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Secretary's foreword

By David Martine

The Department of Treasury and Finance (DTF) provides leading financial and economic advice to the Victorian Government on the allocation of resources to make Victoria a better place to live, now and into the future.

Victoria's Economic Bulletin is a snapshot of staff research being undertaken at DTF that improves our understanding of the Victorian economy. Our research program delivers new, evidence-based insights to support the provision of better advice to government. It is integral to refining our approaches to economic modelling and innovating to solve complex operational and policy problems. By publishing a selection of our work, we hope to contribute to the broader public policy debate on important economic issues, and highlight trends driving change in the Victorian economy.[1]

This fifth volume of Victoria's Economic Bulletin canvasses issues that are especially important at this time of change and heightened economic uncertainty. In responding to the coronavirus (COVID-19) pandemic we have strengthened our understanding of issues like the Victorian labour market and the economic effects of our taxation system. This has enabled a more nuanced approach to advising Government on policies to support our economic recovery and assist Victorian businesses and households through the pandemic.

The events of the past year have underlined the importance of having timely and accurate information on the state of the economy, and the first article in this volume examines techniques for producing higher frequency estimates of gross state product. The second article illustrates a methodology for understanding the underlying compositional drivers of changes in the unemployment rate, while the third article analyses the effect of recent reductions in Victoria's regional payroll tax rate. The final article considers the economic impact of the 2019-20 Victorian bushfires.

I hope these articles provide some insight into the contribution that our research makes to better public policy.

David Martine
Secretary

1 They reflect the views of the authors and not necessarily those of the Department.

Estimating quarterly gross state product[1]

By Bonnie Li and Grace Gao

ABSTRACT

This paper outlines a methodology to estimate the gross state product of Victoria, as well as other states, on a quarterly basis using a mixed-frequency vector auto-regressive model with stochastic volatility. Using these results, we uncover variation in economic performance across the states over the past 30 years and find a reasonably high degree of concordance.

1. Introduction

Growth in gross domestic product (GDP) is one of the most important indicators of a country's economic performance. However, the availability of such a measure at a sub-national level is often limited. In Australia, while GDP is available on a quarterly basis, at the state level, gross state product (GSP) is only available annually.[2] The lack of frequent and timely economic data for the states limits the ability of economists and policymakers to understand local economic conditions, which may differ significantly from the national experience.

This problem is not unique to Australia. Many economists have attempted to fill the data gap using various methods, including a bottom-up approach based on a range of surveys and proxies. Recently, Koop et al. (2020) took a top-down approach and estimated gross regional product (GRP) at the sub-national level in the United Kingdom (UK) using a mixed-frequency vector auto-regressive model with stochastic volatility (MF-VAR-SV). The model involves quarterly national GDP growth and other quarterly economic variables as well as unobserved quarterly regional economic growth, which was estimated in a state-space framework.

We adapt the model developed by Koop et al. (2020) to Australia and estimate GSP growth – the equivalent of GDP growth for states in Australia – for the past 30 years. Our estimates are comparable to historical publications by the Australian Bureau of Statistics (ABS) and Queensland Treasury's ***Queensland State Accounts***. We also identify economic cycles in each state and analyse their synchronisation using these estimates of quarterly GSP growth. Our results suggest several economic cycles at the state level which may have been masked by the annual data.

The remainder of this paper is organised as follows. Section 2 provides some background information on existing data and methodology. Section 3 outlines our adaptation of the recent developments in the literature to Australia. Section 4 presents the results. Section 5 discusses the economic cycles identified in the results and section 6 concludes the paper.

1 The authors are grateful for the generous assistance from James Mitchell and Aubrey Poon. This paper also benefited from comments from Anthony Rossiter. The views expressed are those of the authors and do not necessarily reflect the views of DTF.

2 Australian Bureau of Statistics (ABS) published quarterly GSP estimates for the first time in the December quarter of 1993 and the release was discontinued after the June quarter of 1997.

2. Background

GDP measures the value of goods and services that an economy produces in a period. A country's GDP can be measured using three approaches: production, income and expenditure. GDP measurement is often available at a quarterly frequency at the national level, but the availability of such a measure at a sub-national level is often more limited with respect to the frequency of the measurement and its components. This data limit poses significant constraints on the ability of researchers and policymakers to carry out economic analysis.

In Australia, the ABS publishes the Australian GDP quarterly but GSP is only available annually. While state final demand (SFD) and international trade for each state are available quarterly, both measures are only partial indicators of the economic activity and the remainder, interstate trade and inventories, is unavailable.[3] With GSP being a key economic indicator for states, it is unsurprising that many economists have sought to develop a more frequent indicator than the official annual publication. Researchers have often taken a bottom-up approach, focusing on understanding particular components of the economy for which official data is unavailable. An example is the Queensland Treasury's *Queensland State Accounts*, which takes the expenditure approach and estimates interstate trade and inventories using a range of partial indicators and survey results. Others have focused on production by industries, such as developing sub-national industrial production indices as proxies for economic growth. The bottom-up approaches are often based on a wide range of surveys and tend to provide a clear economic narrative, but their maintenance can be costly and time demanding.

Recently, Koop et al. (2020) have taken a different approach by adopting a top-down approach to estimate the gross regional product (GRP) for the 12 regions in the UK. They develop a mixed-frequency vector autoregressive model with stochastic volatility (MF-VAR-SV).[4] This approach exploits the availability of quarterly GDP at the national level and annual gross regional product for each of the sub-national regions. Cross-sectional and temporal restrictions are imposed to ensure that quarterly GRP estimates are consistent with observed quarterly GDP and the annual GRP figures. They further include national and regional explanatory variables in the model to better capture macroeconomic linkages and improve its performance.

The key advantages of this approach include its incorporation of existing official statistics, its transparency and its low cost. Compared with the low-frequency VAR method developed by Chow and Lin (1971), this approach makes use of an additional cross-sectional restriction and reduces the risk of model misspecification (Ghysels et al., 2011).

3. Methodology

This section provides an overview of our methodology which builds on Koop et al. (2020) and discusses the changes to adapt the model to Australia. The technical specification is detailed in Appendix A.

The model takes a state-space approach to estimate the unobserved quarterly GSP growth. The unobserved quarterly growth for the states is modelled together with observed national GDP growth using a quarterly vector auto-regressive model of up to 7 quarter lags.[5]

To better capture macroeconomic linkages, particularly with the external sector, Koop et al. (2020) include additional quarterly economic variables. At the national level, they include: the Bank of England Bank Rate, the exchange rate, the oil price and the consumer price index. Mirroring these inclusions, this paper includes the Reserve Bank of Australia (RBA) cash rate, the trade weighted exchange rate index, the RBA Commodity Price Index and the Consumer Price Index for Australia.

For the observed quarterly state-level variables, we include SFD for each state in the VAR framework. All variables enter the model in the first difference of logarithm, except for the cash rate which enters in levels. The choice to include other regional variables is significantly limited by data availability, particularly for historical data. Regional employment was also considered but it was found that it does not result in better model performance in Australia.

To ensure quarterly GSP growth is consistent with the official annual GSP growth, we set up a measurement constraint following the linear approximation of annual and quarterly GSP growth in Mitchell et al (2005) and Mariano and Murasawa (2010):

$$y_t^{r,A} = \frac{1}{4}y_t^r + \frac{1}{2}y_{t-1}^r + \frac{3}{4}y_{t-2}^r + y_{t-3}^r + \frac{3}{4}y_{t-4}^r + \frac{1}{2}y_{t-5}^r + \frac{1}{4}y_{t-6}^r \qquad (1)$$

where r is the quarterly GSP growth rate for region r in quarter t, and $y_t^{r,A}$ is the annual GSP growth rate for region r in quarter t that is only observed in quarter 4 of each financial year. This temporal constraint ensures that the interpolated quarterly estimates add up to the observed annual data, and preserves the linear structure of the state-space model.

For the cross-sectional restriction, we set that national GDP growth for a quarter equals the average GSP growth weighted by each state's share of the national economy in the previous financial year. This setting is different from Koop et al. (2020) which used a simple arithmetic average of regional growth. This change is necessary to appropriately model the divergence in economic growth across states over the study period, which saw Western Australia's share of the national economy increasing from 10 to 15 per cent.

3 GSP as measured by a single approach also includes a statistical discrepancy to account for the difference from the headline GSP measure, which is the average of three measures based on the income approach, expenditure approach and production approach.

4 Stochastic volatility is allowed to capture the change in volatility of residuals over time.

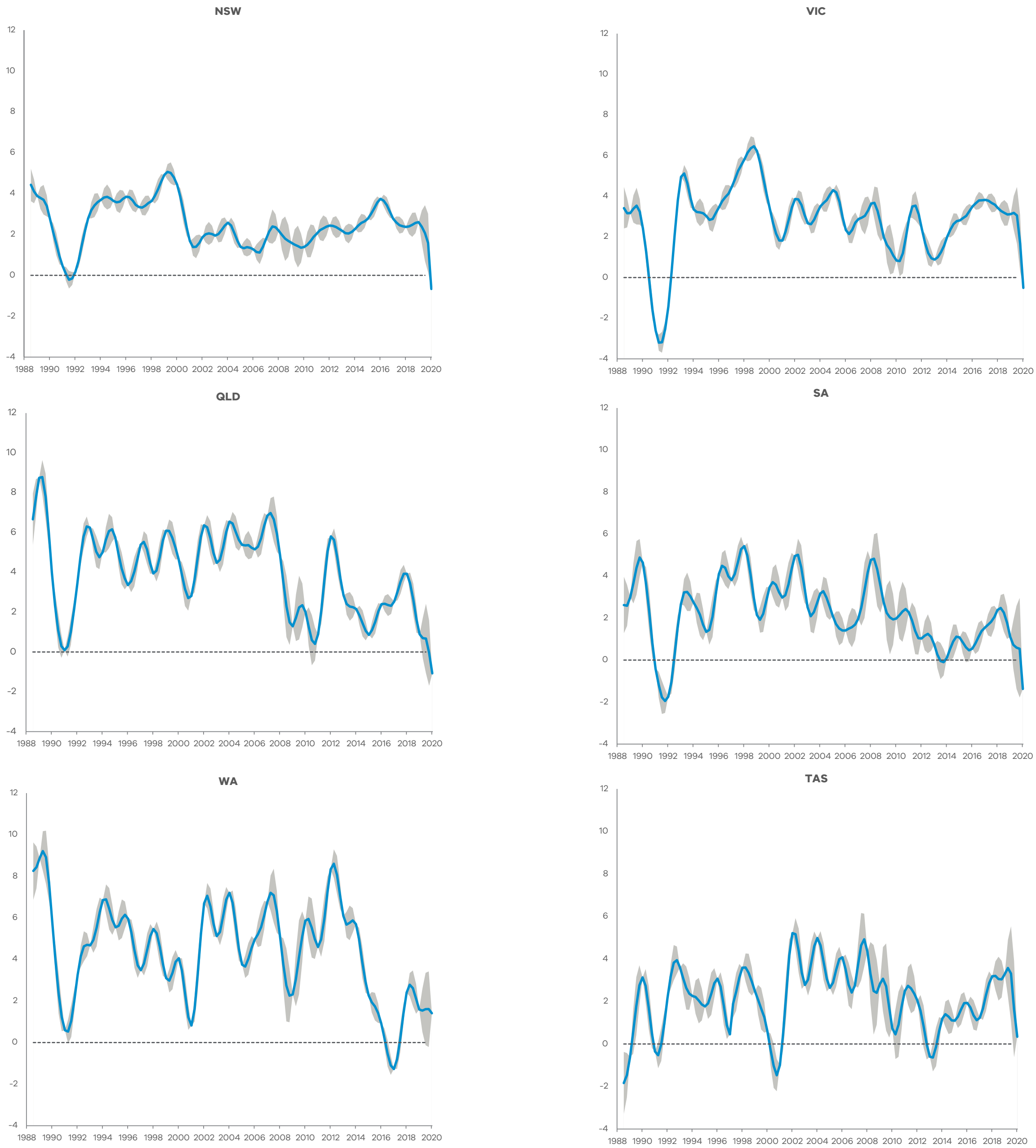
5 The selection of lags is supported by maximum likelihoods and is consistent with the number of lags in the intertemporal restriction in equation (1).

4. Results

Using the methodology and the data outlined in the previous section, we obtain GSP estimates for each state in Australia using Markov Chain Monte Carlo simulations with 30 000 drawings and 10 000 burn-in (Figure 1). Our quarterly estimates suggest that there was significant variation in economic performance across states over the past 30 years, as seen in Figure 1.[6]

Our estimates of economic growth in Queensland and Western Australia (which both have large resources sectors) were significantly stronger than other states in the late 1980s, as Australian commodity export prices rose by around 45 per cent from the low point in mid-1986. These two states also saw a significant uptick in quarterly GSP growth during the 'mining boom' in late 2000s and early 2010s.

Figure 1: Gross state product, annual growth



Note: Shaded areas are the 16th and 84th percentiles of Bayesian estimates. There is no confidence interval for June quarter estimates as they are restricted to be the annual GSP growth rates published by ABS.

6 While the model also produces estimates for the Northern Territory and the Australian Capital Territory, these estimates are not included due to high volatility and uncertainty, likely reflecting their small shares of Australia's economic activity. These territories account for 1 and 2 per cent of GDP respectively – and hence GDP is not representative of their conditions.

As Australia entered a recession in the September quarter of 1990, economic growth slowed significantly across all states, with many seeing negative growth. Our estimates suggest that Victoria and South Australia had the sharpest and longest contraction during this recession, while the contraction in New South Wales and Tasmania was short and shallow. Queensland and Western Australia recorded low but positive growth during this period, partly due to strong commodity prices.

Following the early 1990s recession, Australia enjoyed a prolonged period of economic growth until the COVID-19 pandemic in 2020. Nonetheless, there were periods where economic growth weakened. Most states recorded low growth for a few quarters in 2009–10 following the global financial crisis. Subsequently, the trajectory among the states varied over this period, with the mining states growing much faster than the other states due to high commodity prices. Among the non-mining states, Victoria had the strongest average annual growth after the mining boom from 2015–2019, followed by New South Wales.

