 The modelled scenarios are compared to a base case

The modelled impacts of working from home are compared to a base case spatial distribution of population, employment, transport, and economic outcomes. We developed the base case using VLUTI for Victoria's infrastructure strategy. The base case does not consider any impacts of COVID-19.

The base case assumes that the transport network will develop and expand as the population grows to meet day-to-day travel needs, including the assumption that certain recommendations in Victoria's infrastructure strategy are implemented. This includes the development of the arterial road network and tram and bus services, including into Melbourne's outer growth areas. Projects committed by the Victorian Government to be progressively delivered, such as North East Link, Metro Tunnel Project, Suburban Rail Loop and associated rail services are part of the base case.

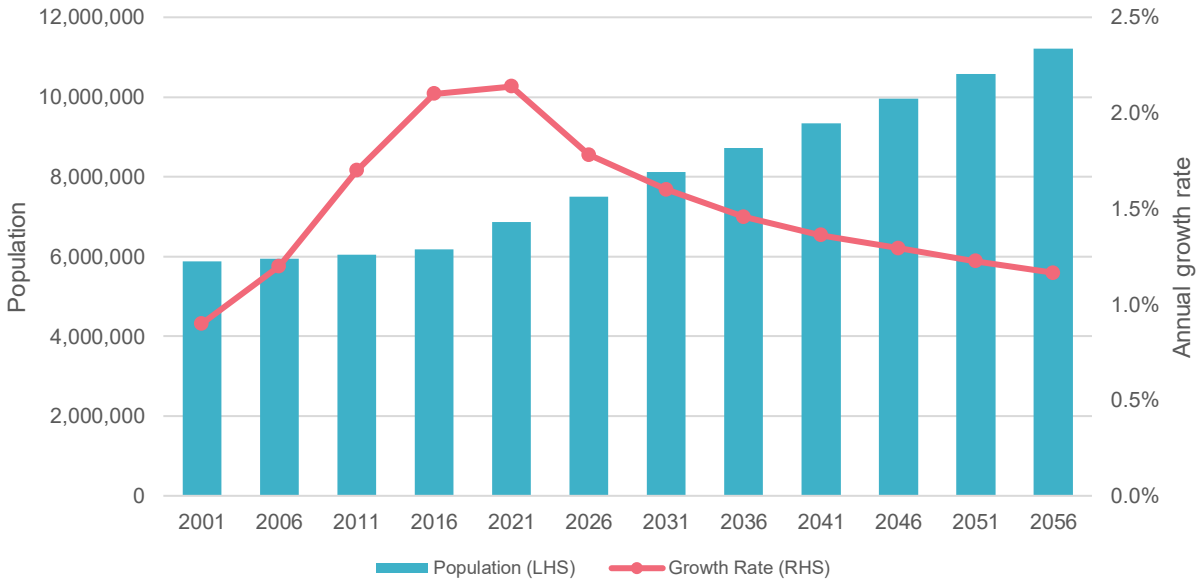
The base case uses statewide totals of population, employment, households and enrolments from the Small Area Land Use Projections (SALUP) and Victoria in Future population projections.[24] These are standard datasets used across the Victorian Government to inform strategic transport modelling assessments in Victoria.

Detail on the development and outcomes of the base case is presented in the *Strategy update assessment strategic modelling outcomes* report prepared by ARUP for Infrastructure Victoria.[25]

3.4.1 Our base case population projection has Melbourne's new growth areas as the fastest growing

Our base case population projection was prepared prior to the COVID-19 pandemic. This projection, as shown in Figure 8, has Victoria increasing from 2018 levels (the latest available population level at the time the projections were prepared) by 2.4 million people by 2036 and 4.4 million people by 2051.

Figure 8. Population projection, base case, Victoria



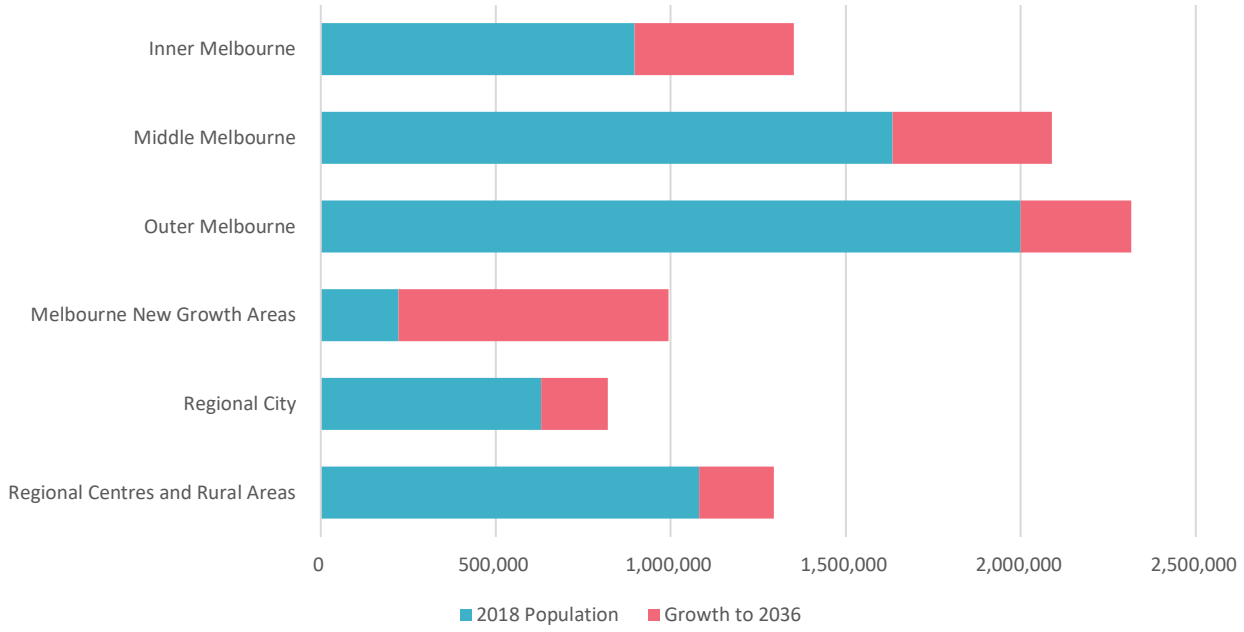
Source: Infrastructure Victoria analysis of Department of Environment, Land, Water and Planning, Victoria in Future 2019, 2019

Base case population growth in Victoria is not uniform, and some places are projected to grow faster than others. Over the next 15 years, the SALUP projects over 30% of Melbourne's population growth will occur in new growth areas in the north, west and south-east. Population growth is also projected within existing urban areas, and regional areas are also expected to grow, albeit at a lower growth rate.

[24] *SGS Economics and Planning for Department of Transport, Small Area Land Use Projections (SALUP), 2019; Department of Environment, Land, Water and Planning, Victoria in Future, 2019, Victorian Government*

[25] *ARUP for Infrastructure Victoria, Strategy Update Assessment Strategic Modelling Outcomes, 2021, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/08/ARUP-Strategic-Modelling-rastructure-strategy-2021-2051.pdf*

Figure 9. Population changes by functional urban area, base case, Victoria



Source: Infrastructure Victoria analysis of Department of Environment, Land, Water and Planning, Victoria in Future 2019, 2019

3.4.2 Our modelling focuses on working from home rather than other direct impacts of COVID-19

The COVID-19 pandemic drastically reduced migration to Australia, and subsequently reduced the nation's population growth rate in 2020. The Australian Government Centre for Population expects population growth rates to return to close to pre-pandemic levels by 2023. However, the pandemic will have a lasting impact. The Centre for Population estimates that by 2031, Australia's population will be around 4% smaller (1.1 million fewer people) than it would have been in the absence of the COVID-19 pandemic.[26]

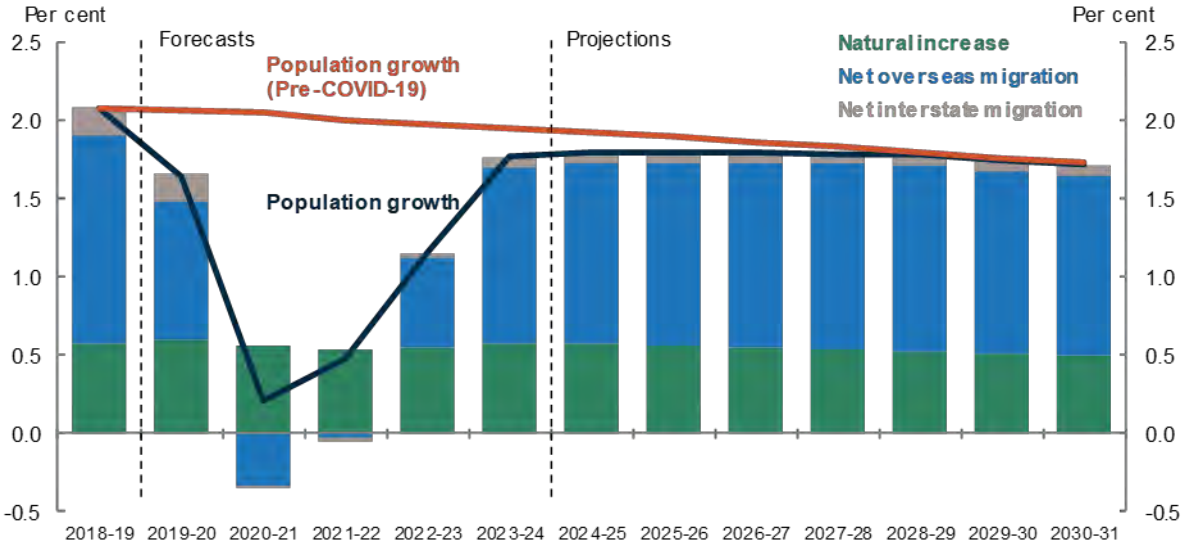
The Centre for Population forecast of population growth for Victoria, accounting for the impact of the COVID-19 pandemic, is shown in Figure 10. This highlights the impacts on short-term population growth rates between 2020 and 2022. Population growth in Victoria is projected to recover to close to what was forecast prior to the COVID-19 pandemic by 2023, faster than other states and territories.[27] The Victorian State Budget 2021-22 forecasts population growth in line with these estimates, with growth picking up from 2022 onwards.[28]

[26] *Australian Government Centre for Population, 2020 Population Statement, 2020, Commonwealth of Australia, https://population.gov.au/publications/publications-population-statement.html*

[27] *Australian Government Centre for Population, 2020 Population Statement, 2020, Commonwealth of Australia, https://population.gov.au/publications/publications-population-statement.html*

[28] *Department of Treasury and Finance, Victorian State Budget 2021-22, Budget Paper 2: Strategy and Outlook, 2021, Victorian Government, https://s3-ap-southeast-2.amazonaws.com/budgetfiles202122.budget.vic.gov.au/2021-22+State+Budget+-+Strategy+and+Outlook.pdf*

Figure 10. Projected population growth rates for Victoria, accounting for COVID-19



Source: Australian Government Centre for Population, 2020 Population Statement, 2020

These direct impacts of COVID-19 on the overall population and employment of Victoria, including changes in overseas migration, are not considered in the base case nor in the modelled scenarios.

Updated Victorian small area population and employment projections which account for the direct impact of COVID-19 were not available at the time of conducting our modelling, and VLUTI requires these inputs. This is not necessarily a deficiency, as it allows us to focus only on the impacts of greater working from home. This means the modelling outputs can be more easily understood as only one phenomenon is used to shock the model.

In any case, we expect the broad trends identified in our modelling results to be instructive of the spatial implications of more working from home, even if the overall population size of Victoria differs from that used in the model.

3.4.3 There is strong growth in health and education sectors in the base case

The base case projects an additional 1.3 million jobs by 2036, compared to today, with over 4.5 million jobs in Victoria in 2036.[29] The base case economy continues its trajectory away from traditional sectors such as manufacturing towards service sectors including health, education, and professional services.

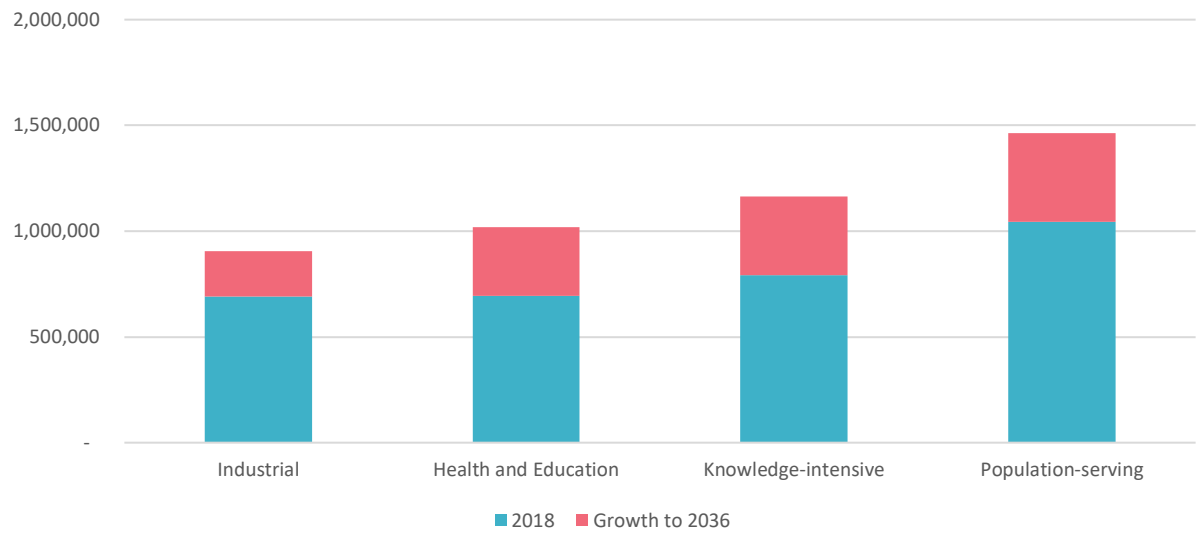
All industry sectors grow under the base case (Figure 11), with health and education projected to have the highest growth, increasing by 2.2% per year to 2036. This strong growth is driven both by the ageing population and by ongoing increased demand for health services across a range of other cohorts.

Likewise, knowledge-intensive jobs are also projected to grow strongly, at an annual average growth rate of 2.2% per year to 2036. Population serving jobs, which include industries such as construction and retail, will remain the largest employing sector, but will grow at a lower rate (1.9% per year) than knowledge-intensive jobs, and the health and education sectors. Lower growth is projected for industrial jobs, which are projected to increase by 1.5% per year to 2036.

Similar to population, the base case and modelled scenarios do not account for the direct impact of COVID-19 on total employment level. Our modelled scenarios do account for how greater working from home, as a result of COVID-19, could impact the spatial distribution of employment in Victoria.

[29] *SGS Economics and Planning for Department of Transport, Small Area Land Use Projections (SALUP), 2019; Department of Environment, Land, Water and Planning, Victoria in Future, 2019, Victorian Government*

Figure 11. Projected base case employment growth by sector Victoria



Source: Infrastructure Victoria analysis of Arup, Strategic Modelling Outcomes Report, 2021
Note: Based on aggregations of ANZSIC industries used in SGS Economics and Planning Pty Ltd, Melbourne Functional Economic Region Report, 2019
***Knowledge-intensive:** information media & telecommunications; financial & insurance services; rental, hiring & real estate services; professional, scientific & technical services; administrative & support services; public administration & safety*
***Industrial:** agriculture, forestry & fishing; mining; manufacturing; electricity, gas, water & waste; wholesale trade; transport, postal & warehousing*
***Health and Education:** education & training; health care & social assistance*
***Population-serving:** construction; retail trade; accommodation & food*

3.5 VLUTI is a tool to help understand the future and it has limitations

Modelling is a tool to help understand how changes may impact outcomes, under particular assumptions and simplifications. Modelling does not predict the future—it is subject to technical limitations and the inherent uncertainty of the future. As such, the VLUTI modelling results should be interpreted with an understanding of the strengths and weaknesses of these modelling tools, as well as the inputs used. Detail on VLUTI, including its limitations, is outlined in our *Victorian Land Use and Transport Integration (VLUTI) model architecture report*.[30]

A limitation particularly relevant to the modelling of working from home is the feature of VLUTI which represents job location where the job is based, and not necessarily where an individual is physically located while working. Changes to working from home are accounted for in the generation of transport trips which means more working from home will be reflected in less travel. However, jobs worked from home are modelled as having land use requirements based on pre-COVID-19 inputs. That is, the possible reduction in office floorspace required for an employer with staff working from home for part of the week is not accounted for in the land use model.

Given the limitations of the model and the uncertainty around how working from home will manifest in the future, it is the broad trends shown in the modelling results which are the most instructive.

[30] *Infrastructure Victoria, Victorian Land Use and Transport Integration (VLUTI) model architecture report, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/08/Victorian-Land-Use-and-Tran_tion-model-architecture-report.pdf*

3.6 Working from home scenario inputs are used to shock VLUTI

We used VLUTI to model the potential medium-term infrastructure and land use implications of increased working from home for specified occupations in Victoria. We modelled the year 2036, representing a medium-term view, 15 years into the future. However, we expect that the broad trends in the results are applicable to a more general definition of the medium-term, 10 to 20 years in the future.

At a high level, the modelling scenarios test the impact of working from home for a certain number of days a week for occupations suited to working from home. Three scenarios are tested, based on the number of additional days a week spent working from home:

- One additional day a week of working from home: low scenario (WFH low)
- Two additional days a week of working from home: medium scenario (WFH medium)
- Three additional days a week of working from home: high scenario (WFH high)

Working from home an additional two days per week in the medium scenario represents a reasonable estimate of what a typical worker who can work from home might do in the future. This is informed by surveys of those who worked from home during the pandemic that suggested people want to work from home 2-3 days per week in the future, and then accounting for the fact that pre-COVID-19, people in occupations suited to working from home already worked from home for just under half a day a week on average.[31] An Australia-wide transport opinion survey found that most Australians who worked from home wished to do so for two days per week following the pandemic,[32] and a DJPR survey suggested that on average, Victorians who worked from home during the pandemic wished to continue doing so for three days per week in the future.[33] The use of additional low and high scenarios in our modelling accounts for a range of working from home outcomes that could take place over the medium-term.

VLUTI models travel behaviour on an average week day. This implicitly assumes that people's working from home days, within the model, are spread evenly throughout a work week.

The modelled scenarios do not vary the total Victorian population or employment levels from the base case. However modelled scenarios do vary the spatial distribution of population and employment within Victoria, as well as the way the transport network is used.

The modelling inputs for the scenarios are explained in detail in the following sections.

3.6.1 Working from home is limited to particular occupations

We limited the modelling shock to VLUTI to occupations which have tasks that can be feasibly performed from home.[34]

To identify occupations which can be worked from home we adapted an Australian version of a US assessment of working from home suitability.[35] Occupations are classed as not able to be conducted at home if they involve physical activities, direct contact with the public, specialised equipment or premises, hazardous conditions, walking or running, or specialised protective safety equipment. All other occupations are assumed to be able to be conducted from home.[36]

To construct a value that can be applied to the standard Australian classification of occupations used in SIRCV (two-digit ANZSCO occupations) we aggregated the values for the more detailed four-digit occupations using Victorian occupational employment statistics from the 2016 Census as weights. As shown in Figure 12, this assigns a percentage of workers who can work from home for each two-digit ANZSCO occupation. This method finds that around 33% of workers in Victorian can work from home.