Australia's economy entered into a technical recession in the June 2020 quarter as the COVID-19 pandemic triggered two consecutive quarters of negative growth, with a record 7.0 per cent fall in the GDP for the June quarter. The recession was over in the September quarter with the economy expanding by 3.4 per cent. Since the model is based on annual GSP growth figures, this paper presents quarterly GSP estimates up to the June quarter 2020.[7]

We compare our results to other published estimates. The ABS did previously publish quarterly GSP data between 1993 and 1997, with historical data provided from 1984–85.[8] Our estimates of GSP growth in the early 1990s are broadly in line with the historical ABS estimates (Figure 2). There are a few exceptions where our estimates are quite different from ABS estimates, although these differences primarily reflect subsequent revisions to ABS annual GSP data. The ABS estimates are from the 1995 vintage publication of quarterly GSP, while our estimates are based on the most recent ABS annual GSP figures, which covers all data revisions over time.[9]

The Queensland Treasury also publishes quarterly GSP estimates for that state in its Queensland State Accounts. Our estimates of Queensland quarterly GSP growth are also aligned to the Queensland Treasury's (Figure 3). Our estimates are generally less volatile, and the annual estimates derived from the quarterly results are consistent with ABS annual GSP estimates due to restrictions imposed in the model.

7 The pandemic has led to considerably large uncertainties in the quarterly GSP estimates for 2020. Econometric models struggle to accommodate the exceptionally severe downturn that the economy experienced in the June quarter of 2020, given the complete absence of any comparable episode in the historical data. Therefore, the estimates for the 2019–20 financial year should be treated with caution. For a similar reason, estimating GSP for the September quarter 2020 is not included in this paper as it requires assumptions on the 2020–21 GSP growth and the contribution from September quarter.

8 Our estimates start from 1988 as the VAR model includes 7 lags and the annual GSP data (in a consistent chain volume measure) starts from 1986–87.

9 For example, 1995 vintage ABS estimates suggest Tasmania's economic growth was negative during 1993–94. However, the most recent ABS State Accounts release shows that Tasmania recorded positive economic growth in every year since 1992–93 to 1999–2000. Similarly, according to the latest ABS annual GSP release, Victoria's GSP grew by 3.4 per cent in 1993–94 and 3.0 per cent in 1994–95, which are closer to our quarterly estimates than the 1995 vintage ABS estimates.

Figure 2: Comparison of results with historical ABS State Accounts and Queensland State Accounts, Dec 1988 – June 1997

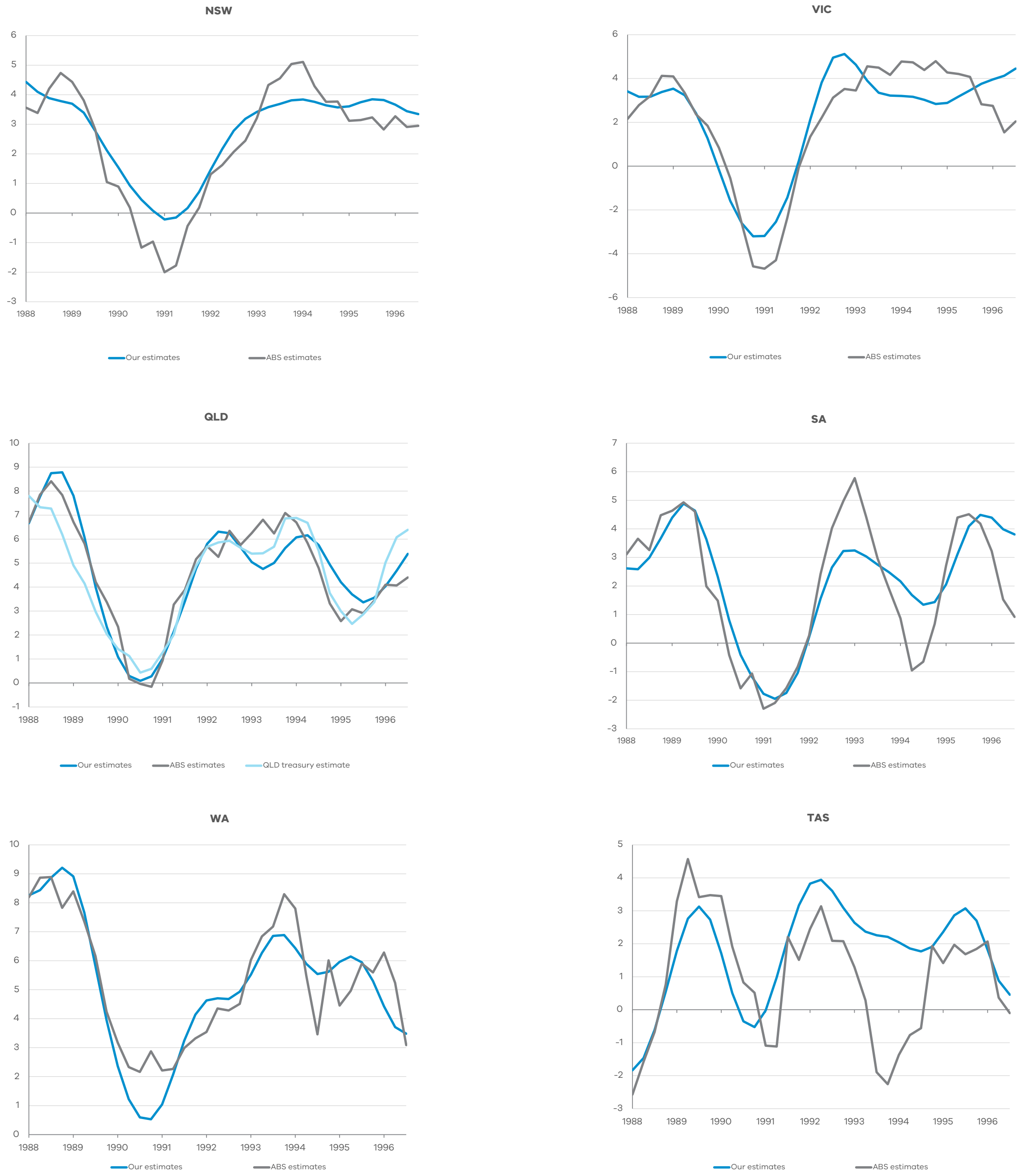
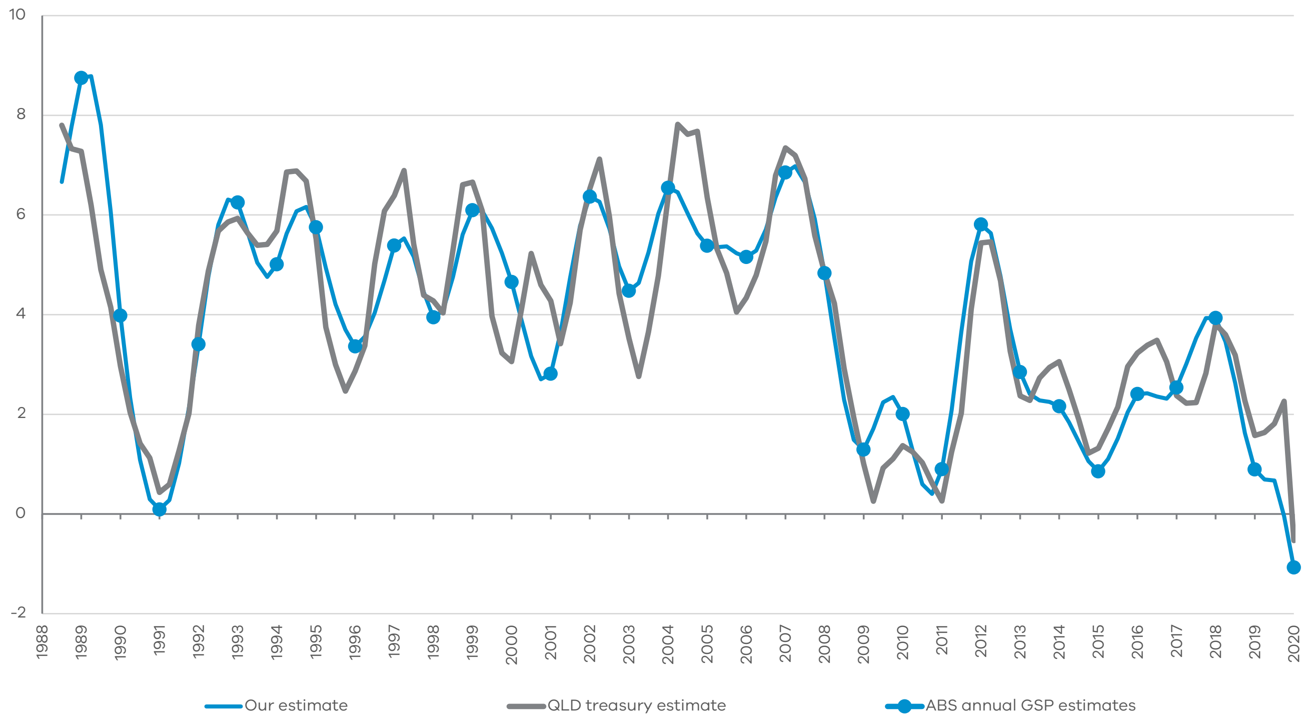


Figure 3: Comparison of results with Queensland State Accounts, September 1989 – June 2020



5. Synchronisation of state economic cycles

Seeing the divergence in our estimates between states, we use our quarterly GSP estimates to identify business cycles for each state which may have been masked by annual state or quarterly national statistics. To do so, we use the non-parametric algorithm of Harding and Pagan (2002).[10] Figure 4 illustrates the economic cycles of each state since the late 1980s.[11]

The results suggest that Australia was in a recession from the September quarter of 1990 to the June quarter of 1991. Over these four quarters, all states experienced some contraction, though with some variation in timing and duration. Victoria, Queensland and South Australia entered the recession in the June quarter, a quarter earlier than the other states.

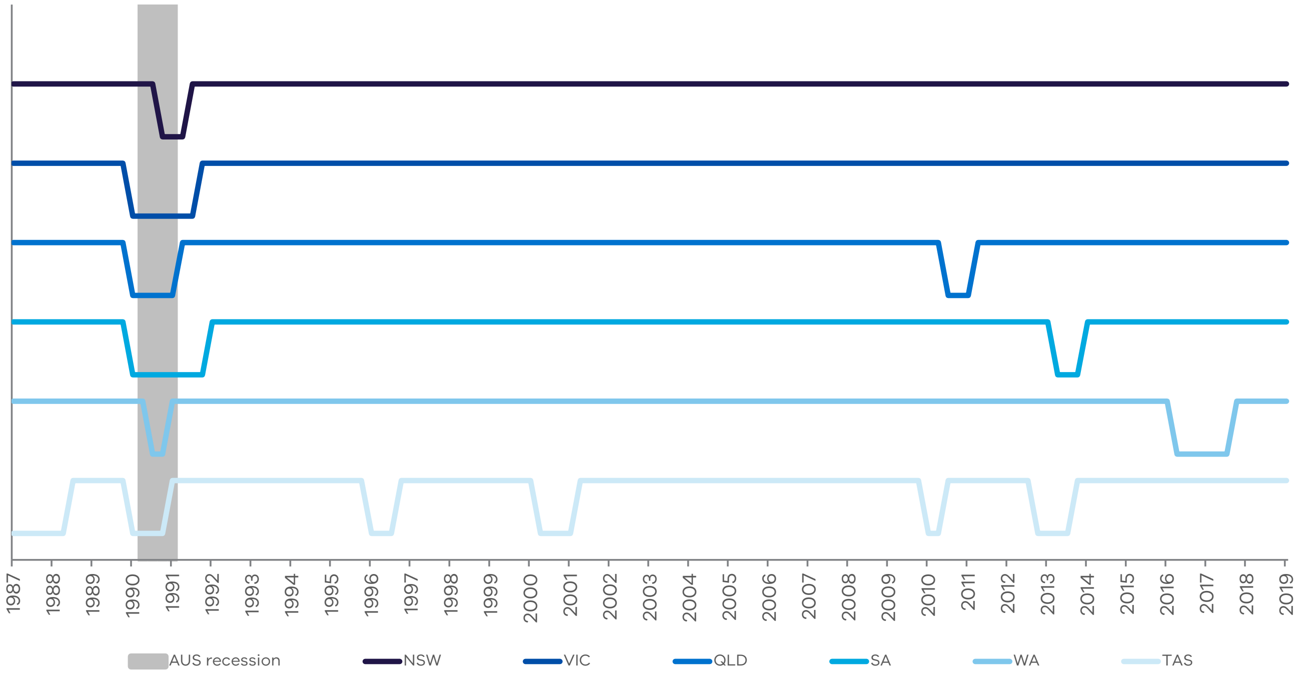
Our data suggests that Victoria and South Australia remained in contraction the longest, for 7 and 8 quarters respectively. A number of financial institutions failed during 1990–1992, including the State Bank of Victoria, the State Bank of South Australia, the Victorian-based Pyramid Building Society and several merchant banks[12] (RBA 2000). Dixon and Mahmood (2008) also concluded that the tariff cuts in the textiles, clothing and footwear sector in 1989–90 resulted in a massive reduction in employment in firms mainly located in Victoria. The large increase in unemployment led to a significant and accelerated outflow of population along with a decline in overseas immigration.

10 The program is widely used for dating business cycles in recent literature, available at http://www.ncer.edu.au/resources/data-and-code.php. We used the parameters for quarterly data suggested by Harding and Pagan (2002): MinimumPhase=2 quarters, MinimumCycle=5 quarters, SymmetricWindow=2 quarters and Threshold=25%. That is, contractions/expansions are at least two quarters of negative/positive growth and cycles (peak-to-peak and trough-to-trough) are at least five quarters long.

11 The results for the 2019–20 financial year is not included in the figure due to high uncertainty in the quarterly GSP estimates for the June quarter 2020 and the incomplete phase of contraction in some states and territories.

12 Large losses were recorded by Westpac, ANZ, the Bank of Melbourne and Metway Bank, which was merged with Suncorp in 1996.

Figure 4: Economic cycles of Australian states, September 1978 – Jun 2019



Notes: An elevated line indicates an expansion and a dent in the line represents a contraction. Expansions and contractions are at least two quarters long. The grey shading indicates the national recession in early 1990s.

Australia then experienced very good growth performance after the early 1990s recession. The output of the mining, financial services and professional services industries grew at a much faster rate than average during 1991–92 to 2008–09, while the output of the manufacturing sector increased by less than average (RBA 2010). Two resource-rich states, Queensland and Western Australia, outperformed the nation as a result of improving commodity prices and world economic recovery after the 1990s recession.

There were a couple of periods when economic growth slowed noticeably after the 1990s, but at no time did quarterly growth turn negative in two consecutive quarters. One slowdown was in 2000–01 following the collapse of the 'dot-com bubble'; and one in 2008 following the collapse of the US sub-prime housing bubble. Due to its sound financial system and substantial macroeconomic stimulus, the Australian economy performed much better than most other advanced economies during the global financial crisis. The temporary but sharp fall in the exchange rate during the crisis also helped cushion the economy on the downside, as did Australia's economic exposure to China's economy.

After commodity prices peaked in July 2011, the decline in mining investment in Australia from 2012 led to lower growth in overall mining activity. Economic conditions in Western Australia, which has a high reliance on the mining sector, weakened and our model suggests negative quarterly growth over the four quarters of 2016–17. The high exchange rate over 2010 to 2014 had put pressure on many industrial sectors and hence state economies that were not benefitting directly from high commodity prices. South Australia recorded state final demand fall in two consecutive quarters during 2013–14 and our model also identified a short period of contraction in the State's GSP growth. The progressive reduction in official interest rates from November 2011 and the depreciation of the exchange rate underpinned a rise in growth of non-mining activity, which led to an improvement in economic conditions in states like New South Wales and Victoria over 2015–2018. Our model also identified a short contraction in Queensland by the end of 2018, compared to Queensland Treasury's estimates which suggested negative quarterly GSP growth in September 2018 and March 2019 separetly.

To understand the similarities in business cycles across the states, Table 1 presents the degree of concordance. The concept was proposed by Harding and Pagan (2002) to measure co-movements between individual cycles. The degree of concordance is defined as the fraction of time both series are simultaneously in the same state of expansion or contraction. If two economies always record growth peaks and troughs at the same time over the whole period, the degree of concordance of these two economies is 100 per cent. A concordance of 80 per cent means both economies are in expansion/contraction in four out of five quarters.

While each state may experience different conditions, state economic growth appears to be in a similar phase (expansion/contraction) to national growth the vast majority of the time, consistent with previous studies such as Norman and Walker (2004). Nonetheless, as Figure 1 and the earlier discussion demonstrated, during expansion phases the economic conditions among states can vary considerably.

Table 1: Concordance between states and the nation

	AUS	NSW	VIC	QLD	SA	WA	TAS
AUS	100%	96.1%	97.7%	96.9%	96.1%	94.6%	83.7%
NSW		100%	95.3%	94.6%	93.8%	92.2%	82.9%
VIC			100%	96.1%	98.4%	92.2%	82.9%
QLD				100%	94.6%	91.5%	82.2%
SA					100%	90.7%	81.4%
WA						100%	79.8%
TAS							100%

Note: The degree of concordance is the fraction of time both series are simultaneously in the same state of expansion ($S_t = 1$) or contraction ($S_t = 0$). That is, $[\#\{S_{it} = S_{jt} = 1\}+\#\{S_{it} = S_{jt} = 0\}]/n$, where i and j represent regions, n is the total number of quarters ($n = 129$), and # represents the total number of quarters that the condition is satisfied. If two GSP series move together with the same cyclical component, the degree of concordance would be unity.

6. Conclusion

This paper proposes a methodology to estimate quarterly gross state product in Australia. We closely follow the approach maintained by Koop et al. (2020) where we made some modifications to adapt the model to Australia.

We also use these estimates to identify economic cycles in each state since 1987. Our results confirm that there is variation in economic growth among states and suggest there may have been several short periods of contractions in some states which were masked by the annual GSP data. Analysing the state and national economic cycles from these new estimates, we find a reasonably high degree of concordance in expansions and contractions between the states' and national economy despite variations in economic performance.

We hope these estimates help economists and policymakers overcome current data limitations in their research and policy decisions in the absence of official quarterly GSP data.

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Appendix A: Detailed methodology

State-space model

This appendix presents the state-space model used in the paper and discusses the Markov chain Monte Carlo (MCMC) algorithm applied to estimate the state variables.

The notations used in this paper are as follows:

- y_t^{AU} is Australian GDP growth rate in quarter t ($t \in [1,...,T]$).
- y_t^r is the quarterly GSP growth rate for region r ($r \in [1,...,R]$) in quarter t, with $R = 8$.
- $y_t^{r,A}$ is the annual GSP growth rate for region r in quarter t, which is observed in quarter 4 of each year.

Our MF-VAR model is a state-space model with the observed national quarterly GDP and unobserved regional quarterly GSP. The state equation of this state-space model is a VAR model given as:

$$\boldsymbol{y}_t = \Phi_0 + \Phi_1 \boldsymbol{y}_{t-1} + \cdots + \Phi_p \boldsymbol{y}_{t-p}) + \boldsymbol{u}_t, \qquad (A.1)$$

where $\boldsymbol{y}_t = (y_t^{AU}, y_t^1, ..., y_t^R)'$ is a $R + 1$ vector, and the random term $\boldsymbol{u}_t$ follows $N(0, \Sigma_t)$. The intercept Φ_0 is a $R + 1$ vector and the coefficient matrices $\Phi_1, ... \Phi_p$ are all $(R + 1) \times (R + 1)$

To improve modelling performance, this VAR model is expanded to include four additional macroeconomic indicators: the official cash rate, trade-weighted exchange rate, consumer price, and commodity prices, with the latter three indicators entering the model in first difference of logarithm. State final demand for each state are also included. That is, $\boldsymbol{y}_t = (y_t^1, ..., y_t^n)'$ with $n = 2R + 5$.

Earlier literatures (Mitchell et al. 2005, Mariano and Murasawa 2010) suggested a linear approximate relationship between the annual GSP growth and quarterly GSP growth:

$$y_t^{r,A} = \tfrac{1}{4} y_t^r + \tfrac{1}{2} y_{t-1}^r + \tfrac{3}{4} y_{t-2}^r + y_{t-3}^r + \tfrac{3}{4} y_{t-4}^r + \tfrac{1}{2} y_{t-5}^r + \tfrac{1}{4} y_{t-6}^r \qquad (A.2)$$

It provides the measurement equations in our state-space model with observed annual growth on the left-hand side and unobserved quarterly growth on the right hand side for each region. Another measurement equation is obtained from the cross-sectional restriction that Australian quarterly GDP growth is the weighted sum of quarterly GSP growth across all the states and territories:

$$y_t^{AU} = \textstyle\sum_{r=1}^{R} w_{r,t} \, y_t^r + \eta_t, \qquad (A.3)$$

where w_{rt} is set as the region's share of national GSP in the previous year and $\eta_t \sim N(0, \sigma_\eta^2)$.

In most mixed-frequency VAR literature, the covariance matrix Σ_t is assumed to be invariant with time. However, there is evidene of change in volatility in empirical macroeconomic applications. Therefore, we follow a multivariate stochastic volatility specification adopted by Koop et al. (2020). The covariance matrix can be decomposed as follows:

$$\Sigma_t = \boldsymbol{L}'\boldsymbol{D}_t\boldsymbol{L}, \qquad (A.4)$$

where L is a n x n lower triangular matrix with a diagonal of ones and other non-zero elements defined in a vector $\boldsymbol{a} = \left(a_1, \ldots, a_{\frac{(n-1)n}{2}}\right)'$.

The diagonal matrix $\boldsymbol{D}_t = diag[\exp(h_{1,t}), ..., \exp(h_{n,t})]$ and the log-volatilities $\boldsymbol{h}_t = (h_{1,t}, ..., h_{n,t})]'$ follows a random walk defined as:

$$\boldsymbol{h}_t = \boldsymbol{h}_{t-1} + v_t, \; v_t \sim N(0, \Sigma_h), \qquad (A.5)$$

where $\Sigma_h = diag[\omega_{h1}^2, ..., \omega_{hn}^2]$ is a time-invariant diagonal matrix.v

Priors and posteriors

The goal of our model is to produce posterior and predictive densities for these unobserved quarterly GSP growth and use posterior means as point estimates of these growth rates and densities to produce credible intervals. Bayesian Markov chain Monte Carlo (MCMC) algorithms that combine Bayesian state-space methods with Bayesian VAR methods are used to estimate our model.

The MF-VAR model defined above is obviously overparametrized with $\boldsymbol{n}$ dependent variables and their $\boldsymbol{p}$ lags. In addition, the multivariate stochastic volatility process (A.1) involves more parameters to be estimated ($\boldsymbol{a}$ and $\boldsymbol{h}_t$). To avoid such overparametrisation, we follow Bhattacharya et al. (2015) and use Direchlet-Laplace shrinkage to define priors for all the coefficients in our model.

If we pool all elements of coefficient matrices $(\Phi_0, ... \Phi_p)$ together and reshape them into a single vector $\boldsymbol{\phi} = (\phi_1, ... \phi_k)'$, where $k = n^2p + n$. The prior for each coefficient is independent and takes the form:

$$\phi_j \sim N(0, \psi_j^\phi \vartheta_{j\phi}^2 \tau_\phi^2), \qquad (A.6)$$

where the variance involves a local term $\psi_j^\phi \sim \exp\left(\frac{1}{2}\right)$, a global term $\tau_\phi^2 \sim G\left(\kappa\alpha_\phi, \frac{1}{2}\right)$ and an extra term $\vartheta_{j\phi}^2 \sim Dir(\alpha_\phi, ..., \alpha_\phi)$. This prior leads to a posterior that contracts to the true value at a rate that is optimal in theory. This prior would shrink the estimate of ϕ_j towards the prior mean of zero relative to maximum likelihood estimate (MLE). This prior involves only one prior hyperparameter $\boldsymbol{a}_\phi$, making the prior elicitation simple. Bhattacharya et al. (2015) recommended setting it to $\frac{1}{2}$ and Koop et al. (2020) approved the selection of prior is reasonably robust.

In addition, we also apply the Dirichlet-Laplace shrinkage to the coefficients in $\boldsymbol{L}$ in equation (A.4). The unknown parameters in log-volatilities is assumed to follow inverse gamma distribution:

$$\omega_{hj}^2 \sim IG(v_{hj}, S_{hj}), \text{ for } j = 1, ..., n. \qquad (A.7)$$

The posterior simulation algorithm related to the Dirichlet-Laplace prior is derived in Bhattacharya et al. (2015). Given the draws of state variables, the conditional posterior for the VAR coefficients takes the following form:

$$\phi | \cdot \sim N(\hat{\phi}, \boldsymbol{K}_\phi^{-1}), \qquad (A.8)$$

where $\boldsymbol{K_\varphi} = \boldsymbol{X'\Sigma^{-1}X} + \boldsymbol{S_\phi^{-1}}$, and $\hat{\phi} = \boldsymbol{K}_\phi^{-1}(\boldsymbol{X'\Sigma^{-1}y})$, with $\boldsymbol{X} = [\boldsymbol{X}_1,\ldots,\boldsymbol{X}_T]$ and $\boldsymbol{X}_t = \boldsymbol{I_n}\otimes[1,\boldsymbol{y'_{t-1}},\ldots,\boldsymbol{y'_{t-p}}]$. The second term in $\boldsymbol{K_\varphi}$ is diagonal, defined as $\boldsymbol{S_\phi} = diag(\psi_1^\phi \vartheta_{1\phi}^2 \tau_\phi^2, \ldots, \psi_k^\phi \vartheta_{k\phi}^2 \tau_\phi^2)$. The conditional posterior distributions for $\psi_j^\phi, \vartheta_{j\phi}$ and τ_ϕ are:

$$\begin{aligned}
&\psi_j^\phi|\cdot \sim iG\left(\left(\frac{\upsilon_{j\phi}\tau_\phi)}{|\phi_j|}, 1\right);\\
&\tau_\phi|\cdot \sim GIG\left(k(\alpha_\phi - 1), 1, 2\Sigma_{j=1}^k \frac{|\phi_j|}{\upsilon_{j\phi}}\right);\\
&\upsilon_{j\phi} = \frac{R_{j\phi}}{\Sigma_{j=1}^k R_{j\phi}}
\end{aligned} \quad \text{(A.9)}$$

with $R_{j\phi}\ |.\sim GIG(\alpha_\phi-1, 1\ ,2|\phi_j\ |)$, for j=1, ..., k. GIG is the generalised inverse Gaussian distribution and iG is the inverse Gaussian distribution.

Similiarly, the posterior for $\boldsymbol{a}$ is given as

$$\boldsymbol{a}\ |.\sim N(\hat{\boldsymbol{a}}, \boldsymbol{K_a^{-1}}) \quad \text{(A.10)}$$

where $\boldsymbol{K_a} = \boldsymbol{E'D^{-1}E} + \boldsymbol{S_a^{-1}}$, and $\hat{\boldsymbol{a}} = \boldsymbol{K_a^{-1}}(\boldsymbol{E'}\mathbf{D}^{-1}\boldsymbol{\epsilon})$, with $\boldsymbol{D} = \boldsymbol{diag\{D_1,\ldots,D_T\}}$. The detailed definition of matrix $\boldsymbol{E}$ and conditional posteriors for $\boldsymbol{S_a}$ can be found in Koop et al. (2020).

For the stochastic volatility $\boldsymbol{D_t}$, we draw the initial condition $\boldsymbol{h_0}$ following Chan and Eisenstat (2018) and its conditional posterior is:

$$\boldsymbol{h}_0|.\sim N(\hat{\boldsymbol{h}}_0, \boldsymbol{K}_{\boldsymbol{h}_0}^{-1}), \text{ where } \boldsymbol{K}_{\boldsymbol{h}_0} = \boldsymbol{V_h^{-1}} + \Sigma_{\boldsymbol{h}}^{-1}, \text{ and } \hat{\boldsymbol{h}}_0 = \boldsymbol{K}_{\boldsymbol{h}_0}^{-1}(\boldsymbol{V_h^{-1}a_h} + \Sigma_{\boldsymbol{h}}^{-1}\boldsymbol{h}_1). \quad \text{A.11)}$$

The diagonal elements of $\Sigma_{\boldsymbol{h}}$ are conditionally independent and follow:

$$\omega_{h_j}^2|.\sim IG\left(\nu_{hj} + \frac{T}{2},\ S_{hj} + \frac{1}{2}\Sigma_{t=1}^T\left(h_{jt} - h_{j,t-1}\right)^2\right) \text{ for } j = 1, \ldots, n. \quad \text{(A.12)}$$

A flow decomposition of the unemployment rate in Victoria[1]

By Omid Mousavi, Maryam Nasiri, Jiayi Wang, Bedika L Mala

ABSTRACT

The unemployment rate is shaped by labour flows between employment and unemployment as well as those in and out of the labour market. In this article, we use a flow-based approach to show the importance of each of these flows in shaping the unemployment rate in Victoria over the past two decades. We find that flows between employment and unemployment primarily explain the fluctuation in the unemployment rate in Victoria. We also find that flows out of the labour market can explain a larger fraction of the unemployment rate during episodes when the unemployment rate is high. Understanding the factors (flows) that drive changes in the unemployment rate at different points in the business cycle can be important for informing labour market policy. This has been particularly evident during the coronavirus (COVID-19) pandemic. While the adverse impacts of the coronavirus pandemic on the labour market are still resolving, the policy responses such as JobKeeper and JobSeeker have focused on maintaining job matches and directly affecting the labour market flows. This may suggest future research examining responses of different labour market flows to these policies and their impact on the labour market.