[31] *Infrastructure Victoria analysis of Melbourne Institute of Applied Economic & Social Research, Household, Income and Labour Dynamics in Australia (HILDA), 2021, prepared for Department of Social Services (DSS), Australian Government and ABS 2016 Census data.*

[32] *Institute of Transport and Logistics Studies, Transport Opinion Survey (TOPS) September 2020, 2020, The University of Sydney, https://www.sydney.edu.au/content/dam/corporate/documents/business-school/research/itls/tops-2020-sep.pdf*

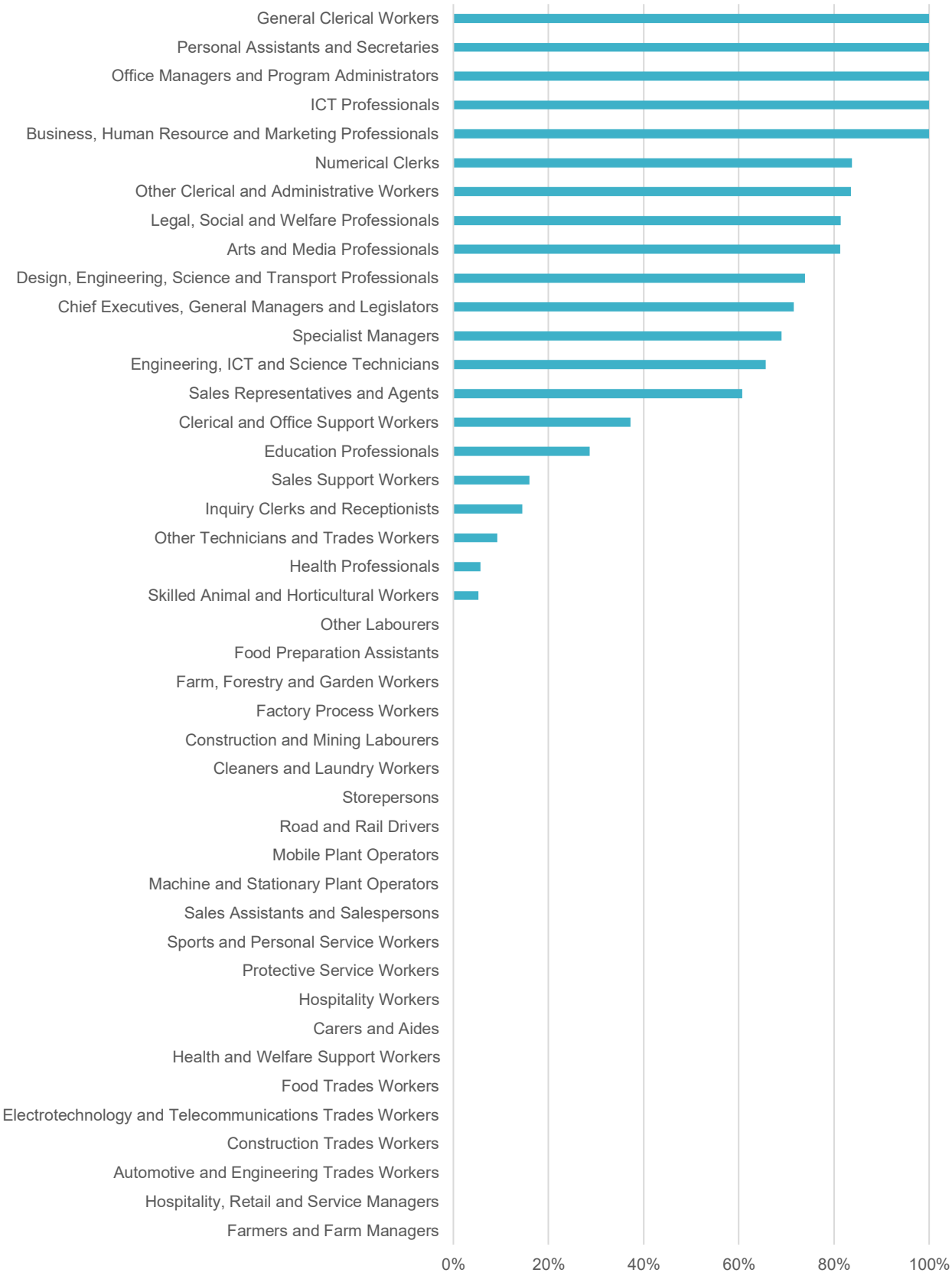
[33] *Kumar, Nitish and Nigel Pugh, Victoria work from home survey, 2020, Conducted on behalf of the Department of Jobs, Precincts and Regions by Venture Insights*

[34] *Detail on the classification of occupations used in VLUTI can be found in: Infrastructure Victoria, Victorian Land Use and Transport Integration (VLUTI) model architecture report, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/08/Victorian-Land-Use-and-Tran_tion-model-architecture-report.pdf*

[35] *Coates, Brendan, Matt Cowgill, Tony Chen and Will Mackey, Shutdown: estimating the COVID-19 employment shock, 2020, Grattan Institute, https://grattan.edu.au/wp-content/uploads/2020/04/Shutdown-estimating-the-COVID-19-employment-shock-Grattan-Institute.pdf*

[36] *Dingel, Jonathan, and Brent Neiman, How Many Jobs Can be Done at Home? 2020, Becker Friedman Institute, https://bfi.uchicago.edu/workingpaper/how-many-jobs-can-be-done-at-home/.*

Figure 12. Estimated share of workers in each occupation who can work from home



Source: Infrastructure Victoria analysis of ABS, Census of Population and Housing, 2016 and Grattan Institute, Shutdown: estimating the COVID-19 employment shock, 2020

3.6.2 Working from home reduces commuting costs

Increased working from home in the economic model, SIRCV, is represented by a reduction in the cost of commuting for those occupations that are suited to work from home. Broadly speaking, this adjustment reduces the commuting cost for those occupations which can work from home and reflects the fact that physical commutes happen less often with more working from home.

This shock is modelled in SIRCV by reducing the commuting cost coefficient (or commuting disutility) signified in the model by zeta (ζ). This means relevant occupations, which can work from home, have lower values for their commuting cost coefficient.

Within SIRCV, commuting costs negatively impact households' indirect utility function, that is households try to avoid higher commuting costs, all things equal. Estimated travel times are used as a proxy for commuting costs, and these enter the model in a negative power law form. The model is calibrated using the estimated commuting gravity coefficient $\zeta_o \varepsilon_L$ where ζ_o is the commuting cost coefficient and the epsilon (ε_L) is the logit parameter for detailed residence and workplace location choices.

The value for the reduction in the commuting cost coefficient in the medium scenario was selected to represent an increase of roughly two days per week worked from home. For the other scenarios, the reduction in the commuting costs coefficient was scaled down by 50% in the low scenario, and scaled up by 50% in the high scenario, to represent working from home one and three days a week, respectively. The reduced commuting costs subsequently impact the choices that households make around where to live and work, as well as the occupations they choose.

3.6.3 Working from home reduces commuting trips

The percentage changes to the commuting cost coefficient for each area and industry outputted by SIRCV are used to identify the location and industry of trips impacted by working from home in the transport model, VITM. In the medium scenario, 40% of these trips are removed because an additional two days per week are worked from home by those occupations that can work from home. Because only a proportion of workers can work from home, this results in around 12.5% of all work trips being removed. As not all trips are commuting trips, the impact of these trips across an entire day is smaller, still impacting 2.0% of all trips in VITM.

The low scenario removes 20% of work trips in occupations that are suited to working from home to represent an increase on one day a week working from home, while the high scenario removes 60% of these trips, representing an additional three days per week worked from home compared with the base case.

When work trips are removed from VITM due to increasing working from home, it also impacts non-home-based trips that were previously made from work. In order to account for this, home-based and non-home-based trips are adjusted in VITM in line with the changes for each scenario (low, medium, and high). As a result, the overall number of trips do not change, however the origins and destinations for a select number of non-home-based trips do change.

3.6.4 Working from home requires more spending on technology

As well as considering the direct transport and commuting effects of working from home, we have also included the following indirect effects: reduction in household transport costs, increase in household internet costs, and increase in firm internet costs.

An indirect impact of shifting to working from home is the reduction in household transport costs from no longer commuting to and from a workplace as frequently. This is reflected in SIRCV as a reduction in household expenditure on transport related industries. For the medium scenario, the adjustment to the cost of transport disutility parameters captures each eligible worker in a household, working an additional two days a week at home. We approximated the reduction in household spending on transport by the change in the share of work-related trips (excluding active transport) for working age people using VISTA. This was calculated to be about a 13% reduction in transport costs for the medium scenario.

Another indirect impact is households' increased reliance on technology to enable working from home. To capture this in SIRCV, the household expenditure share on internet services has been increased for households which work from home. To estimate this impact, we estimated internet usage and costs for a typical household, as well as the uplift in internet usage associated with working from home two days a week.[37] A similar process was used to represent the increase in expenditure share on internet for firms who will be using video more frequently for meetings consisting of a mix of in-person and remote workers, and also reflecting the costs that firms may need to invest in redesigning their systems.

[37] *Pre-COVID-19 data: Department of Infrastructure, Transport, Regional Development and Communications (BCAR), Demand for fixed-line broadband in Australia, 2018-2028, 2020, Australian Government.; Post-COVID-19 data: DeFilippis, Evan, Stephen Michael Impink, Madison Singell, Jeffrey T. Polzer and Raffaella Sadun, Collaborating during coronavirus: The impact of covid-19 on the nature of work, 2020, NBER Working Paper No. 27612.*

For the low and high scenarios all indirect cost changes were scaled down by 50% for the low scenario and up by 50% for the high scenario, in line with the number of additional days worked from home for low and high scenarios.

3.6.5 Summary of working from home scenario shocks to VLUTI

Figure 13 provides a summary of the shocks to VLUTI for low, medium, and high working from home scenarios.

Figure 13. Summary of working from home scenario shocks

	WFH low	WFH medium	WFH high	Impact of shock on modelling outcomes
SIRCV utility function related to commuting	8% reduction in the commuting cost coefficient	16% reduction in the commuting cost coefficient	24% reduction in the commuting cost coefficient	High
VITM work trips	+ 1 day reduction in trips (20% of work trips in working from home occupations / 6.2% of total work trips / 1.1% of total trips)	+2 days working from home reduction in trips (40% of work trips in working from home occupations / 12.5% of total work trips / 2.2% of total trips)	+3 days working from home reduction in trips (60% of work trips in working from home occupations / 18.7% of total work trips / 3.4% of total trips)	High
Adjust VITM non-home-based (NHB) trips to become home based trips due to VITM work trips adjustment.	adjust any NHB trips linked to VITM working from home work trip changes	adjust any NHB trips linked to VITM working from home work trip changes	adjust any NHB trips linked to VITM working from home work trip changes	Medium
Household expenditure share on transport	6.7% reduction in transport expenditure	13.3% reduction in transport expenditure	20% reduction in transport expenditure	Medium
Increase in SIRCV household expenditure share on internet services	50% less than medium	Varies depending on occupation, ability to work from home, and intensity of broadband use (between 0% and 70%)	50% more than medium	Low
Increase in the SIRCV production cost shares for internet services	50% less than medium	Varies depending on the mix of occupations in an industry and how intensively each uses broadband (between 0% and 40%).	50% more than medium	Low

Source: Infrastructure Victoria, 2021

4. Working from home changes land use and transport patterns

This chapter provides detailed VLUTI modelling outputs. This includes modelling results for how greater working from home impacts the spatial distribution of employment and population in 2036. The broad implications for how people travel are presented, as well as detailed transport metrics. The modelled impact on key economic indicators such as gross local product and wages are also included.

4.1 Working from home changes the spatial distribution of employment and people

4.1.1 Population disperses while employment centralises

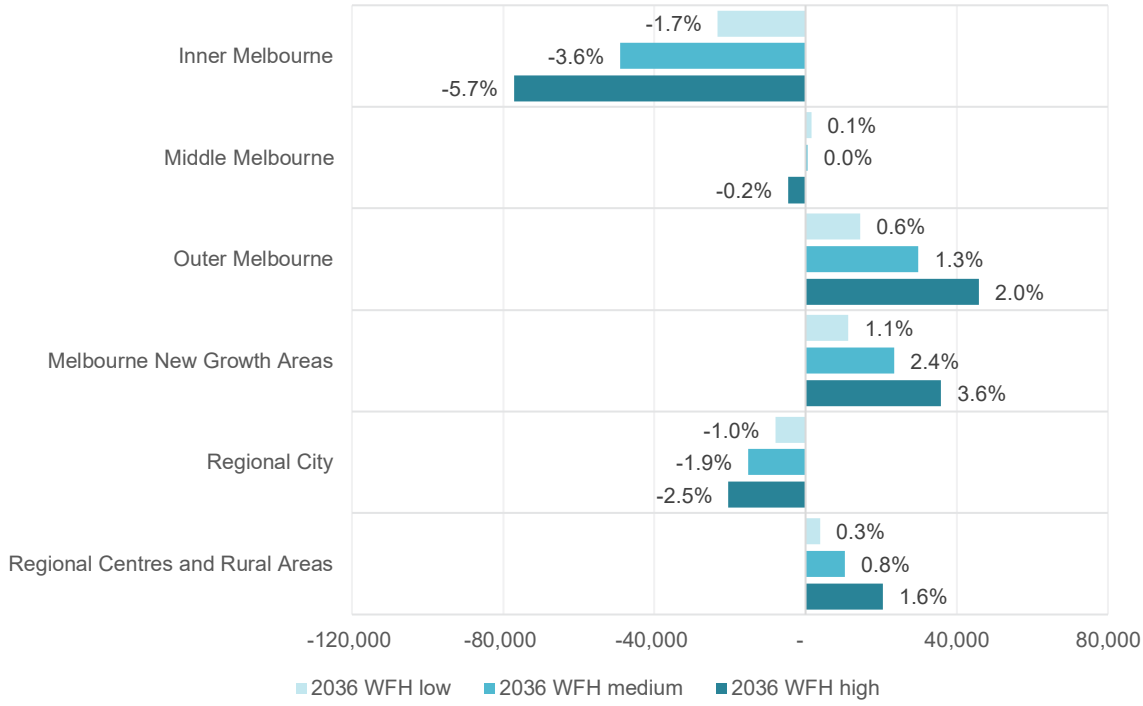
Our land use modelling tests how the location of population and jobs changes in response to people in select occupations working from home, more often, in 2036. The total Victorian population and employment numbers in the working from home scenarios are the same as the base case in 2036.

Our modelling shows that increasing work from home results in population moving away from employment centres, such as the city centre in inner Melbourne, towards outer areas of Melbourne. This is demonstrated by Figure 14, which shows there is slower population growth in the inner Melbourne and regional cities FUAs in 2036, compared to the base case. At the same time outer Melbourne, Melbourne's new growth areas, and regional centres and rural areas FUAs, attract relatively more people in 2036.

Figure 14 shows that working from home results in the population of inner Melbourne growing more slowly, with the FUA home to 3.6% fewer people in 2036 (for the medium scenario) compared to the base case. The working from home scenario also sees population growing slower in regional cities, with 1.9% fewer people (for the medium scenario) compared to the base case. In other FUAs, working from home generally results in stronger population growth under all scenarios, compared to the base case in 2036. The only exception is middle Melbourne, where there is little change across all scenarios in 2036, compared to the base case.

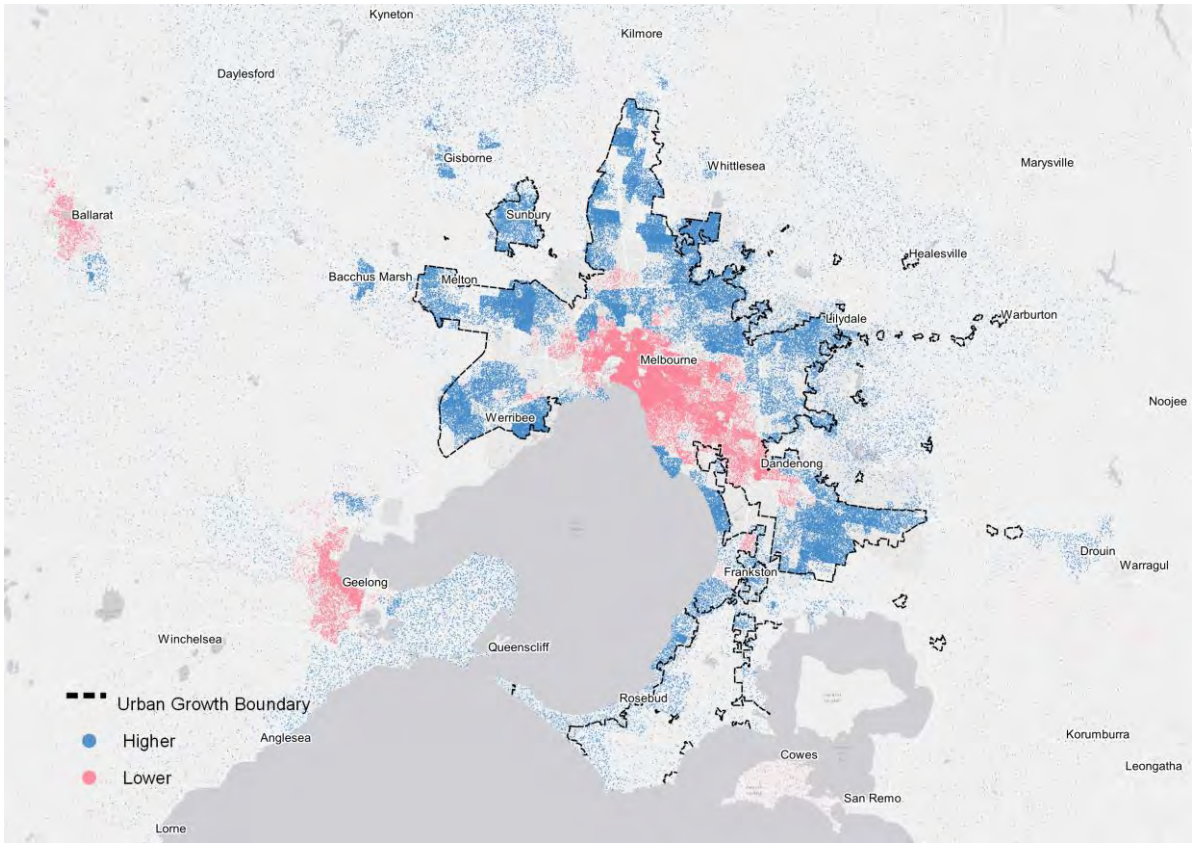
The following map shows differences, compared to the base case, in the total resident population under the medium scenario across greater Melbourne. Each dot represents one more or one less person in a location, compared to the base case. This shows that working from home results in slower population growth in inner Melbourne and regional cities, including Geelong and Ballarat, and more people living in outer Melbourne and Melbourne new growth areas.

Figure 14. Change in population, WFH scenarios 2036 vs base case



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021
Note: Chart shows level change from the base case, with percentage change labelled to indicate change as a proportion.