Overview

The unemployment rate is a summary of different movements (flows) in the labour market that occur in a specified time period. At any point in time, a large number of Victorians move from one job to another, from employment to unemployment and vice versa. There is also a large number of people moving in and out of the labour force at any point in time. This article provides a cyclical perspective on the unemployment rate disaggregated in terms of these labour market flows. We use a flow-based approach to investigate the importance of different labour market flows in explaining the unemployment rate in Victoria over the past two decades.

To inform policy development, it is important to know the source of changes in the unemployment rate. For instance, when an increase in the unemployment rate is driven by a decrease in the number of unemployed workers finding a job then policies can be specifically targeted at improving the job-finding prospects of unemployed workers, such as job training or job search assistance programs.[2] On the other hand, when changes in the unemployment rate are mostly driven by changes in labour market participation, policies may focus on encouraging workers back into the labour market. For instance, via job creation when an increase in the unemployment rate is due to discouraged workers leaving the labour market.

1 The authors would like to thank James Brugler and Gillian Thornton for their comments. The views expressed in this paper are those of the authors and do not necessarily reflect the views of DTF.

2 For example, via reduced job search effort or enhancement of skills required for finding a job.

We find that the unemployment rate is primarily driven by 'turnover', which is defined by the change in the transition of workers between employment and unemployment. This indicates that the majority of cyclical changes in the unemployment rate can be explained by changes in the job-finding rate of unemployed individuals and job separation rate of the employed individuals.

In general, entry to and exit from the labour market do not contribute to fluctuations in the unemployment rate as significantly as turnover. However, the role of labour market participation becomes more important during episodes when the unemployment rate is relatively high, with a lower probability of exiting the labour market observed in the high unemployment rate episode of late 2014.[3] Intuitively, during episodes when the unemployment rate is high, the composition of unemployment may change toward workers who have a lower tendency to exit.

The remainder of this paper is as follows. In Section 1, we review the literature. In Section 2, we explain the data. In Section 3, we outline the methodology for decomposing the unemployment rate into different labour market flows. In Section 4, we present the results of the decomposition. Section 5 describes the role of labour market heterogeneity in shaping the unemployment rate in Victoria and Section 6 concludes.

1. Literature review

Our work focuses on how changes in different labour market flows contribute to shaping the unemployment rate in Victoria. To the best of our knowledge, only a few studies have examined labour market flows in Australia. Our work contributes to the existing literature by using a model that, unlike previous studies, accounts for short run deviations (transitional dynamics) in the unemployment rate from its long-run trend.

A substantial body of research on labour market fluctuations focuses on turnover in the labour market – that is, transitions between employment and unemployment and vice versa. This strand of literature assumes that changes in labour market participation – that is, movements in and out of the labour force, play little to no role in driving fluctuations in the unemployment rate (Aaronson et al., 2010).[4]

Under the assumption that workers neither enter nor exit the labour force, the job-finding rate is found to have a more significant impact on the variation in the unemployment rate than the job loss rate (Shimer, 2012; Elsby et al., 2009; Mazumder, 2007). In particular, movements in the job-finding rate have been found to account for most of the variation in the unemployment rate during the last two decades (Shimer, 2012). However, the amplitude of fluctuations in the flow out of employment is larger than that of the flow into employment, implying a much larger amplitude of the underlying fluctuations in job destruction than that of job creation (Davis and Haltiwanger, 1990).

While most research has neglected transitions relating to labour force participation, Elsby et al. (2015) argue that flows relating to participation account for around one-third of the cyclical variation in the unemployment rate. Similarly, Krusell et al. (2011) found that the participation rate, employment rate and unemployment rate jointly determine the variation in the unemployment rate and suggest that a comprehensive model of the aggregate labour market should explicitly incorporate all three labour market states. This is further explored by Barnichon et al. (2012), who developed a forecasting model for the unemployment rate based on labour market flows between all three labour market states. The model produced more accurate forecasts and performed especially well during large recessions and cyclical turning points.

Among studies that examine various components of unemployment in Australia, Ponomareva and Sheen (2009) use an equilibrium model with four labour market states and estimate the associated transition flows in Australia.[5] They find that transitions within the labour market (specifically the transition from unemployment to employment) contribute more significantly to explaining variation in the unemployment rate than other transitions. Chindamo (2010) also estimates transition probabilities and finds that the decline in the job-finding rate contributed up to 10 percentage points to the economic downturns in the early 1980s and early 1990s.

2. Data

We use gross flows data that is obtained from the Labour Force Survey of the Australian Bureau of Statistics (ABS). The gross flows data provides the counts of individuals transitioning between employment, unemployment and out of the labour force by their geographic location (state), age and gender.[6]

Using the gross flows data, it is straightforward to estimate the transition probabilities associated with each flow. This is accomplished by expressing the number of people who transition from one state (e.g. unemployment) into another state (e.g. employment) as a fraction of the number of people in the original state in the previous period (unemployment in this example). More formally, the transition probabilities for each time t are estimated according to $p_{tij} = ij_t / i_{t-1}$ for i and $j \in \{E, U, N\}$.

3 We investigate three episodes when the unemployment rate in Victoria is relatively high: The global financial crisis (GFC), where the unemployment rate increased to about 6 per cent from a low of about 4 per cent in a short period of time, and two periods in October 2001 and October 2014 where the unemployment rate reached about 7 per cent.

4 These studies are informed by Mortensen and Pissarides (1994) labour search and matching model, which predominantly focuses on transitions between employment and unemployment.

5 In particular, they model full-time and part-time as two separate states for employment.

6 The Labour Force Survey contains a panel of eight rotating groups that are surveyed for eight consecutive months. It includes labour force activity data of around 52 000 people in 26 000 households. A new rotation group is introduced each month to replace an outgoing rotation group, generally from the same geographic area.

These measures are informative about labour market dynamics and have been widely used in research on labour market dynamics. We disaggregate the flows by gender and age group of individuals for each state, over time. Table 1 shows the sample averages for the three labour market states for the whole sample and across different genders.

Table 1 shows that, on average, an unemployed worker in Victoria has a 21 per cent probability of finding a job (p_{UE}). However, an unemployed worker is slightly more likely to drop out of the labour market in a given month (p_{UN}) than finding a job (23 per cent). Additionally, individuals that are not participating in the labour force are more likely to find a job (p_{NE}) than becoming unemployed (p_{NU}) when they begin labour market activity (i.e. searching for a job).

Further, Table 1 shows that men are more likely to find a job than women regardless of their labour market status in the previous month, i.e. they have a higher p_{UE} and p_{NE} than women. Additionally, men are around 7 percentage points less likely to leave the labour market than women. This can be seen by comparing the $p_{EN} + p_{UN}$ between men and women.

Table 1: Transition probabilities by gender

TRANSITION PROBABILITY	WHOLE SAMPLE	MEN	WOMEN
p_{EE}	96.36	96.89	95.72
p_{EU}	0.90	0.97	0.81
p_{EN}	2.74	2.14	3.47
p_{UE}	21.30	21.96	20.54
p_{UU}	56.15	58.11	53.94
p_{UN}	22.55	19.93	25.52
p_{NE}	4.61	5.03	4.34
p_{NU}	2.84	3.35	2.51
p_{NN}	92.56	91.61	93.15

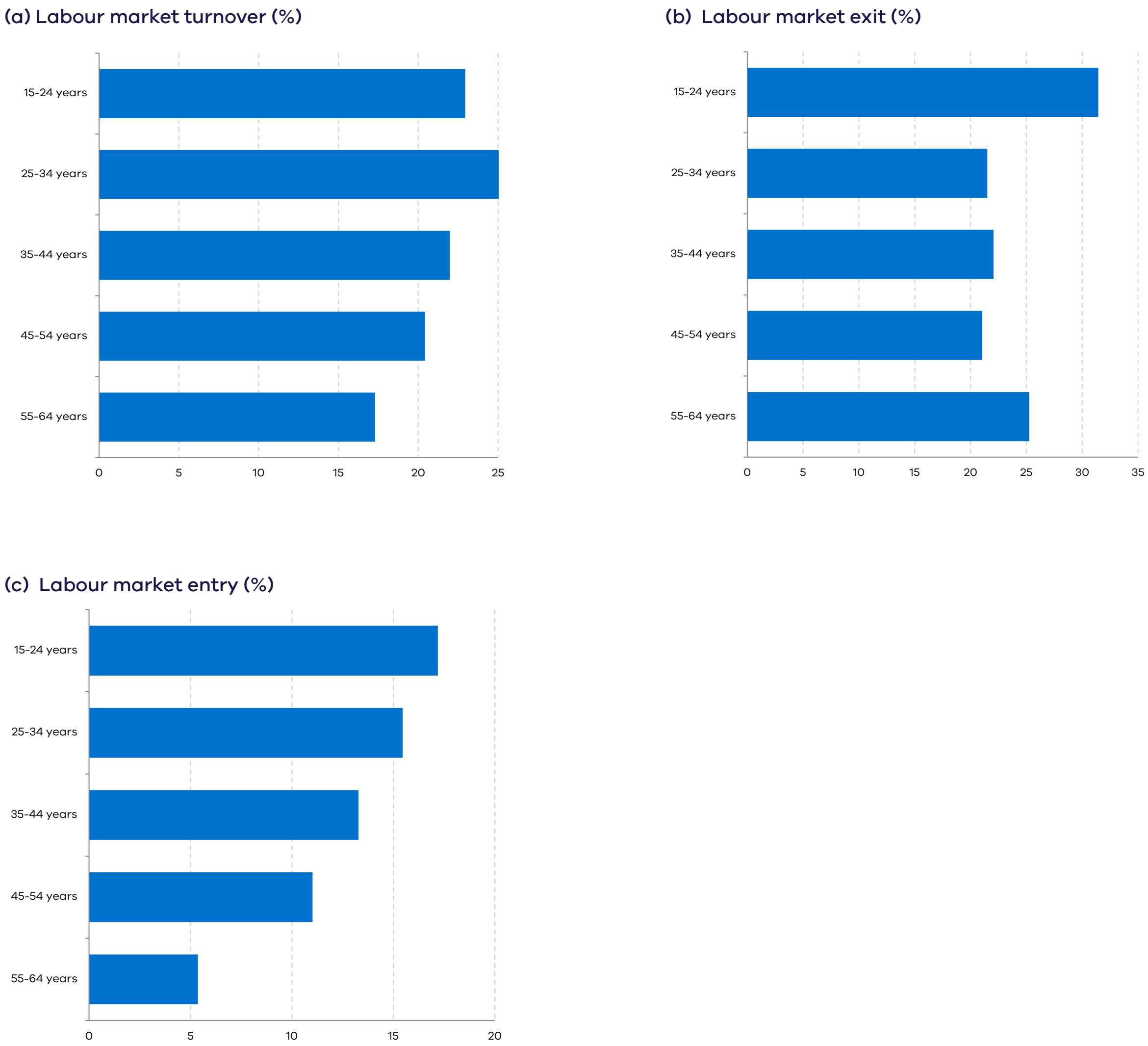
Notes: Average monthly transitions in per cent for December 1999–March 2020.

We delve deeper into the gross flow data from the ABS and construct similar measures as shown in Table 1 for individuals in different age groups in Victoria. Figure 1 shows labour market turnover measured by $p_{EU} + p_{UE}$ labour market exit measured by $p_{EN} + p_{UN}$ and labour market entry measured by $p_{NE} + p_{NU}$ for different age groups of workers in Victoria. The left panel in Figure 1 shows that labour market turnover is highest among workers in the 25–34 years age group, whereas workers in the 55–64 years age group have the lowest turnover among workers in Victoria.

The right panel in Figure 1 reveals that younger workers have the highest tendency to exit the labour market. Workers aged between 25–54 years have a fairly similar tendency of exiting the labour market, while this increases among workers in the 55–64 years age group, potentially reflecting the higher incidence of retirement. Looking into the bottom panel in Figure 1, younger workers have the highest tendency of entering the labour market. Figure 1 also shows that entering the labour market decreases with age.

In general, understanding the impact of age and gender heterogeneities on the unemployment rate is not straightforward. In Section 6, we explore the role of these heterogeneities in explaining the changes in the unemployment rate by asking how the unemployment rate (counterfactual) would have changed if the labour market was formed by each of these groups.

Figure 1: Transition probabilities by age



3. Methodology

This research closely follows Shimer (2012), Elsby et.al (2015) and Elsby et.al (2020) who provide a methodological framework for decomposing the responses of the unemployment rate (along with other labour market outcomes) to different labour market flows. In particular, we are guided by Elsby et.al (2020) who also incorporate transitional dynamics over time. This specifically allows us to address the short run deviation from the long run trend behaviour of the unemployment rate. This is important given the slower return of a short run deviation of the unemployment rate to the long run trend in the data.[7]

Let us begin with a simple discrete time Markov chain that represents the stock and flows in the labour market. This can be shown by

$$\begin{bmatrix} E \\ U \\ N \end{bmatrix}_t = \begin{bmatrix} 1-p_{EU}-p_{EN} & p_{UE} & p_{NE} \\ p_{EU} & 1-p_{UE}-p_{UN} & p_{NU} \\ p_{EN} & p_{UN} & 1-p_{NE}-p_{NU} \end{bmatrix}_t \begin{bmatrix} E \\ U \\ N \end{bmatrix}_{t-1} \qquad (1)$$

where E, U and N denote the stocks of employed, unemployed and non-participating individuals respectively. Without loss of generality, we normalise the size of the population to one, i.e. $e_t+u_t+n_t=1$ in which e and u and n denote the respective shares of employment, unemployment and non-participation in the population. Specifically, we assess the response of the unemployment rate to changes in (i) labour market turnover (measured by p_{EU} and p_{UE}); (ii) labour market exit (measured by p_{UN} and p_{EN} and (iii) labour market entry (measured by p_{NE} and p_{NU}).

To simplify the notation, denote $S_t = \begin{bmatrix} e \\ u \end{bmatrix}_t$ and $d_t = \begin{bmatrix} p_{NE} \\ p_{NU} \end{bmatrix}_t$. Using this we can simplify Equation (1) to

$$S_t = \underbrace{\begin{bmatrix} 1-p_{EU}-p_{EN}-p_{NE} & p_{UE}-p_{NE} \\ p_{EU}-p_{NU} & 1-p_{UE}-p_{UN}-p_{NU} \end{bmatrix}_t}_{P_t} S_{t-1} + d_t \qquad (2)$$

or $S_t = P_t\, S_{t-1} + d_t$. We can also simplify the notation further by defining $\widehat{P_t} = P_t - \mathbf{I}$, where I is an identity matrix. In doing so, Equation (2) can be written as:

$$\Delta S_t = \widehat{P_t} S_t + d_t \qquad (3)$$

Using Equation (3) and for fixed elements of the transition matrix , we can show that the steady state elements of vector is $\overline{S}_t = -\widehat{P_t}^{-1} d_t$. In other words, the elements of the state vector converge to the flow steady state (long run equilibrium) implied by this equation.

Elsby et.al (2020) show that Equation (3) can be written as following[8]:

$$\Delta S_t = \widehat{P_t}\left(I + \hat{P}_{t-1}\right)\hat{P}_{t-1}^{-1}\Delta S_{t-1} + \widehat{P_t}(\widehat{P_t} + \hat{P}_{t-1})^{-1}\left[2\Delta d_t + \Delta\widehat{P_t}\left(\overline{S}_t + \overline{S}_{t-1}\right)\right] \qquad (4)$$

It can be shown that the transitional dynamics, which is a change in the state from the steady state (long run trend), can be written as:

$$S_t - \overline{S}_t = \left(I + \widehat{P_t}\right)\widehat{P_t}^{-1}\Delta S_t \qquad (5)$$

which is reflected in Equation (4). This implies that current change in the state (i.e. S_t) depends on the past changes in the deviation of the state from its steady state. In addition, it can be shown that the second term in Equation (4) accounts for changes in the steady state over time as a function of different transition probabilities.

It should be emphasized that Equation (4) is additive in terms of changes in the transitional probabilities. This result helps us to measure the contribution of each transition probability to changes in the unemployment rate, which we examine in the next section. Specifically, we will measure how changes in the elements of the transition probability matrix affects changes in the states (e.g. unemployment).

4. A cyclical decomposition of the unemployment rate in terms of labour market flows

Our sample covers the period of December 1999 to March 2020. Although this time period does not include a reported recession in Australia, we can observe at least three significant episodes during which the unemployment rate increased significantly in Victoria.

The first episode is associated with the 'dot.com' bust. During this episode, the unemployment rate reached around 7 per cent in the early 2000s.[9] The second episode is associated with the GFC, when the official unemployment rate reached about 6 per cent in August 2009 from a low of 4.2 per cent in the previous year.[10]

The most recent episode in our sample occurs in late 2014, where the unemployment rate reached around 7 per cent in October 2014. Although the peak in the unemployment rate was not associated with a recession, the peak in the unemployment rate was followed by a temporary increase in labour market participation. In addition, this episode was not associated with any noticeable change in the number of job advertisements.[11] This suggests that changes in the flows into and out of the labour market (i.e. entry and exit to the labour market) were potentially the primary sources of the increase in the unemployment rate over this time period.

In the remainder of this section, we analyse how different labour market flows explain changes in the unemployment rate during each episode.

7 In general, following a short run deviation, the unemployment rate returns to the long run trend relatively faster in a labour market with a high turnover rate, for instance, the labour market in the United States. This implies that in a labour market with high turnover, the unemployment rate can be more closely approximated by the steady state (or long run) unemployment rate. Therefore, given the slow return in our data, we need a model that accounts for the transitional dynamics.

8 Please see Elsby et.al (2020) for a more detailed derivation of this result.

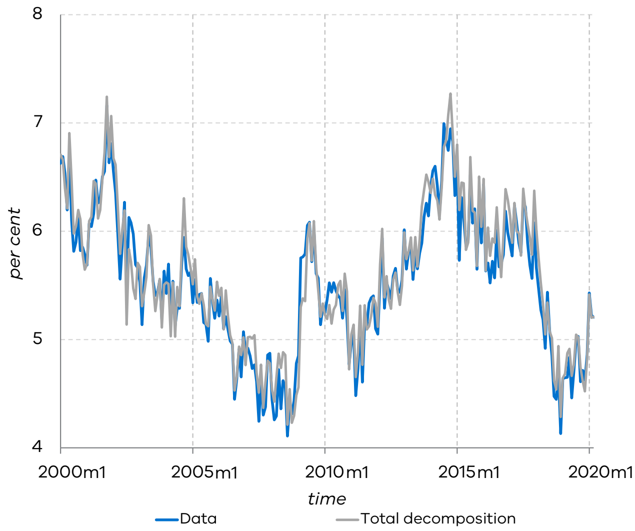
9 Specifically, the seasonally adjusted unemployment rate reached 7.1 per cent in October 2001. Source: ABS.

10 Source: ABS.

11 Source: Labour Market Portal. Please see https://lmip.gov.au/default.aspx?LMIP/GainInsights/VacancyReport

We begin our analysis by showing how the unemployment rate delivered by the model tracks data over time. Figure 2 compares the unemployment rate derived from the model with data. It shows that the model performs well in approximating the unemployment rate in Victoria (correlation ≈ 0.97). Therefore, we can confidently use the model to decompose the unemployment rate in terms of different labour market flows.

Figure 2. Unemployment rate in Victoria—total decomposition



We proceed with highlighting the importance of different transition probabilities in shaping the unemployment rate. In each decomposition, we only allow the associated transition probabilities to vary over time while holding the other transition probabilities fixed at their long run averages. These results are provided in Figure 3.

The decomposition in Figure 3 shows that changes in labour market turnover (i.e. the probability of finding and/or losing a job) has driven most of the variation in the unemployment rate in Victoria over the past two decades. In general, holding other transition probabilities unchanged at their long run averages, the unemployment rate is expected to increase with an increase in the probability of losing a job (p_{EU}) and/or with a decrease in the probability of finding a job (p_{UE}). Over business cycles, these two probabilities vary, which creates variation in the unemployment rate. Overall, the direction of change in the unemployment rate depends on the relative strength of the change in these two probabilities.

To have a better understanding of this, Panel (a) in Figure 4 shows the changes in p_{EU} and p_{UE} over time in Victoria. We can see that over the period leading to an increase in the unemployment rate in the late 2009's, we observe an increase in p_{EU} and a decrease in p_{UE}. However, during the third episode of high unemployment rate in late 2014, although we observe an increase in the probability of losing a job for an employed person, we also observe a slight increase in the probability of finding a job for an unemployed person, which to some extent dampens the increase in the unemployment rate.

Figure 3. Unemployment rate in Victoria—transition decomposition

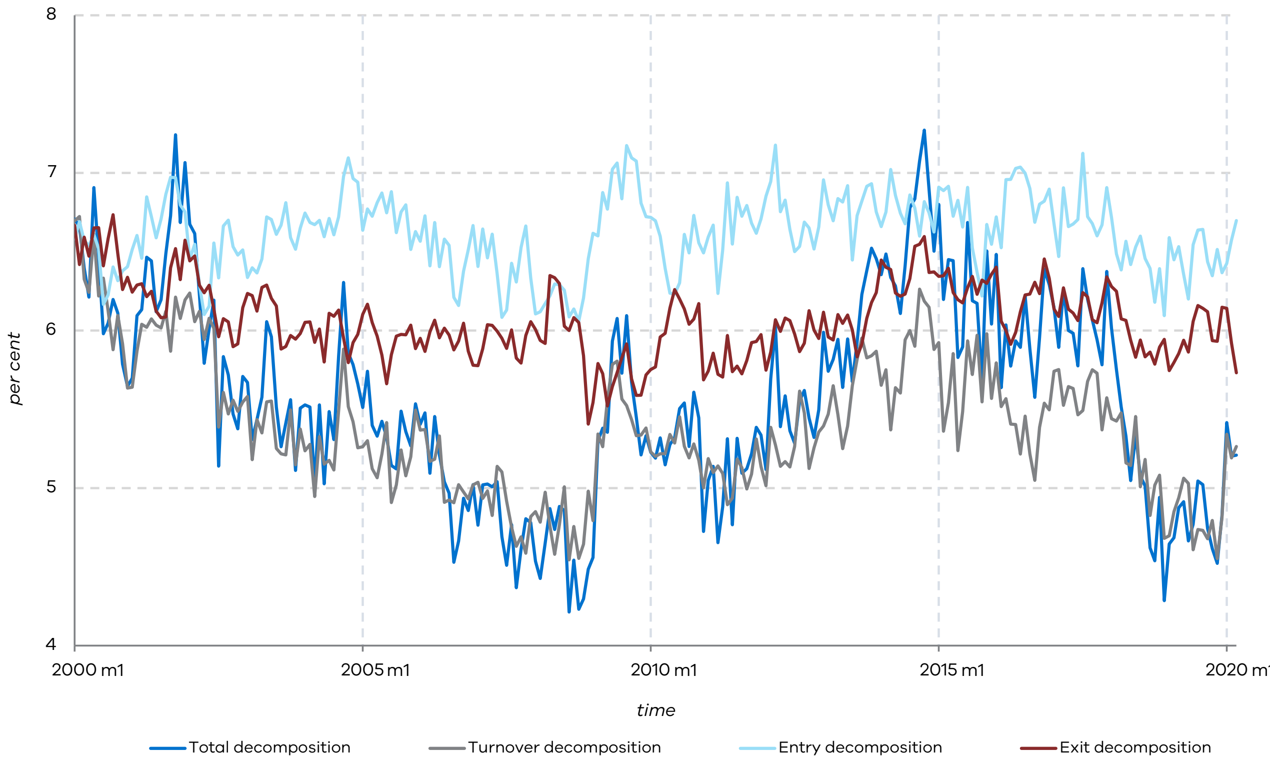


Figure 3 also highlights the role of labour market entry and exit in shaping the unemployment rate. In general, relative to turnover, entry and exit play minor roles in shaping the unemployment rate in Victoria over time. However, we find that exits from the labour market have a larger bearing on the unemployment rate during periods when the unemployment rate is high, such as in the early 2000s and late 2014. In general, during episodes when the unemployment rate is high, with an increase in the flow of workers out of employment toward unemployment, the composition of the unemployment pool changes toward workers who have a lower tendency to exit. This leads to a decline in the transition probability of workers from unemployment to out of the labour market (i.e. p_{UN}) that translates into an increase in the unemployment rate. On the other hand, during times of recovery in the labour market, the composition of unemployment shifts toward workers who are more likely to exit, which results in an improvement in the unemployment rate.

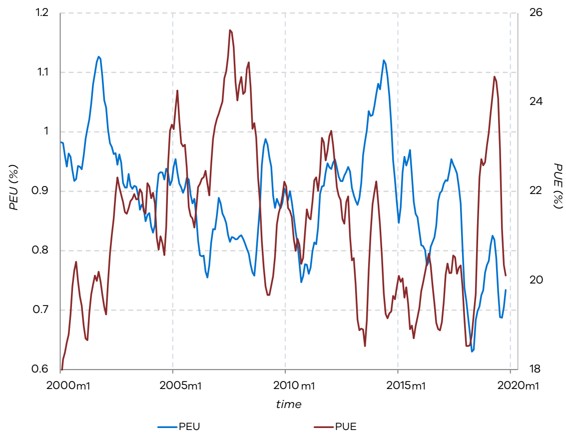
The decrease in exits from the labour market when the unemployment rate is high and the increase in exits during the recovery phase can be seen from Panel (b) of Figure 4. The figure shows that in the periods leading to the peak in the unemployment rate in late 2014, the p_{UN} declines, while it increases afterwards. In the next section, we elaborate on this point by showing the role of labour market heterogeneity in driving the unemployment rate over time.

Finally, we find a smaller role for labour market entry in explaining changes in the unemployment rate. Intuitively, a recovery in the labour market encourages more individuals to enter into the labour market. This implies that during episodes when the unemployment rate is low, we should expect to observe an increase in both p_{NE} and p_{NU}. On the other hand, in a slack labour market, workers may delay their entry into the labour market. Panel (c) in Figure 4 shows the changes in the probability of entry into the labour market over time. Although we can find some periods in which this hypothesis holds (such as an increase in p_{NE} during the recovery after the peak in the unemployment rate in the early 2000s), it is difficult to propose this hypothesis for other periods. Overall, Figure 3 shows that changes in the entry into the labour market (i.e. p_{NE} and p_{NU}), holding other transitions unchanged, does not explain changes in the unemployment rate as significantly as the other two forces.

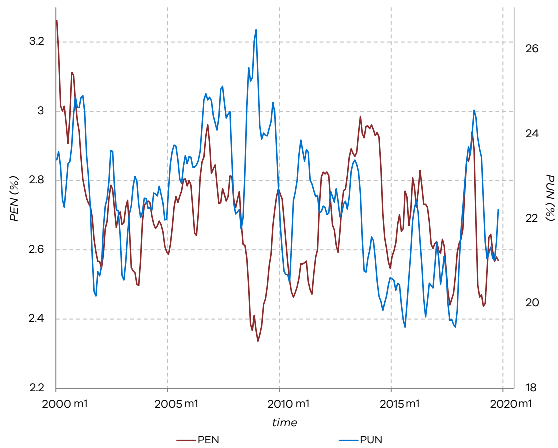
The findings in this section can inform policy development, as it is important to identify the economic mechanisms behind an increase in the unemployment rate. For instance, if changes in the unemployment rate are driven by workers having difficulty in finding a job, then the policy may emphasise programs that aim to help workers to search more effectively for a job such as job training or job search assistance programs. However, if the changes in the unemployment rate are primarily driven by a lower participation rate, the policy may focus on increasing the return to job search, for instance, via programs that help with job creation.