Figure 15. Change in population, WFH medium vs base case, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

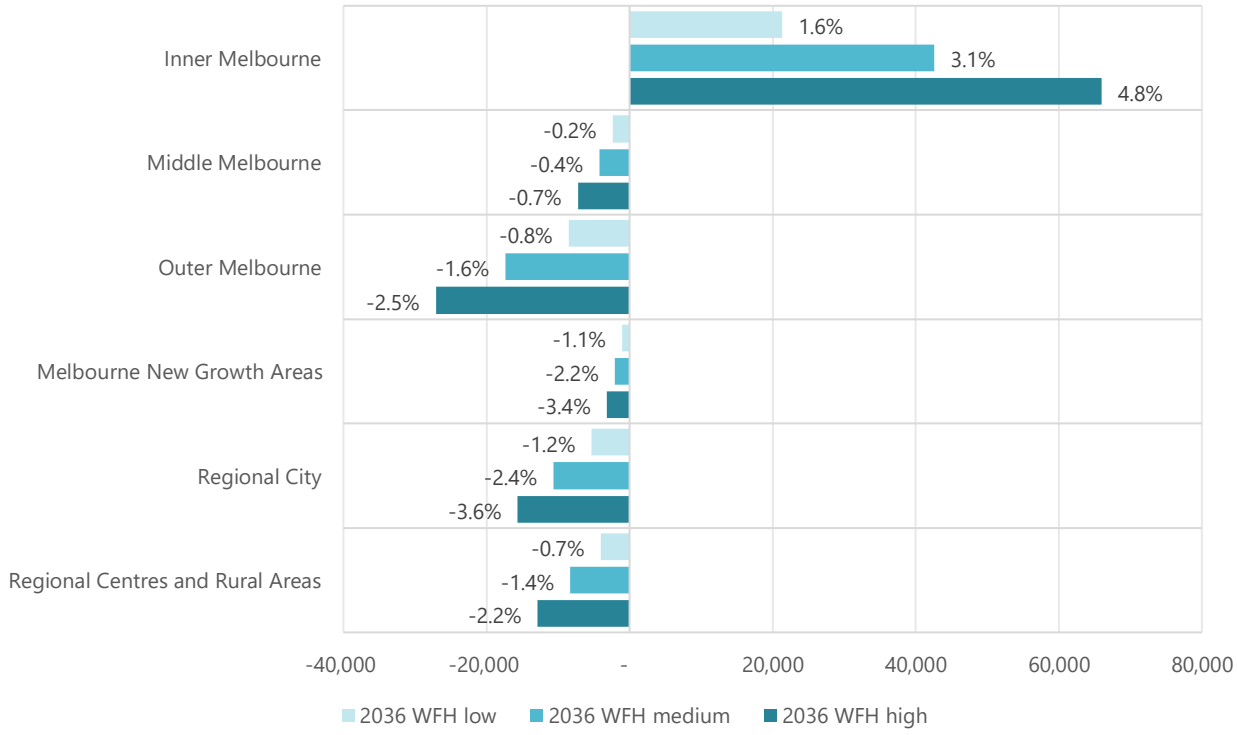
Our modelling shows there is an inverse effect on the location of jobs, compared to population, as a result of increasing work from home. Whereas Victoria's population tends to become more dispersed, the location of jobs centralises in inner Melbourne. Increasing work from home results in more employment located in inner Melbourne, primarily in the city centre, Docklands, Southbank and St Kilda Road precincts. These are places which already have a large share of knowledge-intensive jobs and a comparative advantage in professional, scientific and technical services, financial and insurance services, information media and telecommunications occupations, compared to other regions.[38]

The location of employment represents where the employer or firm is located, rather than where the work is done. Therefore, although more jobs are located in inner Melbourne under all scenarios in 2036, compared to the 2036 base case, people working in these jobs are more likely to be working from home for part of the week.

Figure 16 outlines the changes to employment by FUA under low, medium and high scenarios. It shows 3.1% more jobs in inner Melbourne in the medium scenario in 2036, compared to the base case. All other FUAs attract comparatively fewer jobs in 2036.

The following map shows changes in the location of jobs compared to the base case in 2036 under the medium scenario across greater Melbourne. Each dot represents one more or one less job in a location, compared to the base case. It shows more jobs located in inner Melbourne, compared to the base case in 2036.

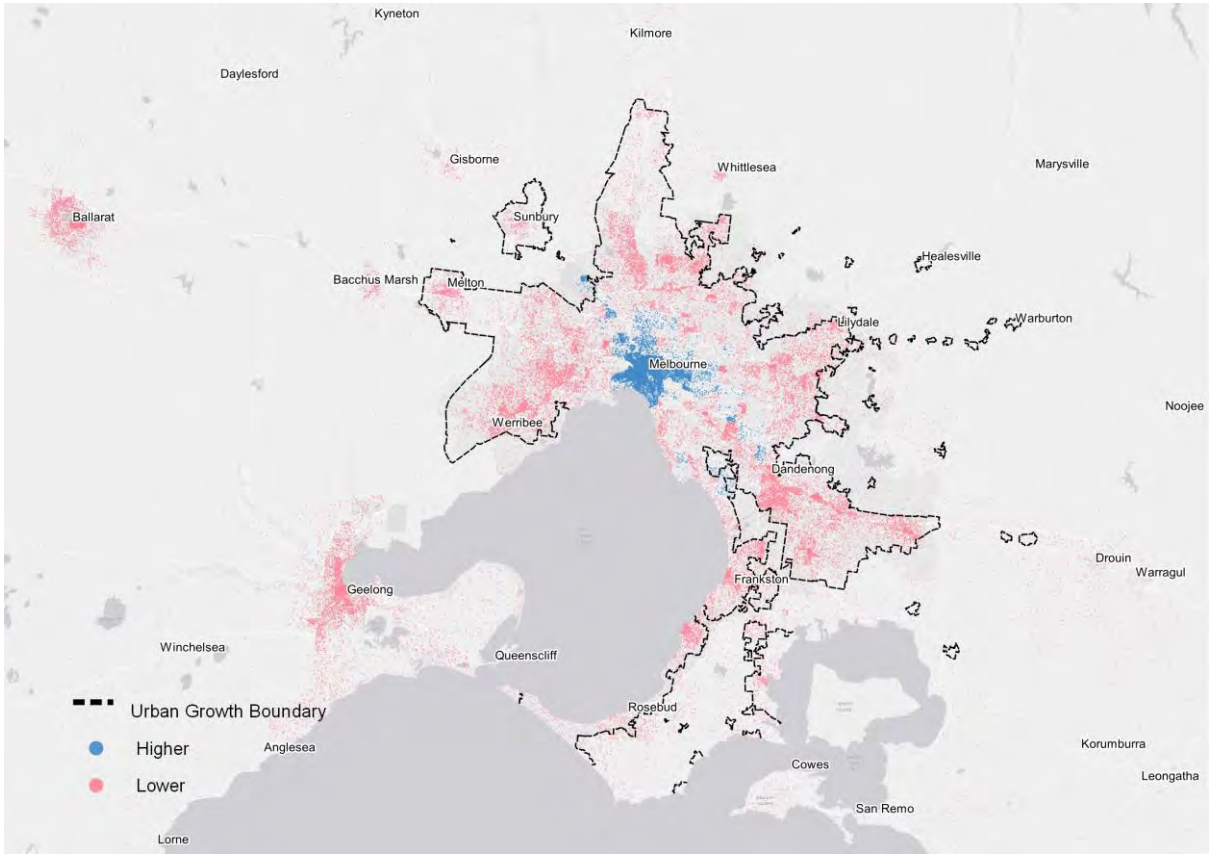
Figure 16. Change in employment, WFH scenarios vs base case, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

[38] *SGS Economics and Planning Pty Ltd, Melbourne Functional Economic Region Report, 2019, prepared for Infrastructure Victoria, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/SGS-Melbourne-Functional-Economic-Region-Report-March-2019.pdf, p.14*

Figure 17. Change in employment, WFH medium vs base case, 2036



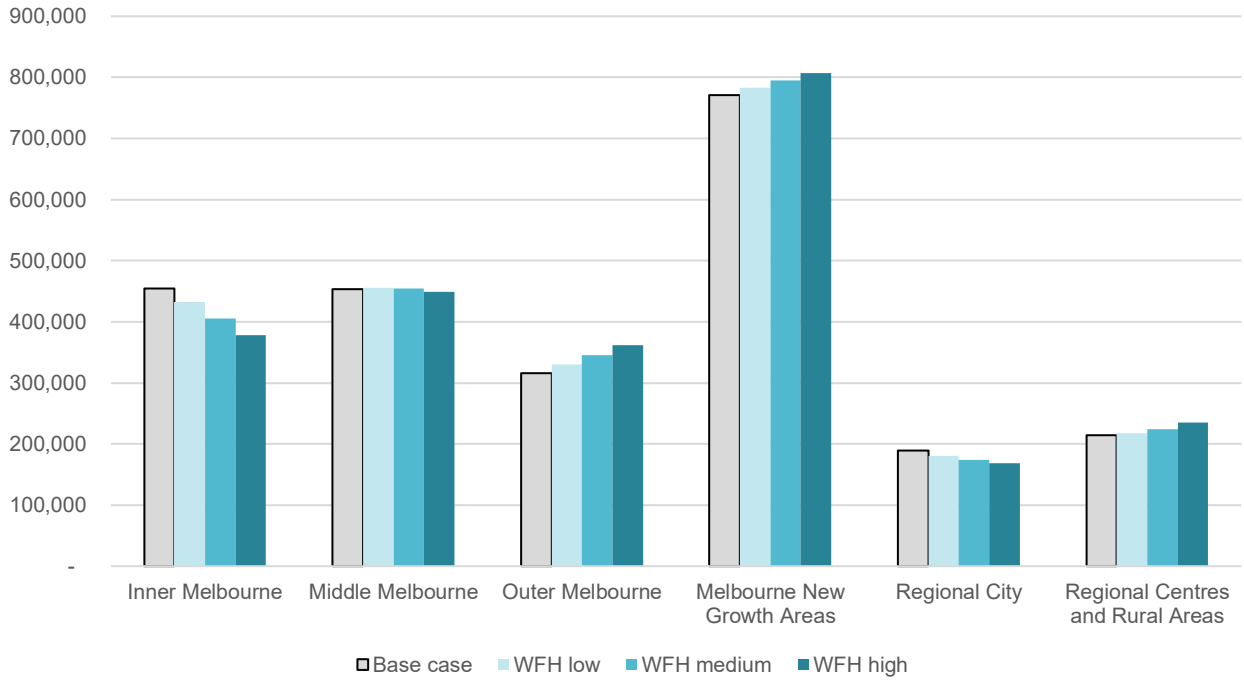
Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

While the modelled impact of working from home shows clear spatial trends, the overall trajectory of employment and population growth throughout Victoria does not materially change. The impacts of working from home are presented in context against the base case growth in employment and population from 2018 to 2036 in Figures 18 and 19. Even though working from home only results in marginal changes, in this context, the broad trends are still instructive, and as we discuss later, the implications for transport are worth exploring.

Additionally, our *Major transport program* report found that other macro trends may also have a dispersion effect on population.[39] A scenario testing the impact of more widespread use of electric vehicles, and further in the future, more autonomous vehicles, revealed that the reductions in transport costs these technologies offer could also result in less population in inner and middle areas of Melbourne. This means the cumulative impact of working from home with the technology change of electric and autonomous vehicles could be a more substantial population dispersion than the impact of working from home alone.

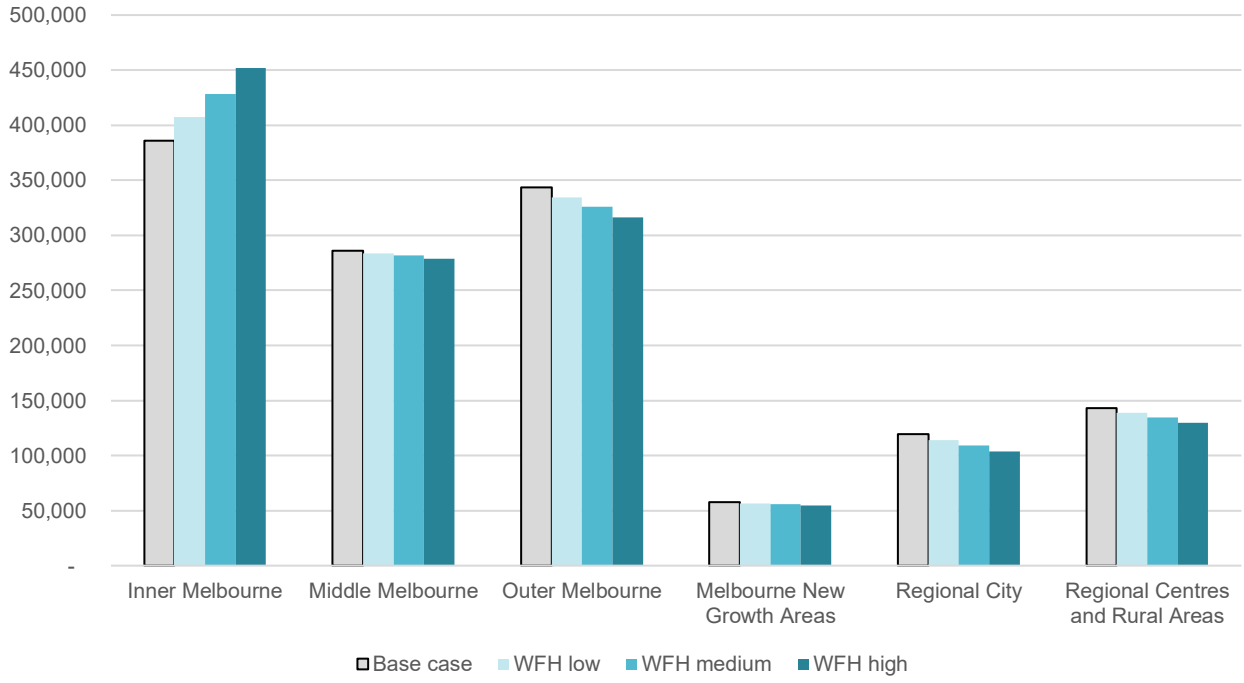
[39] *Infrastructure Victoria, Major Transport Program Strategic Assessment report, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/08/Major-Transport-Program-Strategic-Assessment-Report.pdf*

Figure 18. Change in population 2018 to 2036, WFH scenarios and base case



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Figure 19. Change in employment 2018 to 2036, WFH scenarios and base case



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

4.1.2 Greater Melbourne

Slower population growth and concentrating employment in inner Melbourne

More working from home results in slower population growth in inner Melbourne in 2036, compared with the base case. Within the FUA, there are some local differences in how working from home affects population changes. For example, our scenarios show greater impact of population dispersion in the central city and Fishermans Bend, compared to surrounding areas. This is characteristic of a wider pattern in which places that are predominantly for employment become even more concentrated with employment, and less residential (and vice versa).

As Figures 15 and 17 show, within the FUA, there are some regional differences, including fewer people living around the south-eastern Cranbourne and Pakenham train lines, compared to the base case. By contrast, working from home has a weaker impact on population in the north and north-eastern edges of inner Melbourne. This includes parts of the Moreland and Darebin LGAs around Coburg and parts of Brunswick and Thornbury, which have slightly higher population compared to the base case.

Working from home results in further centralising employment in inner Melbourne. While the central city becomes less residential, it simultaneously attracts a greater share of jobs in 2036 than in the base case. This effect is concentrated within Melbourne's central city and Docklands. The gravity of this pull towards central Melbourne reduces with distance from the central city. Increasing the amount days worked from home extends this effect. Under the high scenario in 2036, employment further consolidates in and around the central city, with the St Kilda Road precinct also attracting a greater number of jobs.

Outside the central city, there are slightly more jobs in the inner south, east and north of the inner Melbourne FUA. There is little change in the number of jobs located in the inner western suburbs, compared to the base case.

Little change in middle Melbourne

Overall, middle Melbourne experiences very little change under all working from home scenarios, compared to the base case in 2036. However, within the FUA, working from home does result in some small local differences in population. As observed earlier, the south-eastern corridor around the Cranbourne and Pakenham train lines attracts fewer residents than the base case. This could be due to the decreasing importance of transport access to employment with the ability to work from home. This effect weakens with distance from central Melbourne.

Similarly, there is very little change in the share of jobs located in middle Melbourne in 2036, compared to the base case. In 2036, there are 0.4% fewer jobs in middle Melbourne under the medium scenario, compared to the base case.

Our modelling results only show net changes, therefore while there is little net change in middle Melbourne, it is possible that underneath this are gross changes which largely balance out. For example, increasing working from home could mean that someone who would have otherwise lived in inner Melbourne decides to live in middle Melbourne. Similarly, someone who would have lived in middle Melbourne decides with working from home, it is now best to live in outer Melbourne. These two changes net each other out within middle Melbourne and would not be captured in the modelling results. This is a 'vacancy chain' conceptualisation of how housing markets operate.[40]

More people but less employment in outer Melbourne

Working from home attracts more population to outer Melbourne in 2036, compared to the base case. This results in higher population of 1.3% over the base case in 2036 under the medium scenario. Across the FUA, population increases with distance from inner Melbourne, resulting in the greatest increases towards the outer edges of the FUA.

There is a tendency for stronger population growth on the edges of outer Melbourne in places like Point Cook, Craigieburn, Doreen, and Taylors Hill. More population is also attracted to the Mornington Peninsula, resulting in Rosebud, Portsea and Dromana having more population than the base case for all scenarios in 2036. Increases in population, compared to the base case, also occur in the eastern part of the FUA, concentrating around the Yarra Ranges LGA.

Some areas around metropolitan activity centres have lower populations compared to the base case. This includes Broadmeadows and Dandenong. These are places with a mixture of employment and residential land, and a greater diversity of land uses than surrounding residential zones. These results could be related to working from home making the proximity to the employment which these areas offer relatively less attractive.

Like other FUAs outside inner Melbourne, jobs generally grow more slowly in outer Melbourne under all scenarios in 2036, compared to the base case.

[40] *SGS Economics and Planning Pty Ltd, Economic analysis of the Better Apartments initiative, prepared for Department of Environment, Land, Water and Planning and the Office of the Victorian Government Architect, 2016, Victorian Government, https://www.planning.vic.gov.au/__data/assets/pdf_file/0031/9985/Better-Apartments-Economic-Assessment-Report-2016SGS.pdf*

More people in Melbourne's new growth areas

The working from home scenarios find Melbourne's new growth areas attracting more new residents under all scenarios in 2036, compared to the base case. This is a similar pattern to outer Melbourne and is also likely a result of the decreasing importance of physical proximity to employment centres working from home brings.

This FUA is made up of greenfield suburbs on the outer edges of Melbourne. Growth area development is occurring in four growth corridors in seven local government areas in Melbourne's north (Mitchell and Whittlesea), south-east (Casey and Cardinia), north-west (Hume) and south-west (Wyndham). These new growth areas, together, experience rapid growth under the base case, with around 770,000 additional residents projected from 2018 to 2036.[41] Under the medium scenario, Melbourne's new growth areas grow even faster, attracting an additional 23,000 people over the base case, or 2.4% higher.

Compared to the base case, working from home results in Melbourne's new growth areas containing fewer jobs. The future greenfield metropolitan activity centres of Cobblebank and Cloverton experience small declines in the number of jobs, compared to the base case. This is a continuation of current trends which result in growth areas having a lower job density per person than other urban areas.[42]

4.1.3 Regional and peri-urban Victoria

Less people in regional cities

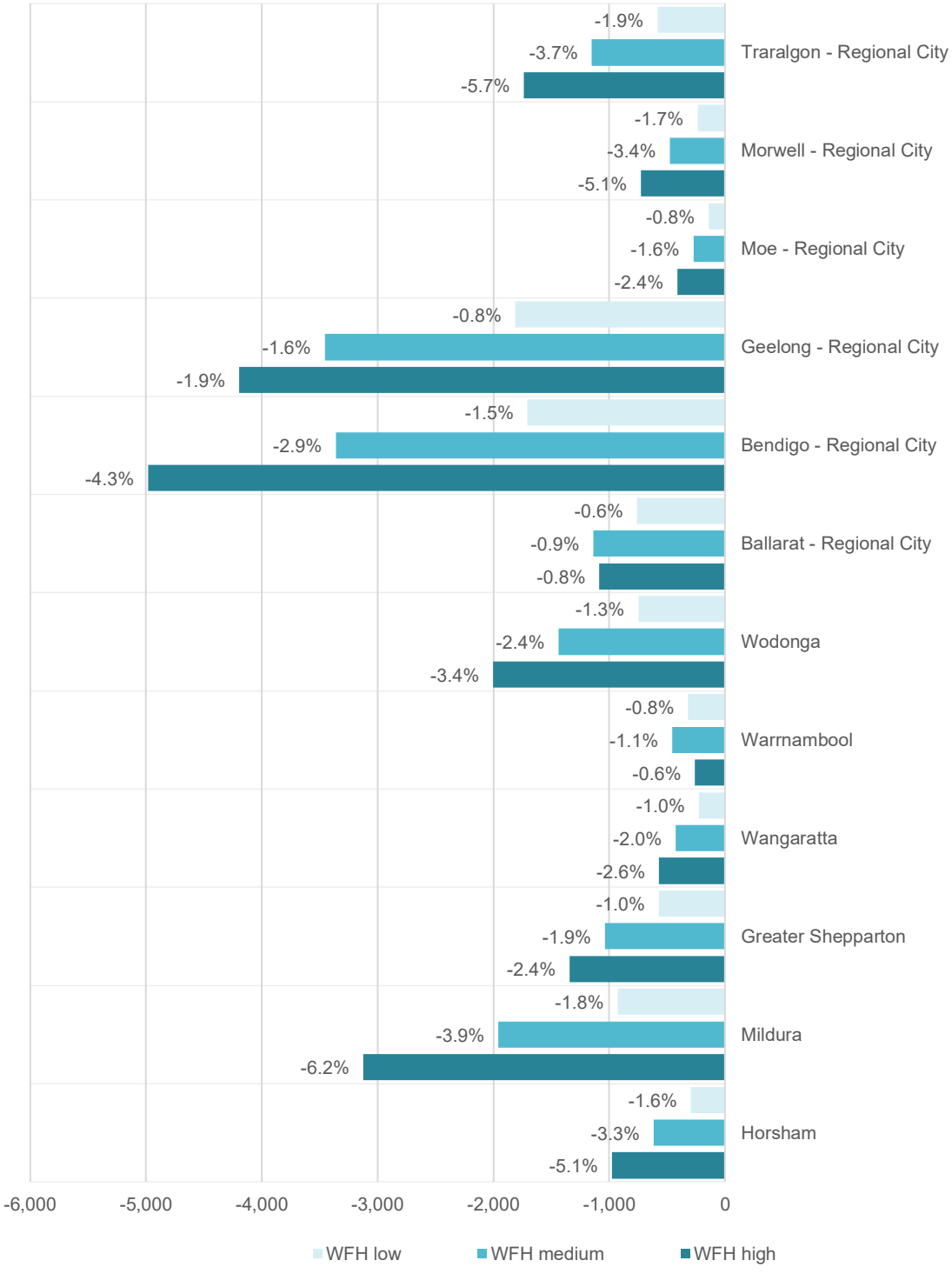
The regional cities FUA includes twelve regional cities: Ballarat, Bendigo, Geelong, Horsham, Mildura, Moe, Morwell, Greater Shepparton, Traralgon, Wangaratta, Warrnambool, and Wodonga. Figure 20 and Figure 21 show differences in resident population compared to the base case in 2036 under the medium scenario in regional Victoria. They show fewer people within the defined boundaries of every regional city, compared to the base case. They also show higher population in other rural areas, outside regional cities. Our modelling finds that increasing the number of days worked from home increases the strength of this population dispersion, resulting in a greater share of people living in the peri-urban areas of rural areas.

Two strong forces appear to be causing the relatively lower populations (compared to the base case) in regional cities. Firstly, there is some dispersion of populations to areas surrounding regional cities due to lower commuting costs for jobs which can be worked from home. Secondly, there is greater population growth in locations with greater proximity to inner Melbourne, where jobs growth is strong (Figure 26).

[41] *Infrastructure Victoria, Social infrastructure in Melbourne's growth areas, 2021, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/09/Background-paper-Social-infrastructure-in-Melbournes-new-growth-areas.pdf*

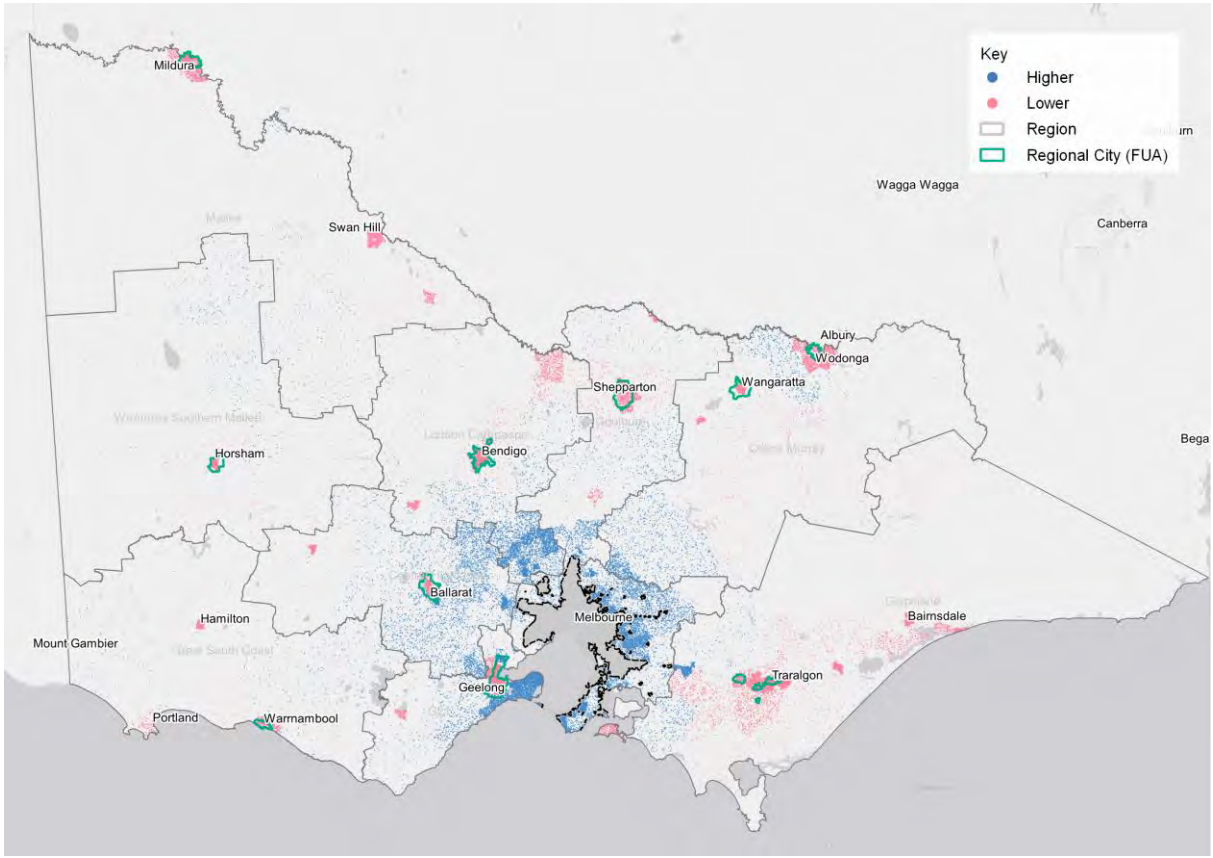
[42] *SGS Economics and Planning Pty Ltd, Economic, Social & Environmental Profile: Inter-regional report, 2019, prepared for Infrastructure Victoria, Victorian Government, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/SGS-Economic-social-and-environmental-profile-Metropolitan-Inter-Regional-Report-April-2019.pdf*

Figure 20. Regional cities change in population (SA2), WFH scenarios vs base case, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

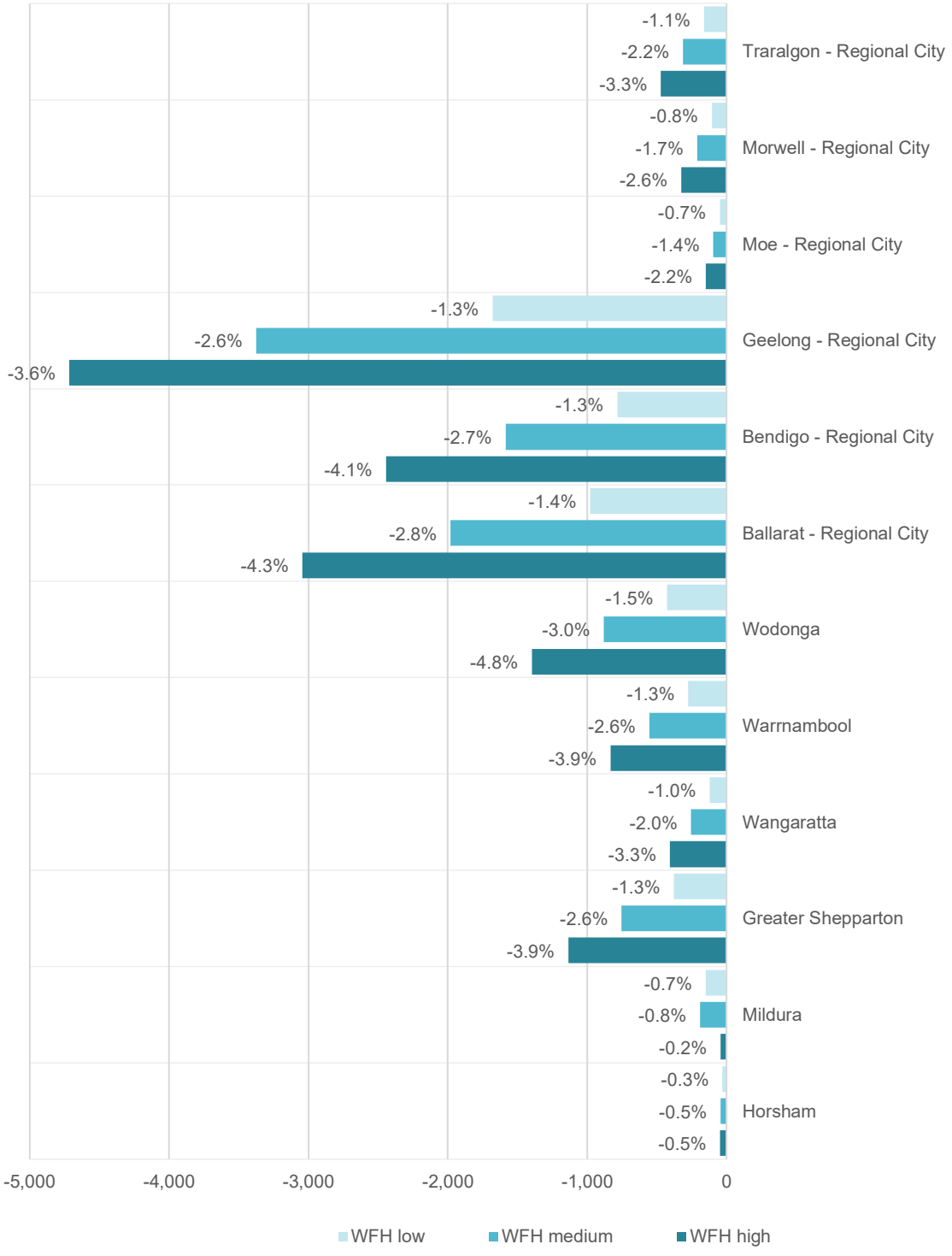
Figure 21. Change in population, WFH medium vs base case, regional Victoria, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

There is also lower jobs growth in regional cities compared to the base case. Figure 22 shows all regional cities experience slower employment growth as a result of working from home. In total, there are 2.4% fewer jobs in regional cities under the medium scenario compared to the base case in 2036.

Figure 22. Regional cities change in employment (SA2), WFH scenarios vs base case, 2036



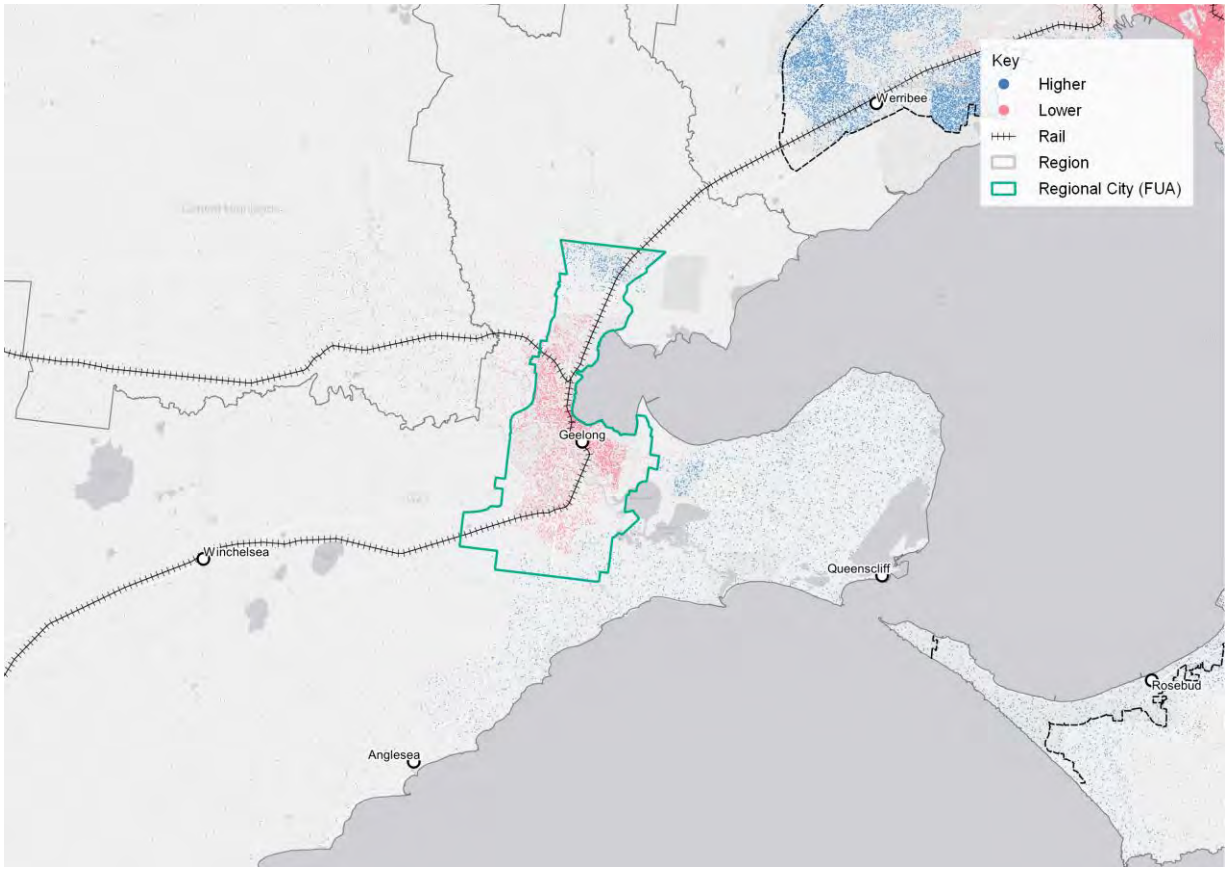
Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Dispersion of populations around regional cities

In some regional cities, areas peripheral to regional cities attract more residents compared to the base case across low, medium, and high scenarios in 2036. For example, working from home results in Geelong's growth areas, such as

Armstrong Creek, Lara and Northern Geelong, attracting more residents while more central, established parts of Geelong have a lower population, compared to the base case. This is related to the reduced importance of proximity to employment opportunities, such as in central Geelong, which working from home enables.

Figure 23. Change in population, WFH medium vs base case, Geelong and surrounding areas, 2036

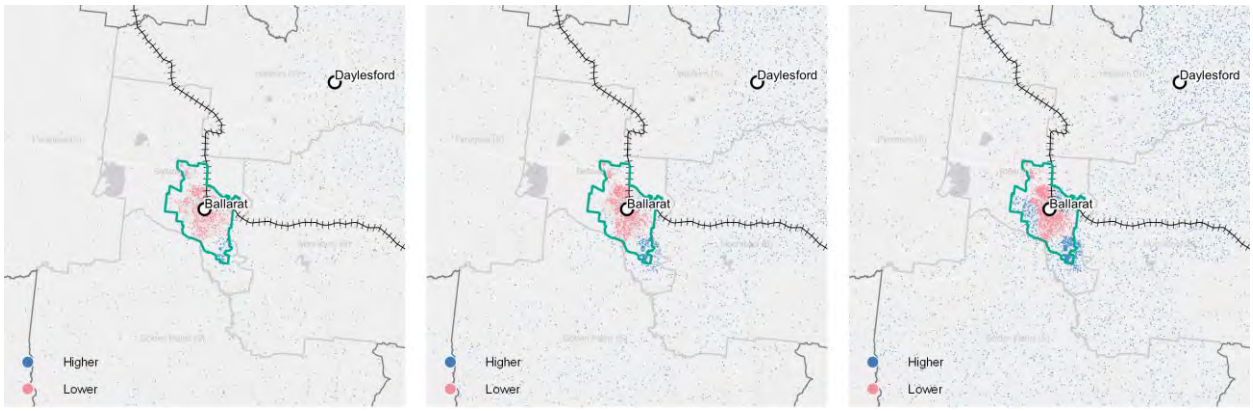


Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Similarly, Ballarat experiences higher growth in some of its peripheral areas. Figure 24 demonstrates that although more central parts of Ballarat attract fewer residents across all scenarios in 2036, increasing the effect of working from home results in southern parts of the city between Mount Helen and Buninyong attracting more residents. There is also higher population growth occurring in rural areas outside the established settlement boundary.