Figure 4. Transition probabilities in Victoria

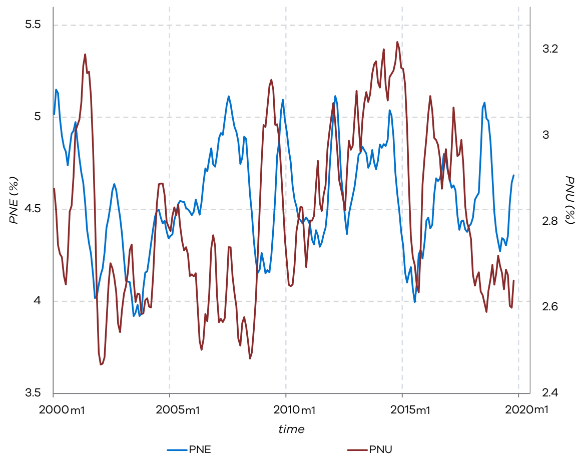
(a) Labour market turnover



(b) Labour market exit



(c) Labour market entry



Notes: All series are seasonally adjusted monthly data and smoothed with a 6-month cantered moving average

5. Accounting for the labour market heterogeneity

We proceed with analysing the role of labour market heterogeneity in explaining the fluctuation in the unemployment rate in Victoria over the past two decades. In doing so, we present the unemployment rate implied by different genders and age groups. The results provide a series of counterfactual unemployment rates where the sample is represented by a specific gender or age group.

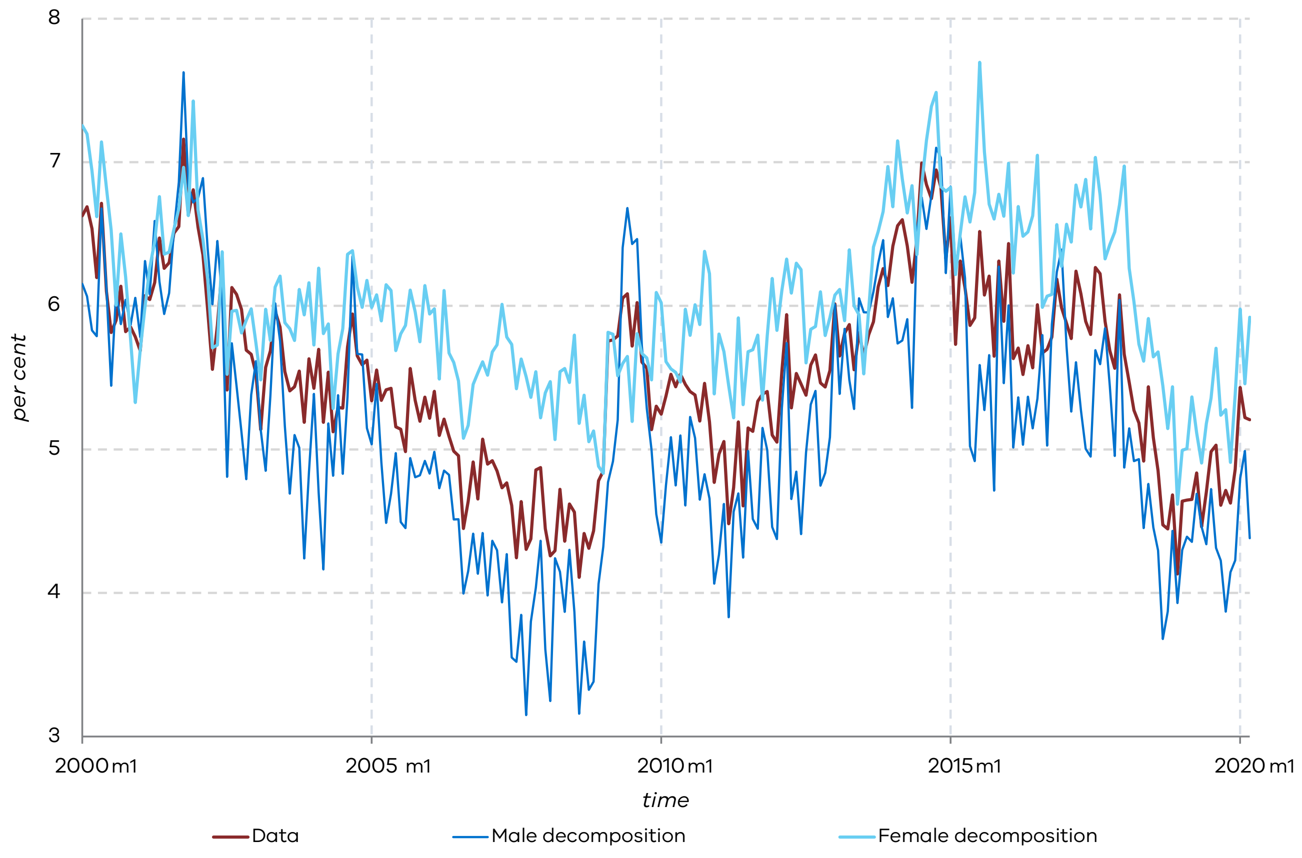
5.1 Role of gender

Figure 5 shows the unemployment rates implied by the model when each gender group represents the entire pool. In other words, it represents the unemployment rate for the situation where only males or females participate in labour market activities.

On average, we observe a lower unemployment rate when the unemployment pool is only represented by men. In contrast, when the unemployment pool is only represented by women, the unemployment rate tends to be higher. This can be explained by a combination of (i) the higher chance of finding a job (p_{UE}) (ii) higher probability of remaining labour market (p_{NU} and p_{EN}) and (iii) higher intensity of entering into the labour market (p_{NU} and p_{NE}) that was presented in Table 1.

A closer look at Figure 5 reveals that the variation in the unemployment rate when only men form the sample is larger than the variation in the unemployment rate when only women form the sample. This suggests that fluctuations in the unemployment rate are mainly driven by the male component. This is particularly evident during the GFC in which the response among men was much higher than women (3 vs <1 percentage points).

Figure 5. Unemployment rate in Victoria—gender decomposition



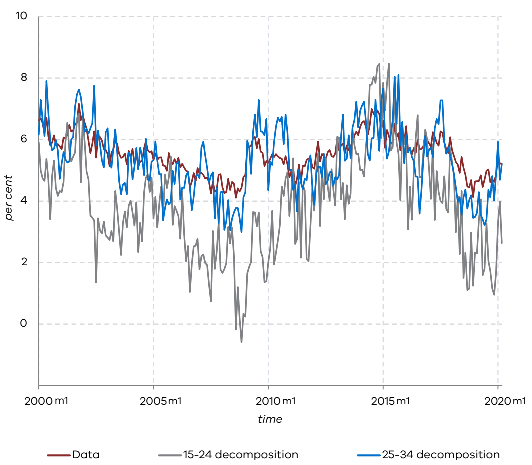
5.2 Role of age

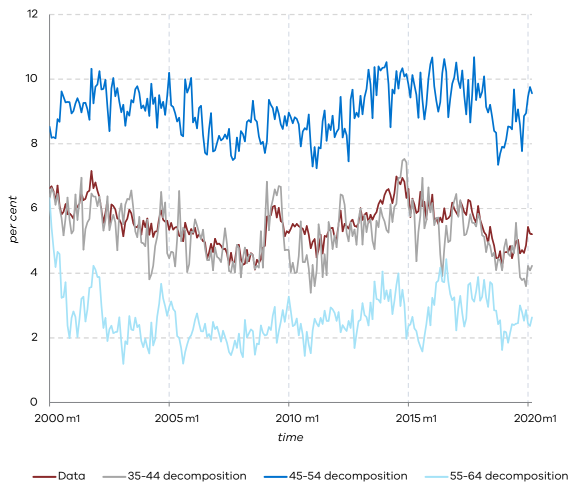
We proceed with analysing how different age groups contribute to the changes in the unemployment rate in Victoria. As before, we compute a series of counterfactual unemployment rates in which only the relevant group constitutes the labour market, i.e. what would the unemployment rate be if all workers behaved as workers in the 34–45 years category?

Figure 6 shows that among five different age groups, workers in the 25–34 and 35–44 years age group are the ones that most closely replicate the total unemployment rate in Victoria.[12,13] Assuming a labour market where individuals characteristics are similar to workers in the 45–54 years age group, we would have expected a higher unemployment rate, whereas if the characteristics are similar to the 55–64 years age group, the unemployment rate would have been lower.

This result reflects the differential impact of entry and exit into the labour market for the different age groups. In general, older workers are less attached to the labour market (i.e. exit more) and also enter the labour market at a lower rate. Whereas, gains from having a job and forming an employment relationship is higher among younger workers so that they are more likely to stay attached to the labour market and enter at a higher rate. The role of labour market participation is particularly evident from the different unemployment rates associated with workers in the age groups of 55–64 and 45–54. The oldest group exit more and enter less relative to the total which explains lower implied unemployment rate. However, workers in the 45–54 age group exit less while entering more, which explains the high unemployment rate relative to the other age groups.

Figure 6. Unemployment rate in Victoria—age decomposition





12 These five age groups are: 15–24, 25–34, 35–44, 45–54 and 55–64 year old.
13 This could also reflect the distribution effect in that this group more closely represent the distribution of unemployment in Victoria.

6. Conclusion

In this paper, we ask how different labour market transition probabilities have shaped the unemployment rate in Victoria over the past two decades. We answer this question by using a labour market flow approach to decompose the unemployment rate into different labour market transitions.

We show that variation in transitions associated with losing and finding a job can significantly explain variation in the unemployment rate over time. Moreover, we show that during the specified episodes of high unemployment, the composition of the unemployment pool changes towards workers with higher incentives to stay attached to the labour market for longer periods of time (such as younger workers). This explains our finding that changes in exits from the labour market can explain changes in the unemployment rate during episodes when the unemployment rate is high.

These findings have important policy implications. In a labour market where changes in the unemployment rate are primarily driven by workers having difficulties in finding and accessing a job, the relevant policies may include ones that help workers to search more effectively for a job (such as job training). However, if the change in the unemployment rate is related to lower labour market participation, policies that focus on maintaining attachment of workers to the labour market, such as policies that focus on job creation, may be more effective.

We also highlight the role of labour market heterogeneity in shaping the unemployment rate in Victoria. We show that when the unemployment pool is represented by men and/or workers in the age group of 25-44, the implied unemployment rate more closely follows the actual unemployment rate in Victoria.

At the time of writing this article, the adverse impacts of the coronavirus pandemic on the labour market are still resolving. Many workers have lost their jobs and many others have dropped out of the labour market. While the coronavirus (COVID-19) pandemic shock has directly (adversely) affected the transition probabilities between labour market states, the policy responses such as JobKeeper and JobSeeker have focused on maintaining job matches and maintaining the labour market participation. This may suggest future research on examining the role of these policies on the different labour market transitions and their impact upon labour market during the pandemic.

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Evaluating the effect of cutting the regional payroll tax rate[1]

By William Keating, Christopher Smart and Samuel Gow

ABSTRACT

How responsive are the remuneration and hiring decisions of Victorian businesses to payroll tax? Using a natural experiment based on the payroll tax rate being reduced in regional Victoria but not metropolitan Melbourne, we show businesses facing lower payroll tax rates increase their total wage bill. Our difference-in-difference estimates demonstrate liable business's total wages increased by approximately 7 to 9 per cent in response to the payroll tax rate cuts totalling 2.425 percentage points over a 24-month period. Notably, the effect was largely concentrated in the first year following an initial tax rate cut of 1.2 percentage points.

Overview

States and Territories in Australia levy payroll tax on the wage bill of liable employers. Payroll taxes are usually imposed at a flat rate, after a tax-free threshold that applies to an employer's total wage bill (not the individual employee) has been removed.

Payroll tax is one of the States' and Territories' most important own-source revenues. In 2019-20, total state and territory payroll tax revenue was $27.0 billion representing 17 per cent of own-source revenue — making this tax the largest collected by states and territories.

State and territory governments have generally reduced the share of revenue raised through payroll taxes over time, in attempts to encourage businesses to increase jobs in their jurisdiction. By evaluating a policy designed to make regional Victoria more attractive to employers, this paper adds to the narrow empirical literature relating to the efficacy of such reforms in Australia.

The payroll tax rate in Victoria has been set at 4.85 per cent since 2014-15. In the 2017-18 financial year, a lower payroll tax rate of 3.65 per cent was introduced for regional businesses. The rate was reduced further to 2.425 per cent from 1 July 2018. This payroll tax cut created a natural experiment which we exploit using difference-in-difference estimators. This paper aims to measure the impact of this cut on business behaviour by comparing the wage bill of businesses eligible for the regional payroll tax cut against the trends among ineligible businesses.

The structure of this article is as follows. Section 1 provides background detail on Victoria's payroll tax system and reviews relevant literature. Section 2 describes the Victorian State Revenue Office (SRO) data and how it differs from more widely used data sources. Section 3 details our estimation strategy. Section 4 describes and discusses the results, and Section 5 concludes.

1 The authors would like to thank the following Department of Treasury and Finance (DTF) staff for their comments: James Brugler, Omid Mousavi, Hao Wang, Shenglang Yang, Gillian Thornton, and Georgina Grant. The views expressed in this paper are those of the authors and do not necessarily reflect the views of DTF.

1. Literature review

Research on payroll tax in Australia tends to revolve around simulated deadweight loss and efficiency such as KPMG Econtech (2011) and Nassios, et al. (2019). There is little empirical literature which attempts to measure business decisions made due to changes in payroll tax policy in Australia.

Two prominent Australian papers use datasets in the Business Longitudinal Analysis Data Environment (BLADE) to measure effects of changes in payroll tax on business behaviour. Ralston (2020) finds little evidence for behavioural effects from payroll taxes. Majeed & Sinning (2019) did not find any evidence of changes affecting wages, employment, or capital expenditure.

Both studies evaluate the effect of tax-free thresholds (and the effective tax rate these imply), rather than the tax rate. In contrast, the natural experiment created in Victoria by the introduction of the regional employer payroll tax rate, provides an opportunity to investigate the effect of rate changes. Unlike a tax-free threshold, rates have a proportional and correctly identifiable impact for all businesses and therefore are more likely to have an identifiable treatment effect.