Figure 24. Change in population, WFH scenarios vs base case, Ballarat and surrounding areas, 2036

Low scenario | Medium scenario | High scenario



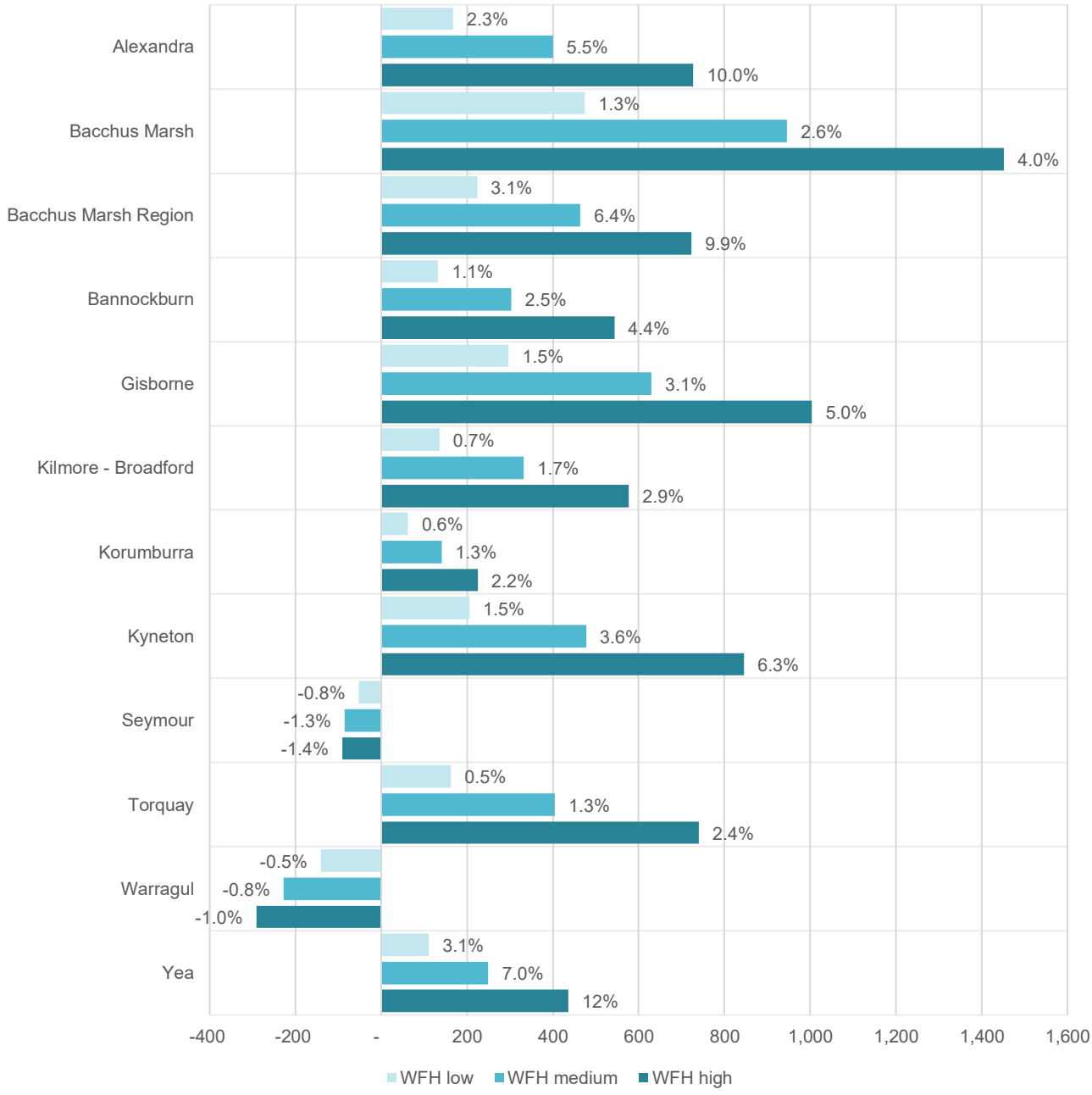
Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

More people in regional locations closer to Melbourne

While regional cities experience slower population growth in the working from home scenarios, regional centres and rural areas (which includes all other areas of regional Victoria) experience stronger population growth: 0.8% higher in 2036 compared to the base case in the medium scenario.

There are substantial differences in population trends within the regional centres and rural areas FUA as a result of working from home. Peri-urban places—regional areas outside of Melbourne within 100km of the city—grow more strongly, while parts of far-western Victoria and east Gippsland have smaller populations compared to the base case (Figure 21). Using SA2s that encompass a selection of existing peri-urban towns (Figure 25) shows higher population in most of these SA2s, compared to the base case.

Figure 25. Change in select peri-urban populations (SA2), WFH scenarios vs base case, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

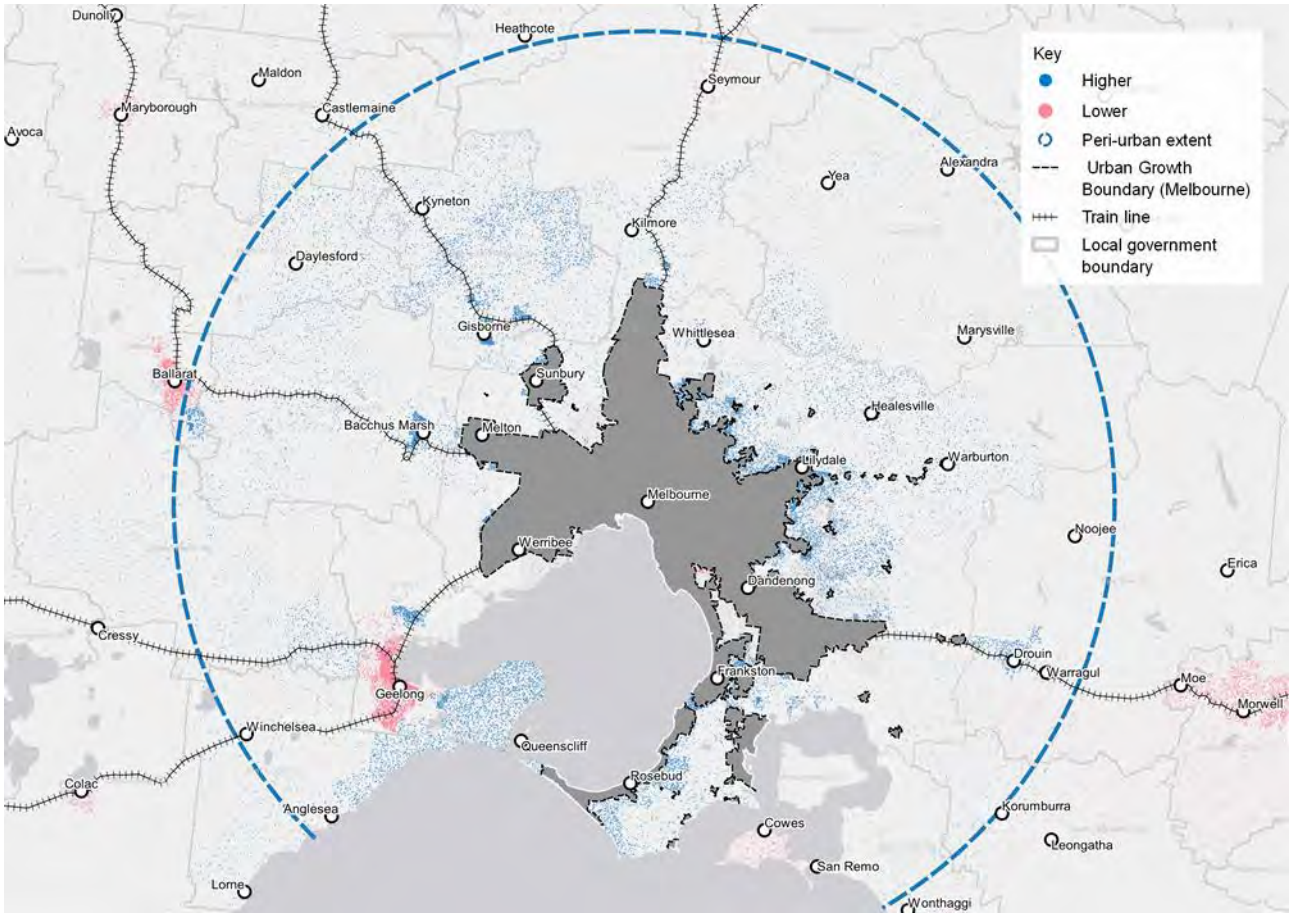
The reason we see this much more significant growth in the peri-urban areas around Melbourne is because people are spreading marginally farther out from Melbourne due to work from home related reductions in commuting costs, while jobs are becoming more concentrated in inner Melbourne. This makes the peri-urban locations more attractive for those

workers who only need to travel a few times a week to Melbourne, while regional centres and rural locations situated farther from Melbourne do not experience this increase in attractiveness due to the larger geographic distances from Melbourne jobs.

Figure 26 shows population differences in peri-urban locations as a result of working from home, compared to the base case. As this figure illustrates, working from home results in a higher population in the Bellarine Peninsula, compared to the base case, across all scenarios. In some cases, this growth is occurring in sensitive coastal environments which are not expected to accommodate strong levels of population growth in the base case. For example, the Borough of Queenscliff grows by an additional 6.5%. Other peri-urban municipalities which experience stronger growth include Murrindindi, Macedon Ranges and Moorabool, which grow by an additional 6.9%, 5.1% and 3.5% respectively under the medium scenario, compared to the base case.

These figures show population growth over the base case occurring in the green wedge municipalities of Mornington Peninsula, Nillumbik and Yarra Ranges, which grow by an additional 1.7%, 3.7% and 2.6% respectively under the medium scenario, compared to the base case. Growth also occurs in other environmentally sensitive areas, such as Kinglake (SA2) which grows by an additional 9% or 400 people compared to the base case.

Figure 26. Change in population vs base case, WFH medium, peri-urban Melbourne (100 km radius), 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

4.2 Working from home changes travel patterns

4.2.1 Working from home takes private vehicles and public transport trips off the network

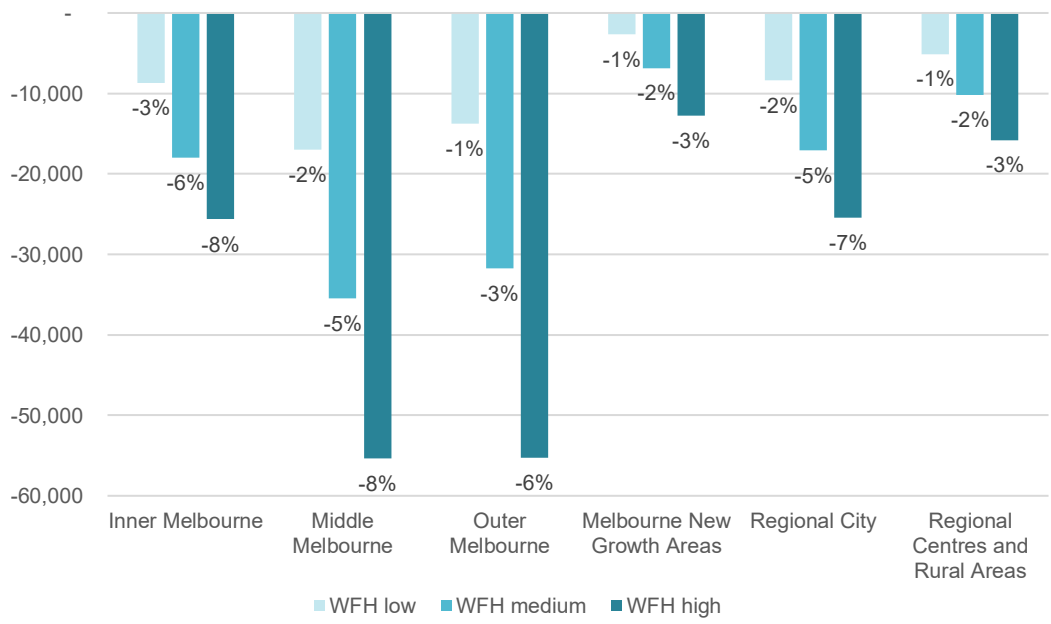
The working from home scenarios simulate the impact of some workers commuting less over the course of a week. This means there is generally less travel across the transport network, specifically, a 2.3% reduction in daily total private vehicle and public transport trips.

Figures 27 and 28 below show the difference in private vehicle and public transport trips during the AM (morning) peak, by origin of trip. The AM peak is defined as 7am to 9am on an average non-school holiday weekday.

As some workers are no longer required to travel for work as frequently, private vehicle (car) use reduces in the AM peak. In areas where residents are heavily dependent on private vehicles this is particularly noticeable, including middle Melbourne and outer Melbourne, which are also impacted by a shift away from private vehicles and towards public transport due to more jobs being located in the central city. Middle and outer Melbourne have around 30,000 fewer private vehicle trips each in the AM peak under the medium scenario.

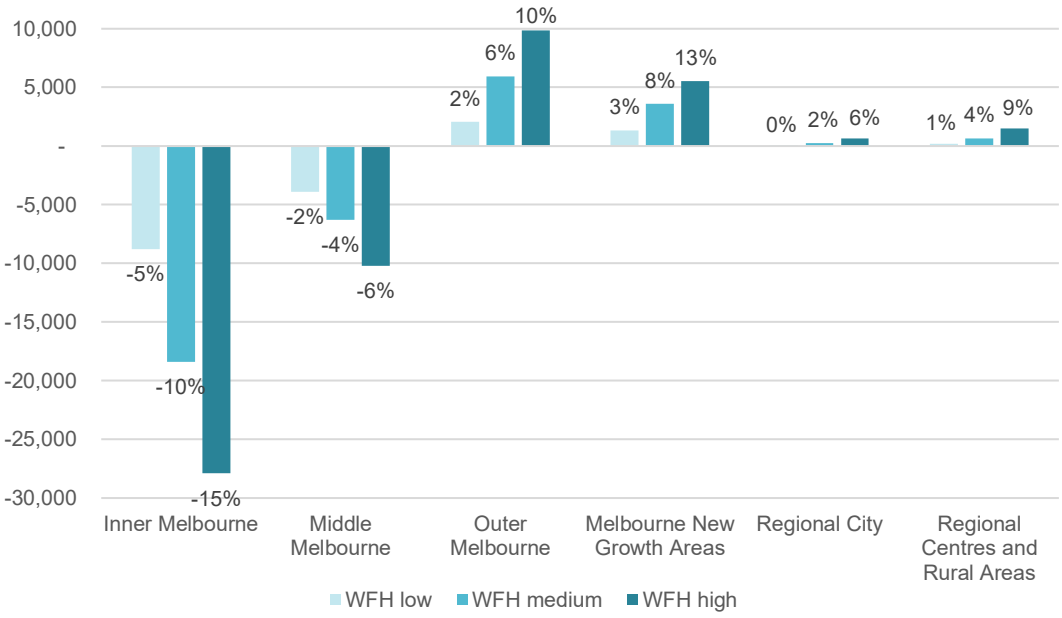
Public transport patronage is also lower in some areas, compared to the base case. Inner Melbourne sees the largest impact, with over 18,000 fewer boardings in the medium scenario, while middle Melbourne also sees fewer boardings. Conversely, boardings in both outer Melbourne and Melbourne new growth areas are higher, attributable to the faster population growth in these FUAs as a result of working from home and the increase of workers with jobs in the central city.

Figure 27. Change in private vehicle trips vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Figure 28. Change in public transport trips vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

These changes in private vehicle and public transport use also impact public transport mode share for each of the FUAs, as illustrated in Figure 29. All FUAs see higher public transport mode share, except for inner Melbourne (by origin of trip). Higher public transport mode share in Melbourne's outer and new growth areas is due to both higher population in these areas and the concentration of employment in inner Melbourne. On the days people are travelling to work, the fastest way to access a job in the inner city from outer areas of Melbourne is by public transport.

Figure 29. Change in public transport mode share (originating) vs base case, AM peak, 2036

FUA	Base	WFH Low	WFH Medium	WFH High
Inner Melbourne	36.9%	-0.5%	-1.0%	-1.8%
Middle Melbourne	19.2%	0.0%	0.2%	0.3%
Outer Melbourne	9.7%	0.3%	0.8%	1.4%
Melbourne New Growth Areas	9.6%	0.3%	0.9%	1.4%
Regional Cities	2.9%	0.1%	0.2%	0.4%
Regional Centres and Rural Areas	3.4%	0.1%	0.2%	0.4%

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

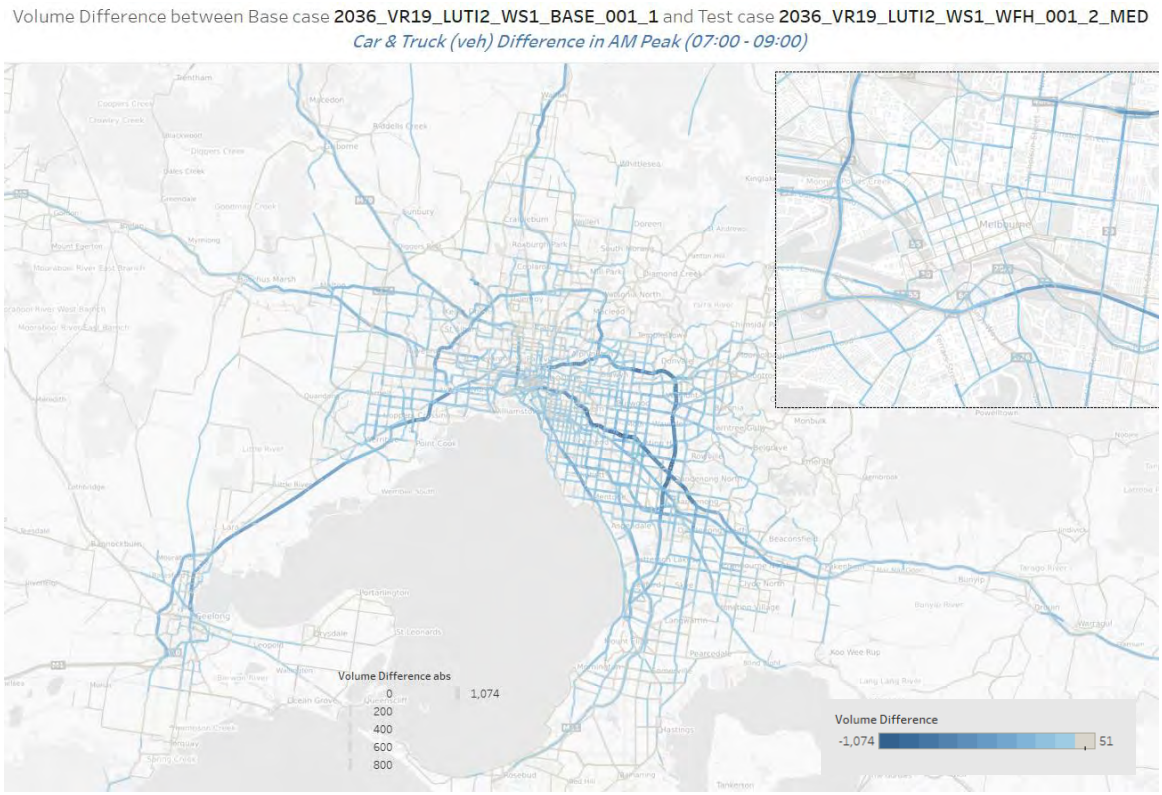
4.2.2 Traffic volumes redistribute from inner city arterials to regional freeways

With population distributed farther away from inner Melbourne, overall traffic volumes rebalance across the network, as shown in the following two figures. Figure 30 shows areas where road network volumes are lower, in blue. This is for the medium scenario, compared to the base case in 2036. In contrast, Figure 31 shows where road network volumes are higher, in orange. Together, these figures show lower traffic volumes within the inner city as well as higher traffic volumes heading into the city on regional freeways. Some roads, such as the Princes Freeway, are prominent in both figures. This suggests that volumes outbound from Melbourne are lower while inbound traffic volumes are higher during the AM peak compared to the base case.

Figure 30 shows moderately lower vehicle volumes along most arterial roads and freeways across Greater Melbourne during the AM peak. As there are fewer residents residing closer to inner Melbourne, there are also fewer trips being undertaken on the network within and around inner Melbourne. This is most notable along some of Melbourne's major freeways, with the Eastern Freeway recording lower outbound volumes of up to 850 vehicles and the Monash Freeway recording lower outbound volumes of over 1000 vehicles during the AM peak. For comparison, in the base case, outbound volumes along these two corridors total around 10,000 vehicles each during the AM peak.

In contrast, as shown in Figure 31, there are higher vehicle volumes along major routes feeding into the central city during the AM peak. Due to employment concentrating in inner Melbourne, there are notable traffic increases along sections of the Princes, Western and Calder Freeways, with the Princes Freeway inbound from Geelong reaching volumes of up to 2100 additional vehicles travelling inbound during the AM peak. To put this in context, if the Princes Freeway were widened and a new lane added, this increase in additional vehicles would immediately take up over half of any single new lane capacity on the freeway.[43]

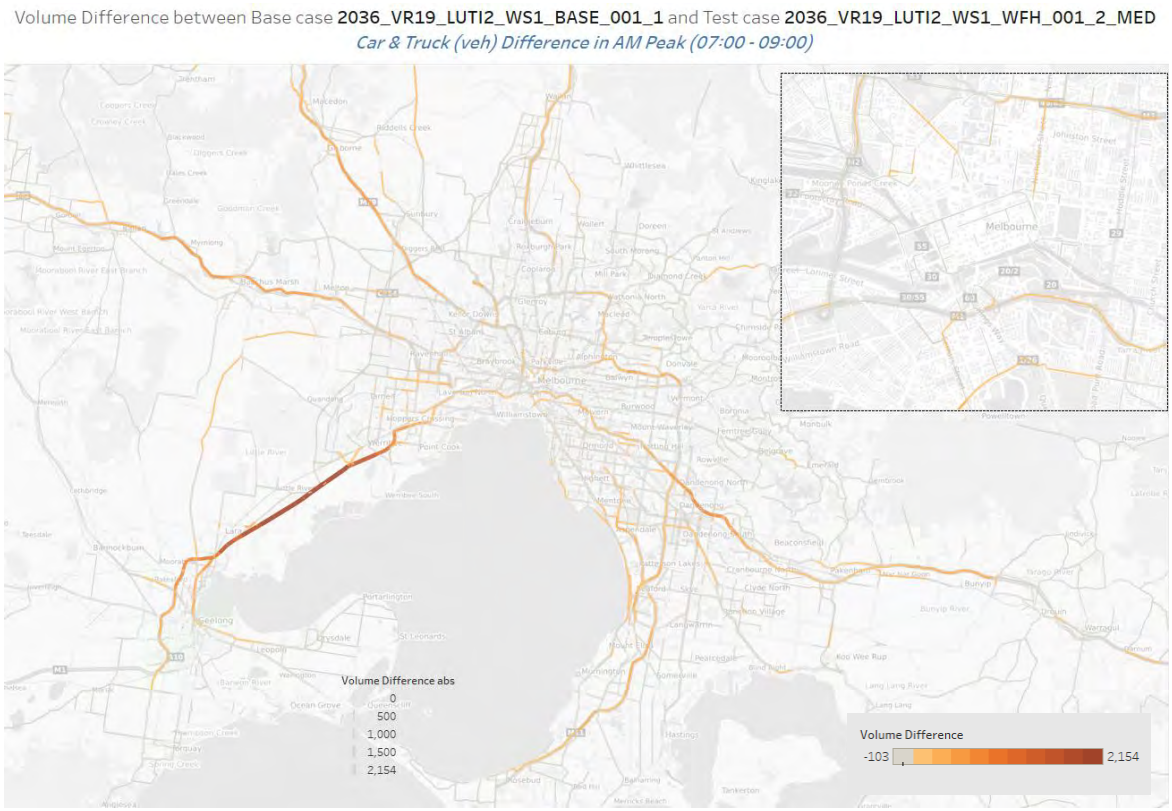
Figure 30. Reduction in vehicle volumes, WFH medium vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

[43] *This is based on approximate capacity of a single freeway lane of 2000 vehicles per hour (2000 veh/h/lane) – or 4000 vehicles for the two hour AM peak period. https://www.vicroads.vic.gov.au/-/media/files/technical-documents-new/managed-motorways-design-guide/volume-1-part-3-motorway-capacity-guide.ashx?la=en&hash=F95698E917B6C49FA780B3AC1C28DA60*

Figure 31. Increase in vehicle volumes, WFH medium vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

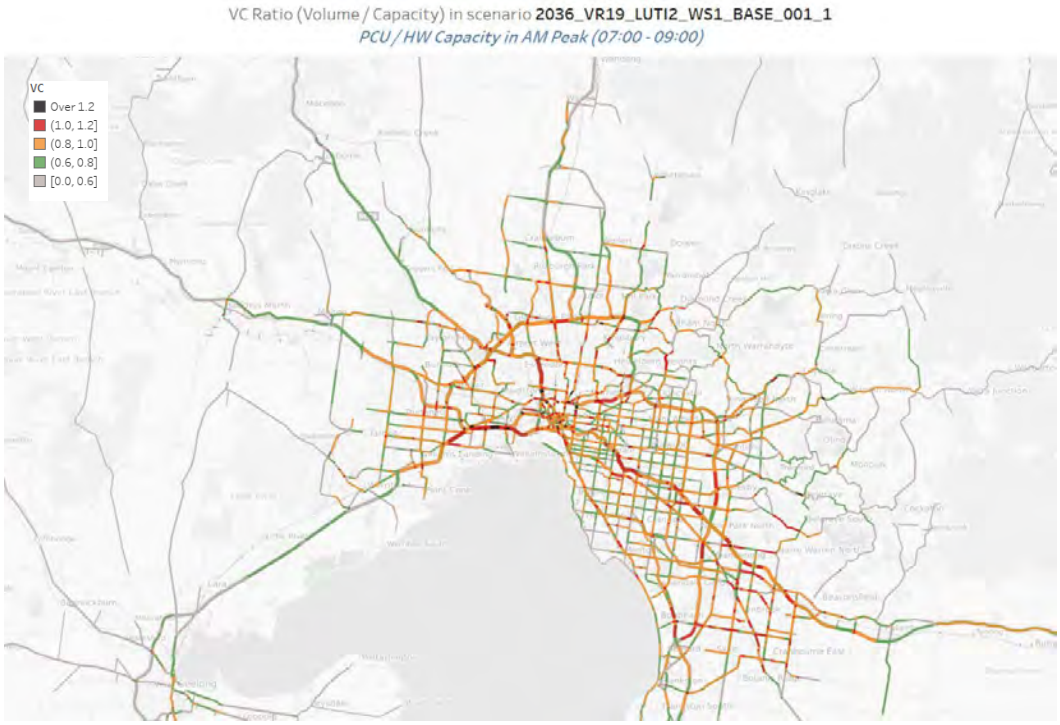
4.2.3 The impact on Melbourne freeway congestion is mixed

Road congestion is a function of both traffic volume and road capacity. The following two figures show the volume to capacity (V/C) for the base case and the medium working from home scenario in 2036. A comparison between the two V/C plots shows multiple bottlenecks appearing across the freeway network as a result of working from home. Consistent with more people living in outer areas and employment centralising in inner Melbourne, many of the radial freeways become more congested.

High demand along the inbound south eastern Monash Freeway corridor increases the level of congestion. This means more sections of the freeway become over-capacity, including sections from Hallam towards Doveton and Dandenong North. Higher congestion is limited to inbound lanes, as noted in section 4.2.2, outbound volumes on the Monash Freeway are lower compared to the base case.

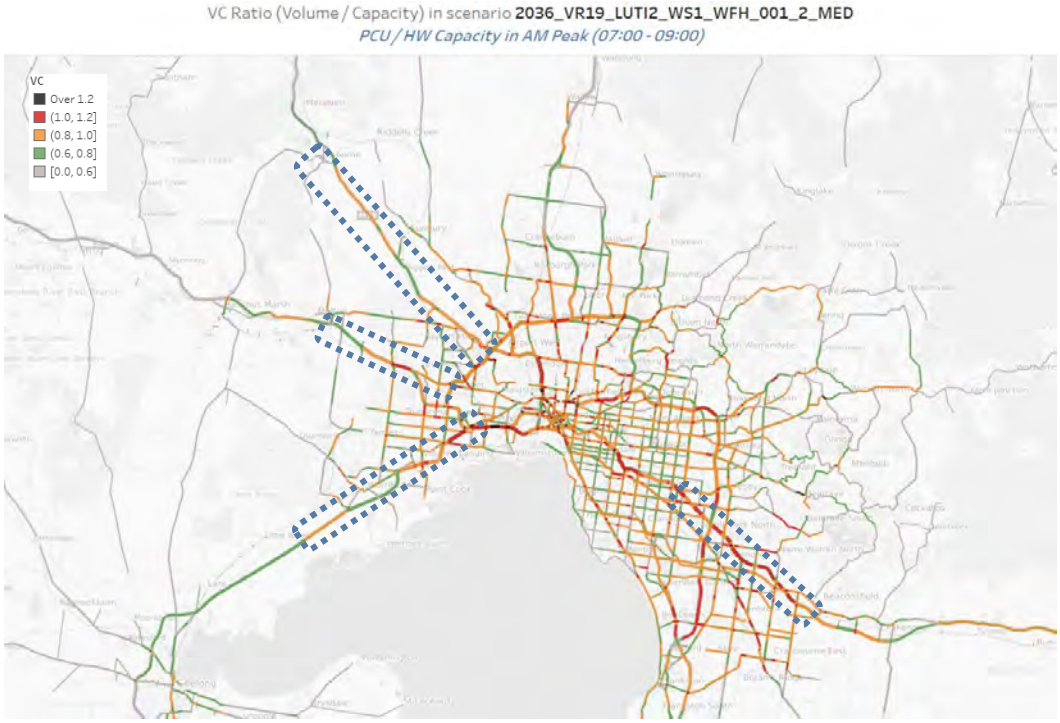
Congestion on the Princes (inbound from Geelong), Western and Calder Freeways also worsens, with many sections of these freeways having bottlenecks near major interchanges. Notable areas include the Western Freeway, travelling towards the Deer Park Bypass and the Calder Freeway, near Kings Road. Congestion along almost all major freeways leading towards Melbourne in the AM peak begins farther out from inner Melbourne than in it does under the base case.

Figure 32. Volume capacity ratio, base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Figure 33. Volume capacity ratio, WFH medium, AM peak, 2036

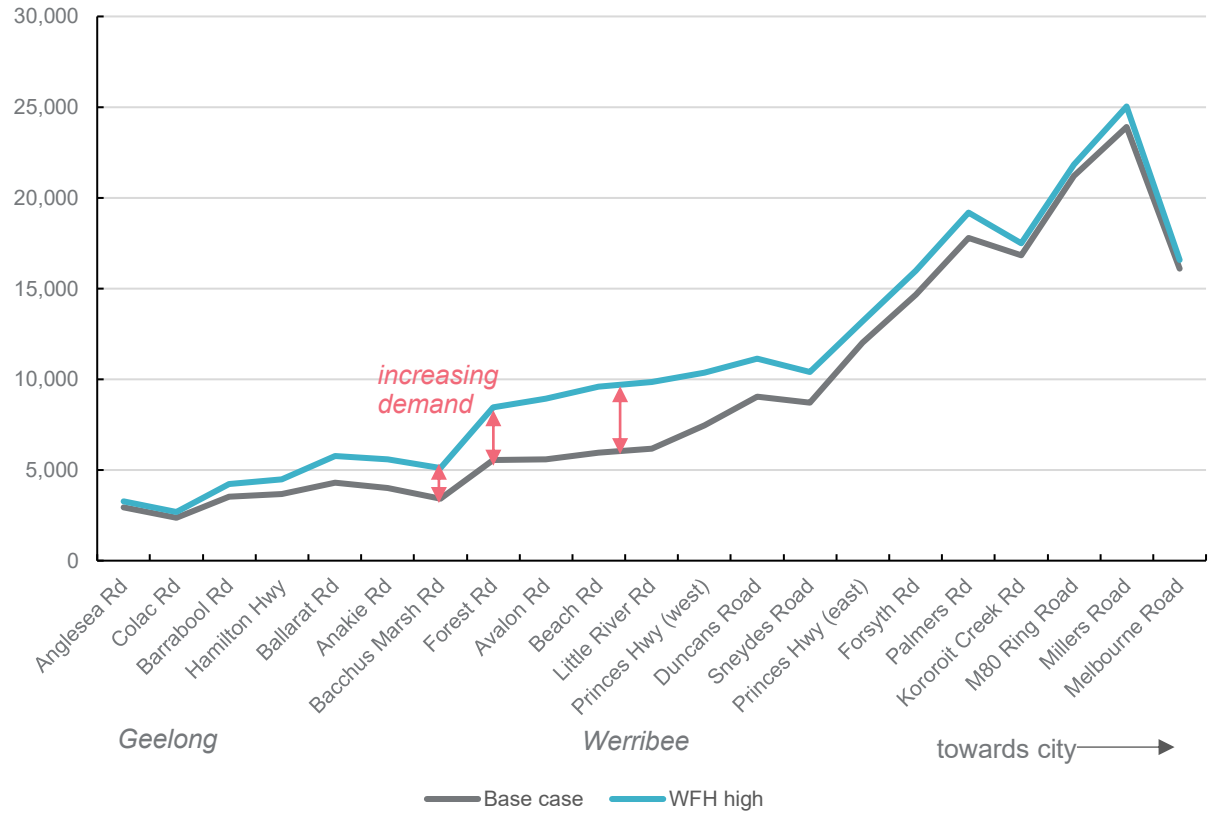


Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

A detailed look at road volumes on one of the most-impacted roads, the Princes Freeway heading inbound from Geelong during the AM peak, is a good example. The following figure shows total road volumes in the base case and working from home high scenario.

Beginning near Waurn Ponds (Anglesea Rd) heading inbound, the Princes Freeway experiences a gradual increase in road volumes, compared with the base case. The largest change in road volumes between the base case and scenario is located around Werribee, before steadily reducing back to base case levels as the Princes Freeway approaches the city and the West Gate Tunnel and bridge. At Werribee (Princes Hwy (west)), the difference between the high working from home scenario and base case is just under 3000 additional vehicles for the AM peak. Another way to frame this challenge is the following: traffic volumes near Point Cook (Sneydes Rd) in the base case are already being recorded as far out as Lara (Avalon Rd) in the working from home high scenario, putting extra pressure on the corridor much earlier on in the commute to Melbourne. Although smaller in magnitude, this trend also exists in the working from home low and medium scenarios.

Figure 34. Road volumes, Princes Freeway, base case and WFH high, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021
Note: By Melbourne Road, West Gate Tunnel traffic has entered the tunnel portal and is no longer included in the line count.

4.2.4 More long-distance public transport commuters

The following table shows the difference in boardings across Victoria, for train, tram, bus and V/Line, using the working from home medium scenario, compared to the base case. Although metro train boardings are slightly lower (under 1%), boardings during the interpeak and off-peak periods are higher.

The largest increase occurs during the 9am to 3pm interpeak period with around 26,000 extra boardings, equivalent to 33 fully loaded trains.[44] This is due to many of the non-commuting trips people make over the course of a day. In this case, while many residents have relocated farther away from the central city, many of their social, recreational and in some cases, shopping trips can stay fixed, meaning that they could be travelling farther than they previously did. With longer trips, the generalised cost for travel by car also increases. In this situation, a viable alternative is to take public transport (often metro train), with comparably lower generalised cost, leading to more train trips during the interpeak and PM peak periods, compared to the base case.

With many bus and tram services operating in and around inner Melbourne and middle Melbourne, where population is relatively smaller with working from home, there are fewer boardings across many hours of the day for these two modes. V/Line services for commuters in regional Victoria and Melbourne new growth areas have more boardings across all time periods, compared to the base case. These services experience the greatest percentage increase of any mode—up to 7.7% for PM peak services (3pm to 6pm on an average non-school holiday weekday). This reflects both the dispersion of population and concentration of employment within inner Melbourne.

Figure 35. Public transport boardings, by mode and time period, WFH medium vs. base, 2036

Boardings (State)	WFH medium vs. base case (change in boardings)	WFH medium vs. base case (% change)
Metro Train		
AM Period	-2,669	-0.61%
IP Period	26,305	6.52%
PM Period	18,601	3.60%
OP Period	-3,466	-0.96%
Tram Boardings		
AM Period	-2,499	-1.22%
IP Period	1,651	0.58%
PM Period	4,377	1.57%
OP Period	-9,787	-4.61%
All Bus Boardings		
AM Period	-4,122	-2.56%
IP Period	3,624	1.80%
PM Period	-1,118	-0.51%
OP Period	-5,112	-3.34%
VLine Boardings		
AM Period	2,653	5.95%
IP Period	3,238	7.39%
PM Period	3,941	7.70%
OP Period	1,341	4.16%

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021
Note: Time periods are for an average non-school holiday weekday.
Morning (AM) peak): *7am to 9am*
Inter-peak (IP): *9am to 3pm*
Evening (PM) peak: *3pm to 6pm*
Off-peak (OP): *6pm to 7am*

[44] *Based on the capacity of the X'Trapolis fleet (standard seated plus standing capacity for a six-car set)*

The following map shows this change in boardings spatially for all public transport modes for the working from home high scenario. Blue lines represent higher passenger numbers along the corridor while red represents lower passenger numbers, compared to the base case.

Figure 36. Change in public transport patronage, WFH medium vs base case, AM peak, 2036

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Similar to the redistribution of private vehicle volumes on the road network, metro and V/Line trains servicing long-distance radial routes experience higher demand while services around inner parts of Melbourne experience a reduction. This is most notable on the Pakenham/Cranbourne, Werribee and Sunshine rail corridors.

Many tram routes through Melbourne's central city have fewer passengers compared to the base case. This is also evident in inner areas around the central city, although the effect weakens with distance from the central city. The majority of bus services, represented by a network of faint red lines, also have fewer passengers. Overall, public transport services experience strong growth in regional and radial metropolitan services, while orbital routes around inner and middle Melbourne experience a reduction in boardings.

The following table shows the magnitude of crowded passenger hours travelled within inner Melbourne and middle Melbourne. Many services in Melbourne's outer and new growth areas only reach highly crowded levels as they travel closer towards inner Melbourne in the AM peak. This suggests that once factoring in base levels of demand, the change in travel patterns means that the proportion of crowded travel in areas of middle Melbourne almost doubles on metro train services in the high working from home scenario. A large increase in crowded travel around inner Melbourne is also experienced.

The Pakenham metro train line is an example of this phenomenon with all working from home scenarios leading to higher levels of crowding farther outwards along the line. Figure 38 illustrates total train load (sum of all AM peak services) for services departing Pakenham in the high working from home scenario.