Studies based on thresholds likely also suffer from the datasets used not being particularly effective for estimating the actual threshold each business is able to deduct or properly identifying wages subject to the tax. Not all businesses can deduct the full amount of each State's or Territory's tax-free threshold from their wages when calculating their payroll tax. For example, when a business:

- is part of a group, the threshold is assigned to one business in that group or shared across the group rather than each business being able to deduct the full amount;[2] and
- operates nationally, the amount they can deduct will be determined by multiplying the State's or Territory's legislated threshold by wages paid in that State divided by their national wages.

Using datasets that do not properly identify payroll tax groups, including those in BLADE data, would result in multiple thresholds being attributed to a group (one for each business), masking the effects of changes to the threshold on these businesses. The BLADE-based papers would have partially mitigated the issues with grouping provisions by discarding businesses with wage bills larger than some threshold value, which are more likely to be part of a business group. However, this issue could still confound the results.

Furthermore, not all forms of wages are subject to payroll tax (for example, wages paid to parents on parental leave are exempt from payroll tax). Identifying the proportion of wages which are taxable is near-impossible using datasets such as those in BLADE that aggregate business wage data. This paper uses data on actual payroll liable Victorian wages.

Internationally, the literature around payroll tax-driven changes to business behaviour is more comprehensive and likely less prone to data issues. This literature provides evidence that targeted payroll tax cuts do effect individual wages of employees and total employees hired.

Saez, Schoefer & Seim (2019a) exploit an age-based payroll tax concession in Sweden to measure the effect of payroll tax cuts on youth unemployment using both worker and business level data. The study finds concessions positively affected the employment rate of eligible younger workers, but not their after-tax wages. Further research by the same authors — Saez, Schoefer & Seim (2019b) — finds the long-run effects on employment of the Swedish payroll tax cuts for young workers were larger than in the short-run and persistent in that they continued after eligible workers became too old (and therefore ineligible) as well as after the policy was repealed.

Stokke (2016) in Norway observed limited effects of regional payroll tax cuts on employment and suggested increased wages is a more likely result. This paper also notes these wage increases become less strong as worker education increases. Cruces, Galiani & Kidyba (2010) in Argentina, also observed limited effects of regional payroll tax cuts on employment but measurable increases to wages. Similarly, Bennmarker, Mellander & Öckert (2009) found that payroll tax cuts in Sweden had a measurable effect on the average wage bill per employee.

Korkeamäki & Uusitalo (2006) performed similar analysis in Finland but used matching techniques on business pairs in order to control for business and industry effects and found a reduction in payroll taxes led to measurably faster wage growth in the target region.

Interestingly Ku, Schönberg & Schreiner (2018) found businesses responded to the abolition of regional Norwegian payroll tax cuts by firing workers to compensate for the larger wage bill, as they could not pass the tax increase on to workers. This finding demonstrates the response of businesses to payroll tax may not be symmetric. This would imply payroll tax initiatives should not be pursued under an assumption they may be reversed without consequences.

2 Businesses can be grouped for payroll tax purposes if there is a link between the businesses. A link exists where:
- Corporations are related bodies corporate within the meaning of s50 of the Corporations Act 2001 (this situation is commonly known as a holding and subsidiary relationship).
- Employees are shared between businesses.
- The same person has (or the same persons together have), a controlling interest in at least two businesses.

The natural experiment created by the introduction of the regional employer rate in Victoria provides an opportunity to apply the basic concept of exploiting place-based changes in payroll tax policy used in this international research to an Australian context. Though the data available doesn't allow us to distinguish between the effect of the tax rate on wages and employment, as we only have access to business level wage data, the natural experiment may allow us to better understand the magnitude of the effect of the tax rate on total wage bills.

2. Data

The analysis in this paper uses data from the Victorian SRO payroll tax unit records, for the financial years 2016-17 to 2018-19. The 2016-17 financial year was the last in which regional employers paid the full rate of payroll tax, 4.85 per cent. In the 2017-18 financial year, a lower payroll tax rate of 3.65 per cent was introduced for regional businesses. The rate was reduced further to 2.425 per cent from 1 July 2018.

The SRO payroll tax unit records are administrative data collected from businesses to allow the SRO to effectively manage the calculation and collection of payroll tax liabilities. The SRO payroll tax unit records possess some unique features compared to datasets used in similar studies.

- No identification strategy is needed to remove payroll exempt businesses, as these are not recorded by the SRO or have a tax liability of zero. Other studies have had to either classify businesses manually or exclude data based on self-reported industry codes, which may be unreliable due to widespread inaccuracies in self-reporting of industry codes.
- Victorian wage bills are clearly reported by businesses and do not need to be derived or estimated from Australia-wide wages.

However, the payroll tax unit records do not contain any information about either the number of employees or any form of compensation per employee or hours worked. This means any observable effect of the regional payroll tax rate on wages will be at a business or group level.

Furthermore, though tax liability data are accurately reported (and heavily scrutinised), user entry is often problematic for wage bills. In cases where wages are clearly misstated, such as when the taxable wage bill is entered instead of the total wage bill, wages are imputed from the tax liability of the payer.

Businesses' regional employer status is recorded in the dataset. This means a business's eligibility for the regional rates does not need to be inferred from locational data, such as postcodes, which may represent the location of a business's (or its business group's) headquarters, not where most workers are located. However, the regional employer status of businesses is only recorded from the first treatment year. So, we cannot differentiate between businesses that would have qualified as regional employers in 2016-17 and those that shifted employees (or increased regional wages) to qualify in 2017-18.

Businesses grouped for payroll tax purposes are separately assessed for eligibility for the lower regional employer rate of payroll tax. For example, a business group could consist of three businesses located in Melbourne, Geelong and Ballarat. The first business would be ineligible for the regional rate due to its location (though this criterion was revoked from 1 July 2019) and would be liable to pay tax at the rate of 4.85 per cent. Eligibility for the Geelong and Ballarat businesses would depend on the location of their employees. If more than 85 per cent of their wage bill was paid to employees performing work in regional Victoria, they would be eligible for the regional employer reduction, even on the small amount of wages paid to employees located in Melbourne.

Where one business in a business group is eligible for the discounted rate but the other two are not, that member is eligible for the lower payroll tax rate of 3.65 per cent (2.425 per cent from 1 July 2018). The other two businesses in the business group will pay payroll tax at the rate of 4.85 per cent.

3. Methodology

We use group level wage panel data to estimate the impact of the regional payroll tax cut using a difference-in-differences (DiD) strategy. This strategy compares the effect of the regional payroll tax rate on groups that include one or more regional employer with a control group of groups comprised entirely of non-regional employers. DiD has become common in a policy evaluation and micro-econometric context since its usage in several seminal papers (Card & Krueger, 1994; Ashenfelter & Card, 1985). Discussed below in Box 1, DiD exploits variation in the application of a policy change across groups and time to identify the causal effect of the policy.

BOX 1: DIFFERENCE-IN-DIFFERENCES

Difference-in-differences (DiD) is an econometric method that compares outcomes across groups. In its simplest form, the outcome is observed for two groups in two time periods. Neither of the groups are exposed to 'treatment' in the first period (in our case, treatment is defined as lowering the payroll tax rate for regional employers). In the second period, however, one group is exposed to the treatment, while the other control group is not (Angrist & Pischke, 2008). Under several identifying assumptions, such as common trends in the absence of treatment, the difference in differences over time between the two groups then represents the causal effect of the treatment. In our example, metropolitan businesses form the control group, and businesses which receive the lower regional tax rate are the treatment group (they have a sudden drop in their tax rate). The advantage of the DiD approach is that broad macroeconomic trends in payrolls and employment are absorbed by the control and treatment groups, and so will not confound the analysis.

A similar approach has been used in overseas payroll tax assessments (Bennmarker, et al., 2009) and prior studies in Australia such as those described in Section 2 (Majeed & Sinning, 2019). In comparison to the latter work, we benefit from a business-level fixed effects specification in addition to direct tax status and liable wage reporting.

The key identifying assumption of this technique is parallel trends. After accounting for any covariates (in our case only fixed effects), both groups that include one or more regional employer and the control group of non-regional employers would follow the same growth path in the absence of policy intervention. Were this not the case, the estimate does not have a causal interpretation. In our context, a theoretical basis for this assumption is that payrolls are fundamentally driven by the level of economic activity, which is linked across the state. We further attempt to mitigate this issue by restricting the sample to businesses on the border of metropolitan Melbourne and regional Victoria which are likely to share most unobserved shocks not otherwise controlled for.

Our DiD specification is the standard form for panels with several years and units, which includes fixed effects at the group level and for every distinct year ('two-way' fixed effects), as opposed to the simpler indicators as discussed in Box 1.

The relevant regression equations are as follows:

$$w_{i,t} = \delta_i + \gamma_t + \beta_1 D_{i,2017-18} + \beta_2 D_{i,2018-19} + \varepsilon_{i,t} \qquad (1)$$

$$w_{i,t} = \delta_i + \gamma_t + \beta_3 (D_{i,2017-18} + D_{i,2018-19}) + \varepsilon_{i,t} \qquad (2)$$

- $w_{i,t}$ refers to the natural logarithm of Victorian taxable wages (payrolls) for business i in period t
- δ_i and γ_t to business and time fixed effects for business i and time t respectively
- $D_{i,t}$ is an indicator variable equal to 1 if business i was eligible for the regional payroll tax rate time t, and 0 otherwise

Specifications (1) and (2) are very similar, except (1) identifies the cumulative effects of the two policy changes (the first and second rate reductions) independently as β_1 and β_2. β_3 identifies the pre-post average impact of all regional tax changes to date – it numerically equates to a weighted average of β_1 and β_2, but provides a useful evaluation of the average effect on payrolls to date.

We calculate standard errors for all estimates clustered at the panel unit (business, in our case) level, as recommended by Bertrand et al. (2004).

While we are confident parallel trends is a reasonable assumption across the data, we apply this model to two subsets of the dataset, being:

- the complete dataset of businesses in the SRO unit records; and
- a subset of businesses in areas near the border of metropolitan Melbourne and regional Victoria. These border areas are shown below in Figure 1 and Table 1.

In both cases, the treatment group is made up of groups that included at least one business that claimed the regional employer rate and the control group is made up of groups comprised entirely of businesses that paid payroll tax at 4.85 per cent.

We have chosen to analyse the effect of the tax policy change on groups rather than individual businesses as responses to the treatment may comprise an income and a substitution effect. Groups can respond to the reduced rate of tax payable on regional employees by either employing more regional employees, as the cost of regional employees has fallen (the substitution effect), or employing more staff in any or all of their businesses, as they have increased purchasing power (the income effect). If we assessed each business individually, then the income effect as it relates to the metropolitan part(s) of grouped businesses would not be captured as an effect of the treatment.

Limiting analysis to the subset of business groups around the border provides an initial robustness check against geographically based confounding factors. For example, the onset of drought or bushfires in regional areas in the same years we measure would confound our estimates as these trends would not apply equally to metropolitan and regional businesses.

Using the subset of border businesses should minimise the potential for unobserved confounding variation, including by removing inner-city-based businesses (which may have substantially different growth trends) and retaining a significant number of both regional and non-regional employers. We include regressions of specifications (1) and (2) on both samples in Section 4.2, with the whole-of-state results primarily acting as a validity check.

Figure 1: Border business area

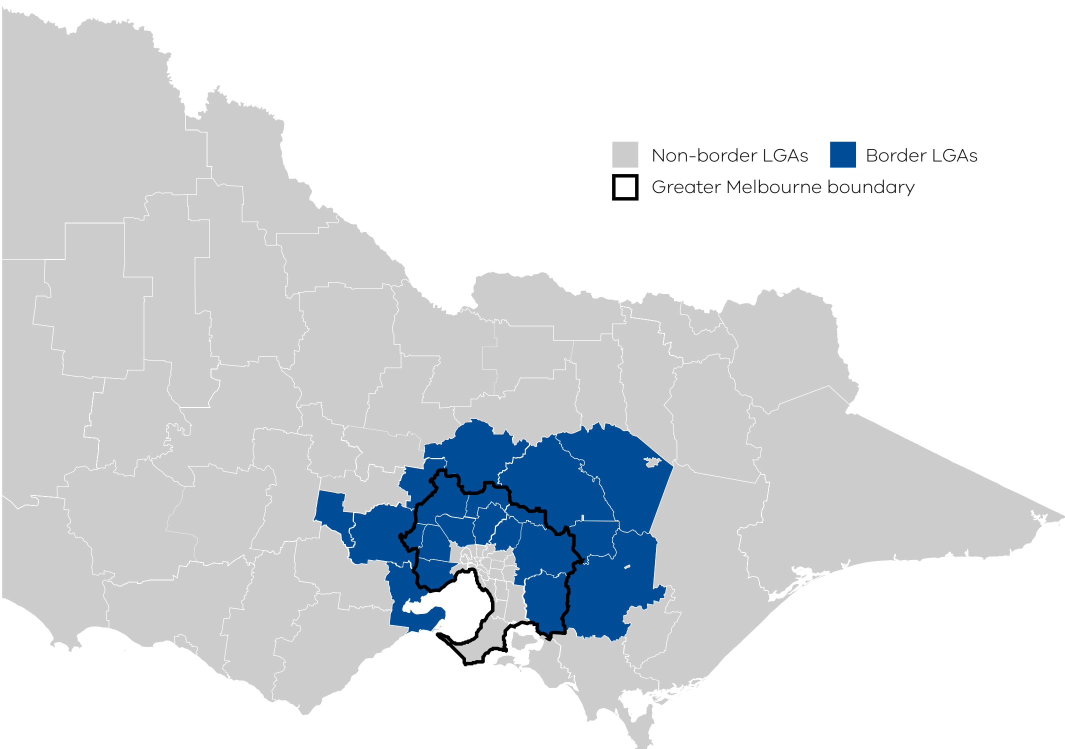


Table 1: Metropolitan-Regional border LGAs

REGIONAL	METROPOLITAN
Greater Geelong City Council	Wyndham City Council
Moorabool Shire Council	Melton City Council
Ballarat City Council	Hume City Council
Macedon Ranges Shire Council	Whittlesea City Council
Mitchell Shire Council	Nillumbik Shire Council
Murrindindi Shire Council	Cardinia Shire Council
Mansfield Shire Council	
Baw Baw Shire Council	
Yarra Ranges Shire Council	

To alleviate concerns regarding treatment status changes — groups switching between regional and non-regional status between the treatment years — we also present results with these (switching) groups dropped.