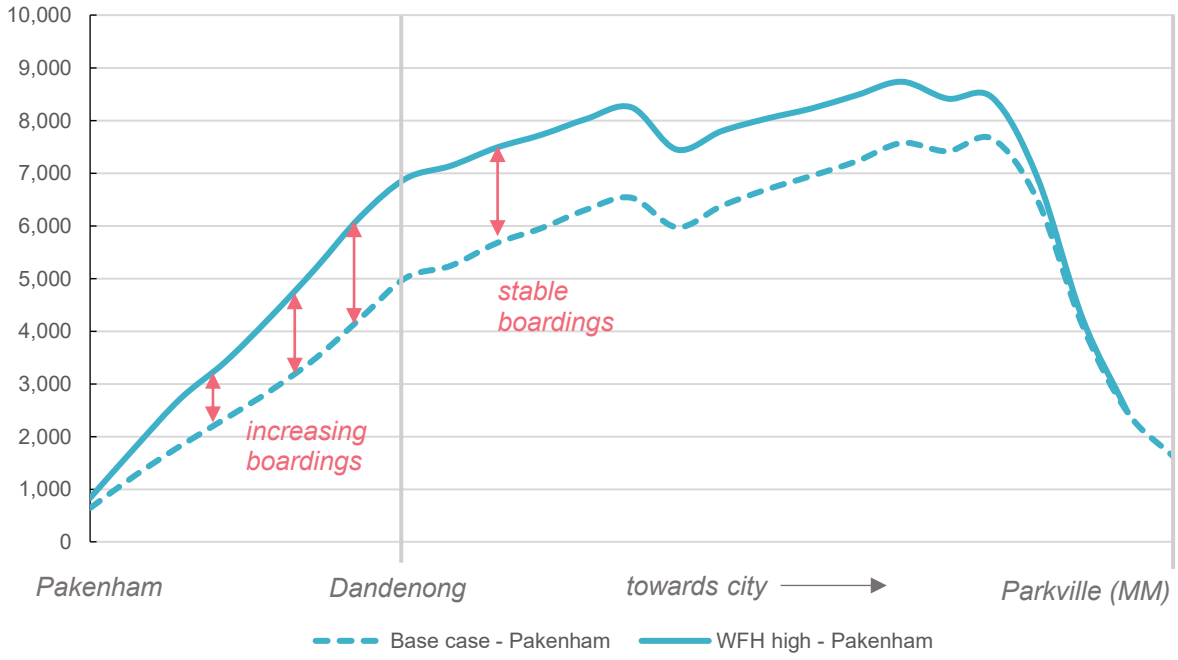
For the section of line between Pakenham and Dandenong stations, the total number of boardings at each station gradually increases until Dandenong, located in outer Melbourne. Once entering into middle Melbourne (after Dandenong), the total number of boardings remains relatively stable in both base case and high working from home scenario. With the increased boardings in the high scenario in outer areas, this means inner and middle areas are more congested.

Figure 37. Crowded train passenger hours travelled, WFH scenarios vs base case, AM peak, 2036

FUA	Base	WFH Low	WFH Medium	WFH High
Inner Melbourne	20.2%	0.0%	6.7%	12.5%
Middle Melbourne	14.5%	0.2%	3.1%	13.1%
Outer Melbourne	0.0%	0.0%	0.0%	3.7%
Melbourne New Growth Areas	0.0%	0.0%	0.0%	0.0%
Regional Cities	0.0%	0.0%	0.0%	0.0%
Regional Centres and Rural Areas	0.0%	0.0%	0.0%	0.0%

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021
Note: The WFH scenarios data shown in the table is the change from the base case.

Figure 38. Train patronage, Pakenham corridor, base case and WFH high, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

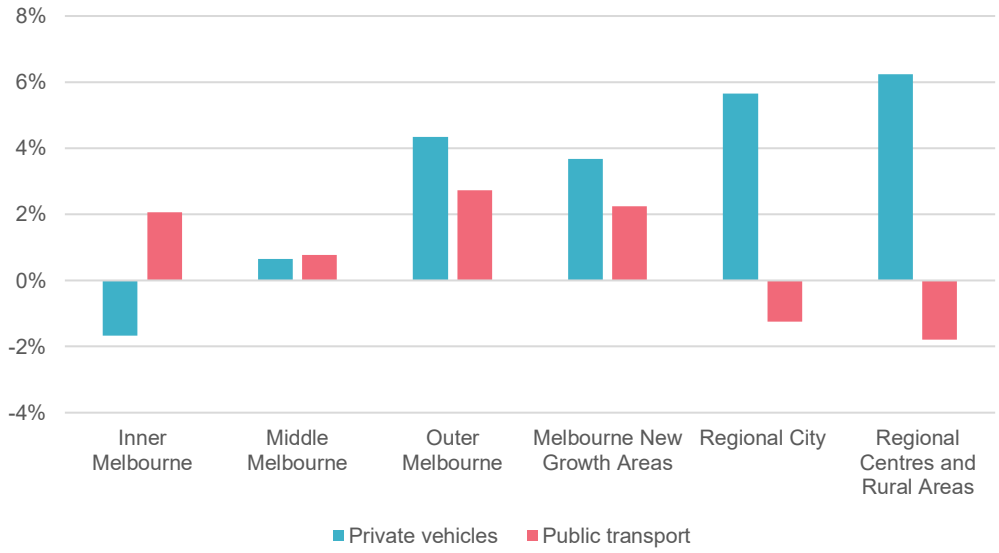
4.2.5 Rising travel times as commuters cover greater distances

The following figure shows the change in travel times originating from the FUAs in the AM peak. Private vehicle trip times increase as a result of two factors, compared to the base case:

- Drivers are travelling longer distances in general
- There are higher levels of congestion along some corridors, such as major freeways travelling into inner Melbourne.

Together, these two factors contribute to increasing private vehicle travel times, especially for outer Melbourne, New growth areas and beyond. An inverse effect applies to travel times in inner Melbourne. With fewer people living within the area, private vehicles experience lower levels of congestion outside of freeways, resulting in faster average trip times. Travel times for public transport are higher across all areas in Greater Melbourne, likely due to population dispersion towards outer areas which are farther from employment and therefore require a longer trip.

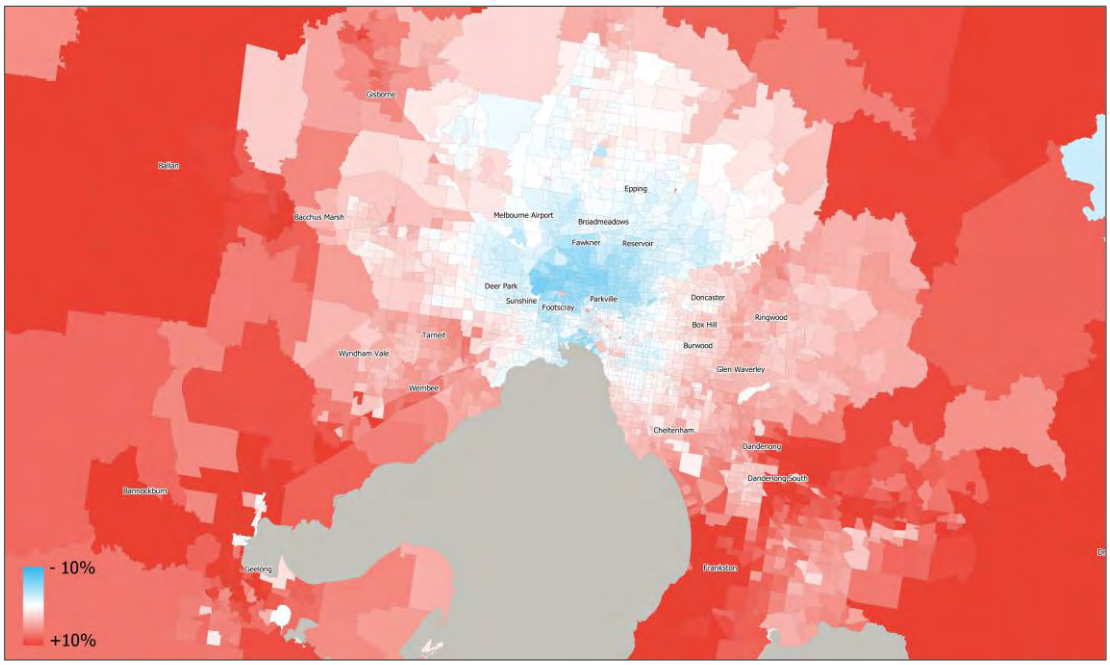
Figure 39. Average trip times (origin), WFH medium vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Shown spatially in Figure 40, small reductions in private vehicle travel times occur in inner northern areas of Melbourne, likely due to reduced congestion in these areas from the land use impacts of increasing work from home. Travel time reductions turn to travel time increases farther away from the central city. This is due to employment concentrating within the inner city meaning some workers must travel farther to work, especially those who would have otherwise lived closer to inner Melbourne.

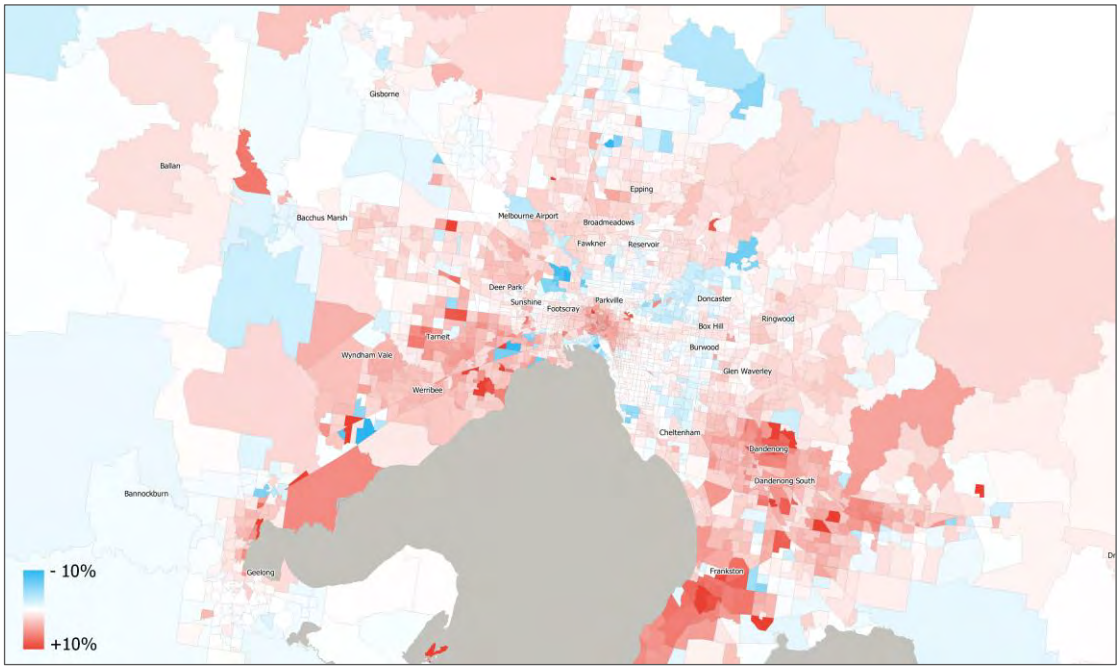
Figure 40. Change in private vehicle average trip times (origin), WFH medium vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Travel time changes are moderate for public transport, when compared with private vehicles. However, localised increases in travel times (shown in Figure 41) from areas of Dandenong, Frankston and Tarneit via public transport are observed during the AM peak. This is potentially a result of higher demand (and crowding) along the Pakenham/Cranbourne and Wyndham Vale RRL corridors related to the dispersion of population to outer Melbourne and new growth areas as well as the concentration of employment in inner Melbourne. This pattern may also be the result of people from these areas travelling farther, which is takes longer.

Figure 41. Change in public transport average trip times (origin), WFH medium vs base case, AM peak, 2036

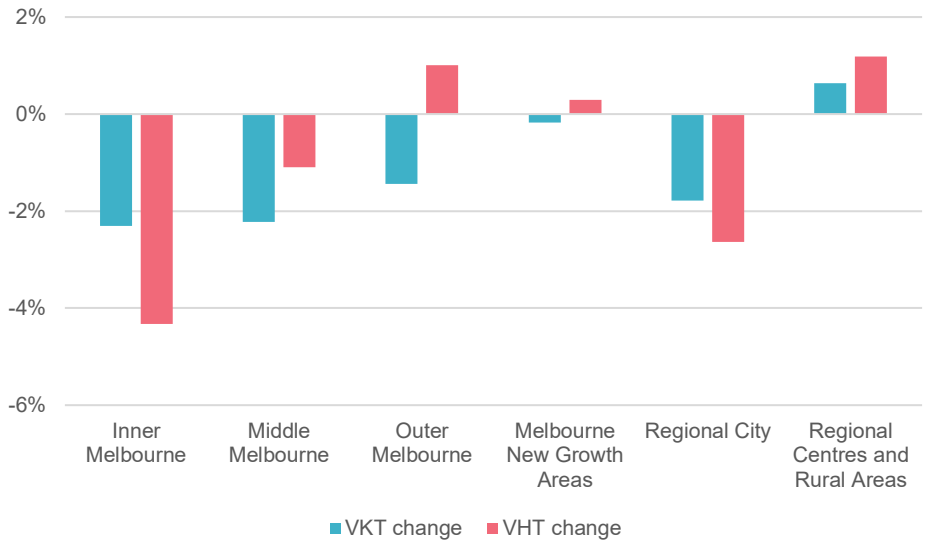


Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

The following two figures show network performance indicators of vehicle kilometres and hours travelled as well as public transport kilometres and hours travelled.

On the road network, most regions experience a decrease in total time travelled greater than the decrease in total distance travelled. This means that on average, travel via private vehicle is covering longer distances, in less time. This is likely due to the reduction in overall vehicle trips, but also a shift to long-distance commuting, utilising the freeway network across Victoria and travelling at higher speeds. Across Victoria, private vehicle trips also lengthen, with average vehicle trip lengths increasing by around 4%. Origin-destination data in the following section describes this trend spatially.

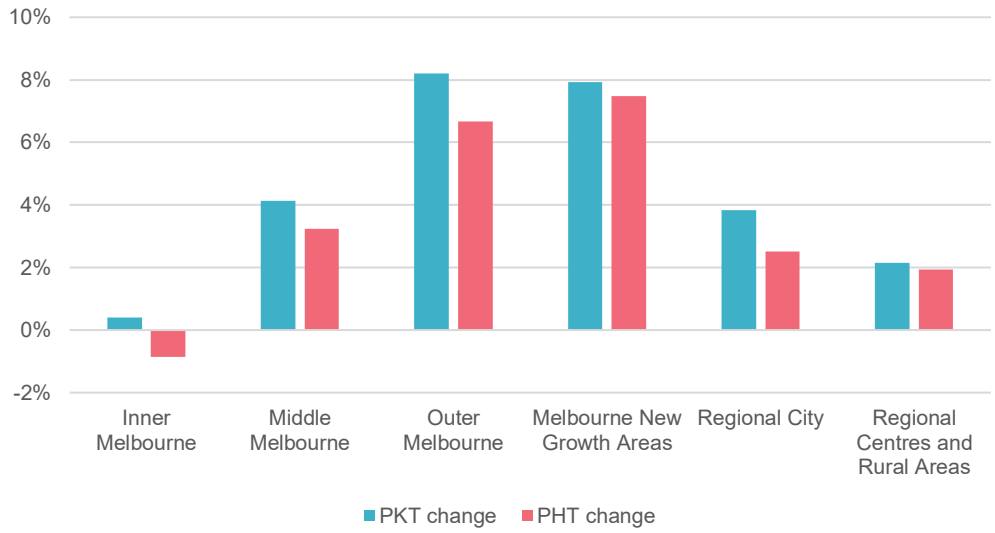
Figure 42. Change in vehicle kilometres travelled (VKT) and vehicle hours travelled (VHT), WFH medium vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

Due to the increase in public transport mode share, both total distance and hours travelled on public transport increase with working from home. Figure 43 shows that the proportional increase in distance travelled on public transport is greater than the increase in time on public transport. Therefore, while trips are getting longer, they are also being undertaken at higher speeds. Similar to the road network, this trend is likely driven by longer-distance commutes towards the central city on the metropolitan and regional rail lines. This is also supported by average public transport trip lengths, increasing by over 6% across the state. Again, this reflects the dispersion of people from inner areas (which have relatively shorter public transport commutes) to outer areas which have longer public transport commutes.

Figure 43. Change in passenger kilometres travelled (PKT) and passenger hours travelled (PHT), WFH medium vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

4.2.6 Less local travel

The following figures show changes in travel by origin and destination pairs for the working from home medium scenario. For private vehicles, as illustrated in Figure 44, there are fewer trips which start and end within the same area, indicating less local travel. Origin locations are identified for each row while destinations are located at the top of each column. For example, the 12,000 fewer private vehicle trips within inner Melbourne are represented by the top left red square in Figure 44.

However, despite fewer trips occurring within the same FUA, there is a pattern of more trips occurring that begin from further out and travel inwards to inner Melbourne. This is shown by the gradual shading of blue squares towards the lower left hand corner of the Origin-Destination matrix. Of all increases in trips, the largest increase is from outer Melbourne travelling to middle Melbourne, a reflection of the strong concentration of employment shifting towards the inner and middle ring suburbs. Also noteworthy is the increase in drivers from regional cities and regional centres and rural areas FUAs, now travelling towards outer Melbourne and new growth areas. Despite the increase in private vehicle trips (blue) being small compared to the reduction private vehicle trips (red), these changes in travel patterns place further pressure on the road network, resulting in greater levels of congestion on some roads as discussed in section 4.2.3.

Figure 44. Change in private vehicle origin-destination pairs, WFH medium vs base case, AM peak, 2036

Origin \ Destination	Inner Melbourne	Middle Melbourne	Outer Melbourne	Melbourne New Growth Areas	Regional City	Regional Centres and Rural Areas
Inner Melbourne	-12,095	-5,324	-504	-28	-0	-20
Middle Melbourne	-94	-26,940	-7,721	-297	2	-380
Outer Melbourne	1,999	2,570	-29,860	-4,399	-193	-1,868
Melbourne New Growth Areas	902	1,556	-2,910	-4,816	-264	-1,324
Regional City	58	118	1,137	1,134	-18,643	-866
Regional Centres and Rural Areas	335	544	2,223	2,061	-1,571	-13,765

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021
Note: Blue indicates more trips, compared to the base case, for the origin and destination pair. Red indicates less trips.

The trend of trips starting farther out and heading towards inner Melbourne is more concentrated around metropolitan Melbourne when looking at public transport trips, as shown in Figure 45. There are more trips from outer Melbourne and new growth areas heading towards inner Melbourne compared to the base case, while trips solely within inner Melbourne are lower.

Figure 45. Change in public transport origin-destination pairs, WFH medium vs base case, AM peak, 2036

Origin \ Destination	Inner Melbourne	Middle Melbourne	Outer Melbourne	Melbourne New Growth Areas	Regional City	Regional Centres and Rural Areas
Inner Melbourne	-16,019	-2,931	228	377	-2	-50
Middle Melbourne	1,010	-5,560	-1,656	-37	10	-77
Outer Melbourne	6,792	2,214	-2,559	-378	-37	-85
Melbourne New Growth Areas	2,900	1,566	-176	-592	-49	-67
Regional City	85	-20	114	194	-196	79
Regional Centres and Rural Areas	328	72	172	99	9	-42

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021
Note: Blue indicates more trips, compared to the base case, for the origin and destination pair. Red indicates less trips.

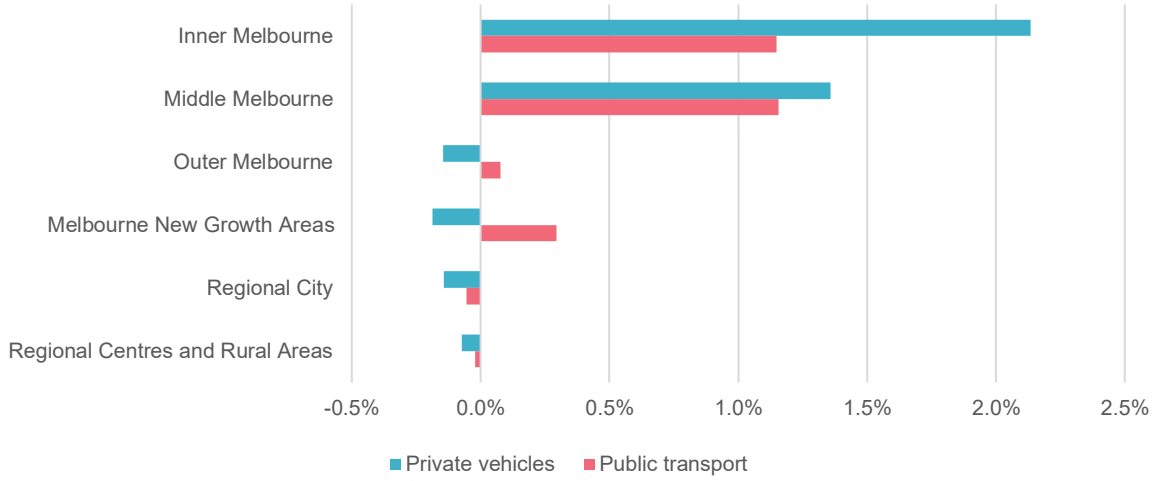
4.2.7 Inner and middle ring residents benefit from greater physical access to jobs

With more jobs centrally located in and around the central city under the working from home scenarios, inner Melbourne and middle Melbourne residents can physically access more jobs—travelling by both public transport and private vehicle.

Figure 46 shows changes in transport access to jobs by FUA. Transport access is defined as the proportion of jobs accessible from home locations via private vehicle or public transport within 45 minutes. With greater working from home, more jobs are physically located in inner Melbourne and fewer jobs are located across the remainder of Victoria. This causes accessibility to jobs via private vehicle to reduce in all areas outside inner and middle Melbourne. However, because of the radial public transport network, the additional central city jobs are now more accessible via public transport to those living in outer Melbourne and Melbourne new growth areas. This means these areas have higher access to jobs via public transport, compared to the base case.

This particular metric of transport access to jobs does not account for the greater job accessibility being able to work from home enables.

Figure 46. Change in transport access to jobs (within 45 minutes), WFH medium vs base case, AM peak, 2036



Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

4.2.8 Most regions have slightly lower vehicle emissions

With fewer private vehicle trips in the working from home scenarios, there are also fewer emissions from vehicles in most areas. Emissions are calculated from the travel patterns of cars and trucks within VLUTI, as a function of distance travelled and network speeds. The following chart shows the difference in daily emissions (CO_2 metric tonnes) between the working from home scenarios and the base case.

This metric only captures emissions from the number of cars and trucks using the road network and does not include public transport emissions. It also assumes all vehicles are powered by internal combustion engines in the base case and working from home scenarios. In reality, it is likely that over coming years an increasing proportion of the fleet will be zero emissions vehicles. In this case, there would be less of a difference between base case and working from home scenario emissions. However, the full transition of private vehicles to zero emissions vehicles is not expected for several decades.[45]

In inner, middle and outer Melbourne, emissions are lower, in line with the transport impacts of working from home. The high scenario sees the greatest reduction in vehicle emissions (compared to the base case) for outer Melbourne—approximately 867 metric tonnes of CO_2. This reduction is equivalent to the amount of CO_2 sequestered by over 400 hectares of forest.[46]

The only increase in emissions is found in the high scenario in regional centres and rural areas. This increase, driven by population redistribution to the peri-urban areas, is offset by heavy reductions in vehicle emissions within Greater Melbourne.

The overall lower emissions for the working from home medium scenario is still relatively small: 0.6% fewer total emissions from vehicles, compared with the base case. The medium scenario has the greatest impact, recording 1392 fewer metric tonnes of CO_2 compared with the base case, equivalent to burning over 700,000 litres of fuel or the amount of CO_2 sequestered by around 690 hectares of forest This overall reduction is likely due to the emissions increase, as a result of longer distance travel being more than offset by the emissions reduction due to reduced congestion in the city and less travel in general.

[45] *Department of Environment, Land, Water and Planning, Victoria's Zero Emissions Vehicle Roadmap, 2021, Victorian Government, https://www.energy.vic.gov.au/__data/assets/pdf_file/0014/521312/Zero-Emission-Vehicle-ZEV-Roadmap-FINAL.pdf*

[46] *United States Environmental Protection Agency, Greenhouse Gas Equivalencies Calculator, 2021, United States government, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator*

Figure 47. Change in CO_2 emissions, daily total (metric tonnes), WFH medium vs base case, 2036

CO2 emissions (metric tonnes)	*Change compared to Base* WFH low	WFH med	WFH high
Inner Melbourne	-62	-150	-182
Middle Melbourne	-207	-446	-621
Outer Melbourne	-263	-478	-867
Melbourne New Growth Areas	-40	-36	-7
Regional City	-97	-109	-81
Regional Centres and Rural Areas	-385	-172	446
TOTAL Victoria	**-1053 (-0.47%)**	**-1392 (-0.62%)**	**-1312 (-0.58%)**

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

4.3 Economic activity concentrates in inner Melbourne

This section explores some of the high-level economic outputs of the working from home scenarios.

Gross local product (GLP) measures economic activity and is equivalent to gross domestic product (GDP), but at a local, rather than national, level. Working from home results in firms locating more centrally within Melbourne, and this subsequently concentrates economic activity, as measured by GLP. Accordingly, inner Melbourne sees an uplift in economic activity of around 4% in 2036 in the medium scenario compared to the base case. As illustrated in Figure 48, the economic impact of working from home in other areas is more muted. Areas which have less employment, compared to the base case, generally see less GLP compared to the base case. This includes outer Melbourne, regional cities, and regional centres and rural areas, which all see lower economic activity compared to the base case.

Our modelling reduces the costs of commuting for some occupations. With lower transaction costs of travel there is an efficiency gain in the economy. Additionally, occupations which can work from home, such as professional services, tend to be in more productive industries, and these jobs are concentrating to benefit from agglomeration economies.[47] With reduced travel costs, workers shifting to more productive occupations, and jobs clustering more tightly, the modelled net change to Victorian GLP is positive, at around 1% higher in the medium scenario, compared to the base in 2036.

Figure 48. Change in Gross Local Product, WFH scenarios vs base case, 2036

[47] *As evident in working from home occupations tending to be better paid and having higher skill levels, see Figure 1.*

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

The occupations which can work from home experience an increase in employment across Victoria. This is illustrated in Figure 49. This includes traditionally office-based occupations of managers, professionals, and administration workers. Professionals and administration workers have more employment of around 1.5% and 2.1% respectively, in the medium scenario compared to the base case, while managers increase by 0.3%. This is due to the increase in relative attractiveness of employment in these occupations with the shift to working from home. Working from home enables a greater pool of jobs to be accessed from any given location for these occupations. All other occupations have less employment, as a result of decreased relative attractiveness. This includes machinery operators and labourers, which each have around 2% less employment in the medium scenario compared to the base case.

Figure 49. Change in employment by occupation, WFH scenarios vs base case, 2036

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

The pattern of employment change is generally inversed for changes in wages by occupation, as shown in Figure 50. Those occupations which have higher employment compared to the base case typically have lower wages compared to the base case. This is due, in part, to the increased attractiveness of occupations which are able to work from home, bringing more workers into those occupations (that is, labour supply increases), and subsequently lower wages. Conversely, occupations from which workers have moved away typically experience an increase in wages, such as labourers, machinery operators and community service workers—occupations in which there are no work from home jobs in our modelling assumptions.

Figure 50. Change in wages by occupation, WFH scenarios vs base case, 2036

Source: Infrastructure Victoria analysis of ARUP and Victoria University, Working from home VLUTI modelling, 2021

5. Appendix: working from home and location – historical analysis

This appendix provides an overview of our analysis of working from home and home location, prior to COVID-19, using the Household Income and Labour Dynamics in Australia survey.

5.1 We have tested the historical relationship between working from home and location

The VLUTI modelling results show a dispersion of population with increasing working from home in the future. This implies a relationship between more working from home, a reduction in the need to commute, and households locating farther from city centres.

To test for historical evidence of this relationship, we have analysed Australian data from the past two decades. Our analysis draws on established international literature which has studied the relationship between working from home, commute time, and urban form.[48]

For our analysis we are using the Household Income and Labour Dynamics in Australia survey (HILDA). HILDA is a household-based panel study which has run since 2001 and surveys more than 17,000 Australians about many aspects of their lives. HILDA follows the same individuals throughout their lifetime, asking them the same set of questions year to year. This allows us to understand how changes in an individual's life may change their behaviour. The latest available version of HILDA at the time of our analysis covered 2001 to 2019, therefore the impacts of COVID-19 are not included in this analysis.

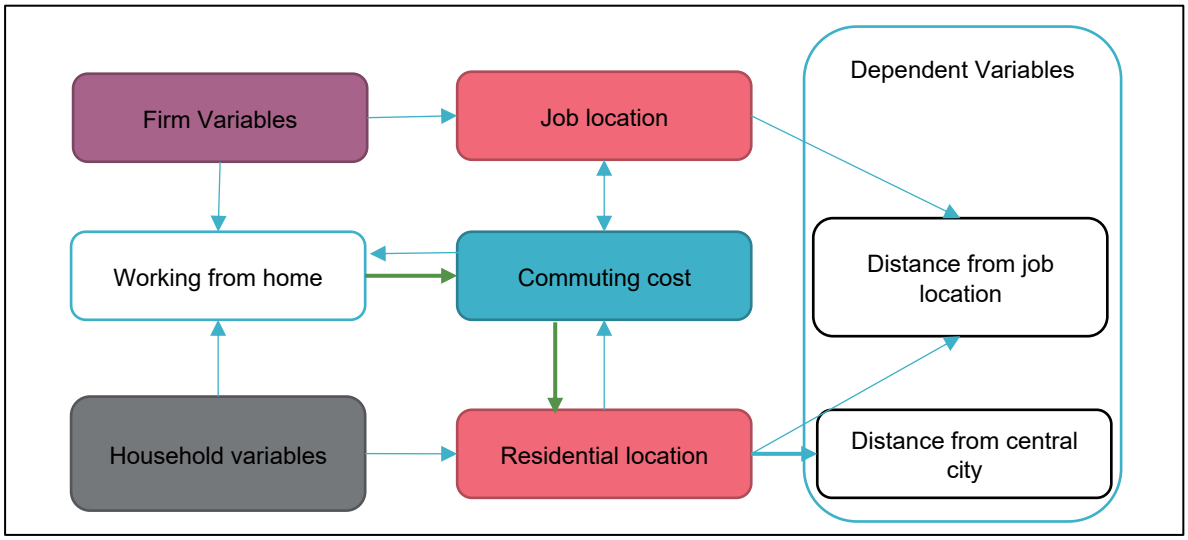
5.2 There are empirical challenges in establishing a relationship

Establishing the impact of working from home on residential location poses some empirical challenges. The decision to work from home and where a household resides is a joint decision, meaning the knowledge of both factors influence each other. For example, an employee who resides in a peri-urban area and commutes to the central city may advocate more strongly to be able to work from home than an employee with a shorter commute. In this case a mis-specified model may overstate the effect of working from home, as it cannot separate the group of workers with longer commutes who opt into working from home because of their long commute, from those who work from home, and as a result lengthen their commute.

These complications are illustrated in our theoretical framework in Figure 51. In our model, we are looking to identify the direction of causality indicated by the green arrows (the impact of working from home on residential location) but risk biasing our estimator due to the direction of causality which flows in the opposite direction, the blue arrows.

[48] *For example: de Vos, Duco, Evert Meijers, and Maarten van Ham, Working from home and the willingness to accept a longer commute, 2018, The Annals of Regional Science, 61(2); Kim, Sun-Wung, Impact of telecommuting policies on urban spatial structure and the environment: Home-based and center-based telecommuting, 1997, Unpublished doctoral dissertation, Regional Science Program, University of Pennsylvania; Andreev, Pavel, Ilan Salomon, and Nava Pliskin, State of teleactivities, 2010, Transportation Research Part C: Emerging Technologies, 18(1); Kim, Seung-Nam, Patricia L. Mokhtarian, and Kun-Hyuck Ahn, The Seoul of Alonso: New perspectives on telecommuting and residential location from South Korea, 2012, Urban Geography 33(8)*

Figure 51. A theoretical framework for the impact of working from home



Source: Infrastructure Victoria, 2021

5.3 Our model specification draws on established methods

To help establish the impact of working from home on household location, we have selected a 'fixed effects' model. This draws on the method used in a Netherlands analysis of the long-term effects of working from home on commute time.[49]

The fixed effects model takes advantage of the panel dimension of HILDA and observes only changes in working from home (the independent variable) with changes in household location (the dependent variable). As the model only observes changes, the impact of residential and commuting preferences which do not change over time will be excluded. This means the potential for reverse causality (that is, location influencing working from home), is reduced. For example, a peri-urban household which opted into working from home but did not change residential location would be excluded from the model. On the other hand, a household which began working from home and then relocated farther from the central city, into a peri-urban area, would be captured. While a fixed effects model can help focus the analysis, reverse causality may not be eliminated entirely.

We have tested two dependent variables in separate models: the existence of a formal working from home arrangement, and the number of hours worked from home. A formal arrangement indicates that the respondent has answered yes to 'Are hours worked at home the result of formal arrangement with employer?'.[50] The hours worked from home variable is the number of hours worked from home over a usual week.[51]

The independent variable of interest is home distance to central city. We synthesised this variable based on household postcode. This serves as a proxy for distance to employment, which has only been included as a question in recent years, and would prohibitively cut our sample size if we used it. The use of distance to central city is a reasonable approximation as employment for all occupations which are suited to working from home is generally concentrated in the central city.[52] Furthermore it allows for a direct comparison to our VLUTI results which see a dispersion of population away from central cities with more working from home.

To address the additional challenge of residential location changing infrequently, we have used the full 19 years of available HILDA data. We also include a number of control variables of individual and household characteristics to account for the impact of things like having children or changes in income as well as other control variables to account for differences between Australian cities.

[49] *de Vos, Duco, Evert Meijers, and Maarten van Ham, Working from home and the willingness to accept a longer commute, 2018, The Annals of Regional Science, 61(2)*

[50] *Melbourne Institute: Applied Economic & Social Research, Household, Income and Labour Dynamics in Australia (HILDA) Survey Online Data Dictionary Release 19.0, 2021, University of Melbourne, https://www.online.fbe.unimelb.edu.au/HILDAodd/KWCrossWaveCategoryDetails.aspx?varnt=jbmagh*

[51] *Melbourne Institute: Applied Economic & Social Research, Household, Income and Labour Dynamics in Australia (HILDA) Survey Online Data Dictionary Release 19.0, 2021, University of Melbourne, https://www.online.fbe.unimelb.edu.au/HILDAodd/KWCrossWaveCategoryDetails.aspx?varnt=jbmagh*

[52] *Kelly, Jane-Frances and Peter Mares, Productive cities, Opportunity in a changing economy, 2013, Grattan Institute, https://grattan.edu.au/wp-content/uploads/2014/04/188_productive_cities.pdf*

To further refine the model, we also restrict the sample to occupations which can feasibly work from home, consistent with that used for the VLUTI modelling (see Section 3.6.1). These occupations are traditionally office-based and in knowledge-intensive industries. We also restrict the sample to individuals in Australia's major capital cities: Melbourne, Sydney, Perth, Brisbane, and Adelaide. We define these areas as a radius of 80km from the city centre, as this generally captures capital cities as one functional urban area.

5.4 There is a significant effect of working from home on household location

The modelling results find a small positive effect of a formal working from home arrangement on household distance to the city centre. Our results show an employee with a formal working from home arrangement lives, on average, 2% farther from the central city area. The estimated coefficients for the model explaining distance to the city centre is shown in the following table. The estimated coefficients can be interpreted as percentage change to distance to the city centre.[53] We found consistent results for the effect of a formal working from home arrangement over a variety of model specifications.

Figure 52. Estimated fixed effects model, distance to central city

Variables	Estimated coefficient	Robust standard errors	Significant at 95% level
Age	0.00217	0.00575	*
Age^2	0.00004	0.00006	
NSW	-0.14871	0.17006	
VIC	-0.12783	0.14766	
QLD	-0.14591	0.16723	
SA	-0.43084	0.19449	*
WA (omitted)			
Hours Worked per week	-0.00123	0.00048	*
Formal working from home arrangement	0.02040	0.01008	*
Log Weekly Wage	-0.02675	0.00171	*
Log Household Income	0.00603	0.00171	*
No. Bedrooms in house	0.16791	0.00856	*
Children under 4	0.08668	0.01093	*
Children 5 - 14	0.03651	0.00950	*
Children 15 - 24	0.00290	0.00921	
Children 25+	-0.02085	0.01078	
Constant	2.18263	0.18474	*
Dependent variable	Log of home distance to central city		
R-squared	0.11		
Number of Observations	38,532		
Number of individuals	7,736		

Source: Infrastructure Victoria analysis of Department of Social Services (DSS), Household, Income and Labour Dynamics in Australia Survey, 2021.
Note: Industry of work variables included in the model but not displayed in the table, all were not significant at the 95% level.

[53] *As the dependent variable, distance to central city, is in log form.*

We also tested the impact of the number of hours worked from home but did not observe a consistent effect over various model specifications. This could be related to how hours worked from home are reported in HILDA. Hours worked from home per week are reported but the number of days worked from home are not. This makes it harder to discern the link between working from home, the need to commute, and subsequently home location.

Ultimately, we have found evidence that a formal working from home arrangement is associated with an increase in a household's distance to the city centre. This is broadly consistent with the relationship between working from home and household location demonstrated in our VLUTI modelling results.

About us

Infrastructure Victoria is an independent advisory body, which began operating on 1 October 2015 under the *Infrastructure Victoria Act 2015*.

Infrastructure Victoria has three main functions:

- preparing a 30-year infrastructure strategy for Victoria, which is refreshed every three to five years
- providing written advice to government on specific infrastructure matters
- publishing original research on infrastructure-related issues.

Infrastructure Victoria also supports the development of sectoral infrastructure plans by government departments and agencies.

The aim of Infrastructure Victoria is to take a long-term, evidence-based view of infrastructure planning and raise the level of community debate about infrastructure provision.

Infrastructure Victoria does not directly oversee or fund infrastructure projects.

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