One caveat of the DiD technique applied here is that, due to regional and metropolitan businesses drawing from a broadly shared labour force (i.e. there is minimal distinction between potential workers), increases in regional payrolls may, in part, be a result of reductions in metropolitan wages. These general equilibrium effects are not separately identified under this research design (Ku, et al., 2018, p. 13). However, such effects are still captured in our estimates. This means, in part, our results cannot be interpreted generally for business responses to reductions in the overall payroll tax rate as the increase in wages may be zero sum. Uniform payroll tax rate cuts do not incentivise region-based labour shifting in the same way targeted variation does, so the impacts are likely to be smaller.

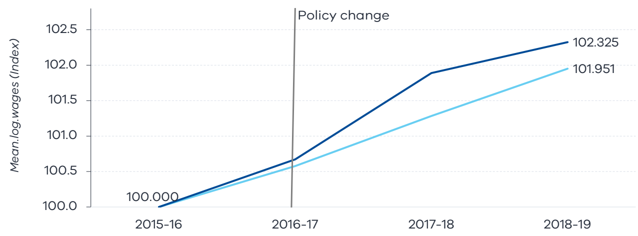
4. Empirical results

4.1 Evaluating parallel trends

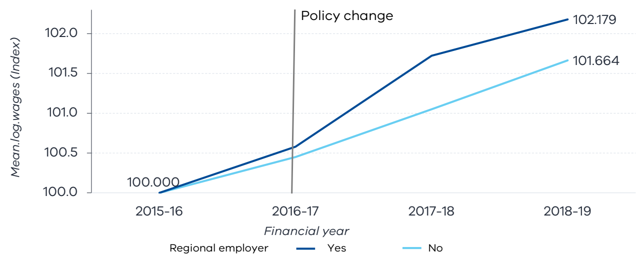
We plot the trends of the variable of interest (log Victorian wages) among groups with regional employers and groups without regional employers and examine their growth paths. Graphical evidence that the trends are very different would potentially invalidate our identification strategy. The wage trends are plotted on an index against the relevant group average in 2015-16.

Figure 2: Parallel trends plots, 2015-16 to 2018-19

(a) Border firm subset



(b) All firms



Note: Groups which recorded as regional payers in either 2017-18 or 2018-19 are carried backwards and assigned as 'regional' in earlier years. The mean log-wages show the average of the logarithm of firm wages bills, across the firms in each subset shown.

With regional and without regional average log wages appear to follow shared paths, with a significant increase following the initial regional payroll tax change as demonstrated by the increased slope on the yellow series between 2016–17 and 2017–18. This suggests parallel trends is a reasonable assumption and an effect is present in the data.

4.2 Difference-in-differences estimation results

We estimated both DiD specifications as described in Section 3 by ordinary least squares (OLS), with the results shown in Table 2.

We find positive increases to businesses' total wage bills from the regional tax rate in Victoria as a whole and within border areas. Overall, the effect of rate cuts up to 2018–19 was an increase in the value of the regional-employer payrolls of 6.8 per cent for all businesses in Victoria, and 7.9 per cent for all those within border areas.

Table 2: Fixed effects regressions — border businesses and all businesses

	LOG VICTORIAN WAGES			
	BORDER BUSINESSES		ALL BUSINESSES	
	(1)	(2)	(3)	(4)
Diff-in-Diff 2017–18 (β_1)	0.070***		0.071***	
	(0.014)		(0.009)	
Diff-in-Diff 2018–19 (β_2)	0.088***		0.066***	
	(0.017)		(0.010)	
Diff-in-Diff aggregate (β_3)		0.079***		0.068***
		(0.015)		(0.009)
Fixed effects:				
Business group	Yes	Yes	Yes	Yes
Financial year	Yes	Yes	Yes	Yes
Businesses	6 661	6 661	46 185	46 185
Years	4	4	4	4
Observations	21 927	21 927	149 341	149 341

Notes:

***Significant at the 1 percent level
**Significant at the 5 percent level
*Significant at the 10 percent level

Under our assumption of conditional parallel trends, these findings indicate that the introduction of the regional payroll tax rate increased regional business payrolls, which is significant statistically and with a noticeable large magnitude.

We conducted hypothesis tests to evaluate whether there was a statistically significant difference in the coefficients for each treatment (β_1 and β_2). The results of these tests, shown below in Table 3, and demonstrate the null hypothesis of equal coefficients cannot be rejected in the data. This means we cannot conclude there was any increased effect on payrolls moving from the initial regional payroll tax cut in 2017-18 to the subsequent rate in 2018-19. This result is somewhat counterintuitive and further work confirming this outcome would be prudent.

Table 3: Testing for coefficient variation — $H_0{:}\beta_1{=}\beta_2$

MODEL	χ^2 STATISTIC	P-VALUE
Marginal businesses (model (1))	1.769	0.183
All businesses (model (3))	0.473	0.491

4.3 Robustness check and additional tests

The primary robustness check of our results is the application of the methodology to the subset of near-border businesses as well as the whole-of-state dataset. However, as some businesses switch treatment status, this is a potential area which could confuse the interpretation of the primary results. A business which is not treated in 2017-18 but is in 2018-19, will be affected differently to those treated in both years. The same issue arises when businesses exit the treated group. This necessitates a robustness check to determine these businesses do not dramatically change the outcome of our analysis. Though the study design consisting of two distinct treatment estimators validates the primary results, we assess the robustness of the results by discarding all businesses which did not have a consistent treatment status across the policy years. This results in 261 businesses (or 3.9 per cent) being dropped from the border business sample.

Shown in Table 4, this approach yields a smaller estimate for each year of the policy, though still statistically significant (within half a percentage point of the 1 per cent level). The same coefficient hypothesis testing as in Table 3 was also conducted for this model, again returning insufficient evidence to conclude the rate reduction had a further marginal effect between 2017-18 and 2018-19.

Table 4: Regression results — border business subset, switching businesses dropped

	LOG VICTORIAN WAGES	
	(5)	**(6)**
Diff-in-Diff 2017–18 (β_1)	0.044***	
	(0.016)	
Diff-in-Diff 2018–19 (β_2)	0.037**	
	(0.017)	
Diff-in-Diff Aggregate (β_3)		0.041***
		(0.015)
Fixed effects:		
Business group	Yes	Yes
Financial year	Yes	Yes
Businesses	6 400	6 400
Years	4	4
Observations	20 013	20 013

Notes:

***Significant at the 1 percent level
**Significant at the 5 percent level
*Significant at the 10 percent level

5. Discussion

The estimates shown in Section 4.2 are useful from a policy analysis standpoint. Our findings demonstrate businesses that received the regional rate of payroll tax increased total wages at a faster rate than businesses which were not eligible. However, for several reasons, the interpretation of this disparity is unclear without further research.

The relative effects of the policy interventions in 2017-18 and 2018-19 highlight this. Though the rate cut in 2018-19 was larger than the one in 2017-18, its marginal impact was statistically insignificant, contrary to the response to the first reduction. The elasticity of business-level aggregate employee remuneration with respect to the payroll tax rate in the first year was -0.287, but the cumulative elasticity over both periods is lower at -0.136. This is unexpected if the benefits were derived purely from the reduced marginal costs induced by payroll tax cuts, as these should be reasonably linear.

We considered several hypothetical explanations for this observed reaction. First, full adjustment in advance of subsequent rate changes — that is, businesses may have reacted to future reductions in the initial year. However, the timing of regional rate announcements means this effect seems unlikely.[3] We are sceptical of this because the regional rates taken up in 2017-18 and 2018-19 were announced in their respective financial years' Victorian Government budget. It is possible businesses foresaw a future policy agenda of further cuts, but there is little chance this effect would be sufficient to explain the subdued reaction to the second cut we observe. An alternative explanation is increased regional payrolls in the first policy year resulted from a larger workforce due to improved competitiveness with metropolitan businesses or relocating resources within businesses.

Under the first explanation, the primary benefit to regional businesses came from having any significant cost reduction, and so the subsequent change may have minimal benefits. Under the second explanation, businesses benefited from the regional rate reduction by relocating employees to qualify rather than changing remuneration. These explanations are difficult to fully assess at this time but could be assisted by investigating the impact of further legislated regional rate changes.

We find the alternative explanation compelling and, while further research is warranted, it suggests the primary benefit from the regional payroll tax rate may be yielded by a non-negligible tax advantage of businesses employing staff in regional locations compared to metropolitan locations. The diminished response to the secondary rate cut suggests this is a non-linear effect, possibly resulting from work that is significantly substitutable between regions being captured in the initial change. However, reviewing Figure 2 brings this substitution effect into question — there is no clearly visible reduction in payroll growth for non-regional businesses, as would be expected if regional businesses were 'crowding out' metropolitan employers.

3 Change for 2018-19 was read first in May 2018. Technically this could allow pre-emptive behaviour by businesses, but this seems unlikely given the short time frame (remembering that 2018-19 ended on 30 June 2019). The relevant bills and timelines can be found at: https://www.legislation.vic.gov.au/bills/state-taxation-acts-amendment-bill-2017 and https://www.legislation.vic.gov.au/bills/state-taxation-acts-amendment-bill-2018

It is impossible to say, however, whether the non-linearity means future rate cuts will be ineffective. This is primarily because there may be a step-functional relationship where cuts elicit reactions as they pass thresholds, as opposed to a diminishing effect in general. As DTF receives periodic updates to this administrative data from the SRO, it would be prudent to continue to monitor the trends among regional and non-regional businesses using the framework set out in this paper.

Lastly, as our dataset does not include information on employee numbers or work hours, we cannot distinguish between employment (hours worked) and wage (increased pay per hour) effects. This is a significant avenue for future inquiry but would require additional data.

6. Conclusion

Our analysis concludes cutting the rate of payroll tax for regional Victorian employers from 4.85 per cent to 3.65 per cent had a statistically significant positive effect on business-level aggregate employee remuneration in the first financial year it was introduced. However, the effect of the further reduction of the regional employer rate from 3.65 per cent to 2.425 per cent from 1 July 2018 was not statistically differentiable. These results suggest the regional employer rate has been successful in influencing the behaviour of eligible regional businesses in 2017-18.

The second finding suggests subsequent changes in regional payroll tax rates may not motivate further increases in regional wage bills. The significant change in wage bills in 2017-18 may have resulted primarily from improved competitiveness of employing workers in regional businesses relative to metropolitan businesses. We hypothesise that subsequent changes to the tax rate may have effects on payrolls depending on if they pass some 'threshold' levels required for businesses to relocate or increase activity. As further regional payroll tax rate cuts in Victoria have been planned, this will be observable and provides an avenue for future work to identify these 'threshold' levels and to confirm that this finding is valid.

The results may also have implications for state and territory policies designed to attract businesses or increase employment by lowering payroll tax rates. If business-level aggregate employee remuneration responds non-linearly to reductions in payroll tax rates, then policies that lower payroll tax rates (including threshold increases) to attract businesses may only be effective if the reductions exceed 'threshold' levels required for businesses to relocate activity.[4] If this is the case, a State or Territory reducing the rate of its payroll tax may do little to further encourage business to relocate if the rate reduction does not exceed some threshold.

The use of SRO payroll tax unit records mitigates many issues that have historically made evaluating payroll tax policy difficult, such as grouping provisions and state wage bill separation. Our significant results demonstrate the benefit of using state level unit records to answer state and territory tax policy questions.

This study raises questions about how we view and discuss payroll tax policy in Australia. This work is important as discussions around payroll tax policy in Australia have seldom included empirical evaluations of the efficacy of payroll tax policy initiatives. Once policy has been implemented, the ability to empirically test is greatly increased when tax record data can be obtained. We believe this is key to discussions of tax reform work as it provides governments with greater information as to what initiatives should be implemented in future and encourage other agencies with access to similar data to evaluate the empirical effects of their own payroll tax policies.

4 A threshold increase reduces the effective payroll tax rate for a business by reducing the share of its wages subject to tax. For example, the scheduled increase in Victoria's tax-free threshold from $650,000 to $700,000 will reduce the effective tax rate, or tax as a share of total wages, for a business with wages of $1 million from 1.7 per cent to 1.45 per cent.

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The economic impacts of the 2019-20 bushfires on Victoria[1]

By Glyn Wittwer[2], Kuo Li and Shenglang Yang

ABSTRACT

Understanding the economic impacts of the 2019-20 bushfires on the State can help inform future policy making. This paper has been jointly produced by the Department of Treasury and Finance and Centre of Policy Studies (CoPS) and uses the Dynamic VU-TERM computable general equilibrium (CGE) model to quantify the economy-wide impacts of the 2019-20 bushfires in Victoria.

The direct impacts of the bushfires in terms of capital destruction and labour productivity losses, along with the indirect impacts to international tourism, which are assumed to be sizeable and prolonged, result in a 0.1 per cent fall in Victoria's real gross state product (GSP) in 2019-20, with output remaining below baseline levels for more than five years. The overall welfare losses to Victoria are estimated to be $2.1 billion in net present value terms (in real 2017-18 dollars), with around 70 per cent of the total economic impacts attributed to the assumed effects of the bushfires in supressing international tourism to Victoria over the forward years. Accommodation and food services, transportation and construction sectors incur substantial losses due to their supply chain linkages with international tourism.

It is important to note that this analysis does not account for the Government's responses to the bushfires. Broader costs relating to the environment, health and wellbeing are also not considered in this modelling.

While the economic impacts of the bushfires have now been overwhelmed by the impacts of the coronavirus (COVID-19) pandemic, this study shows the impacts of bushfires alone. The pandemic would worsen outcomes in regions directly affected by bushfires by slowing building and property restoration and hindering a return to business-as-usual.

Overview

The Australian bushfires in 2019-20 left a devastating impact on communities, through loss of lives, destruction to homes, farmland, infrastructure, crops and conservation land and the corresponding impact on livelihoods.

In Victoria, more than 1.3 million hectares of land were burned with close to 400 homes destroyed and five fatalities. Most of the fire-related direct impact (i.e. asset losses, smoke damage and production disruption) occurred in North East Victoria (comprising Wangaratta and Wodonga) and East Gippsland. As at May 2020, the Insurance Council of Australia estimated the total insurance loss attributed to the bushfires nationwide to be $2.3 billion with over 38 000 claims.

1 We would like to thank Andrew O'Keefe, Georgina Grant, Gillian Thornton, Hao Wang, Marcella Choy and Maryam Nasiri for their kind comments and suggestions. The views expressed are those of the authors and do not necessarily reflect the views of DTF.

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Around 8 per cent of the total insurance loss was attributed to Victoria (Insurance Council of Australia, 2020). Prolific media coverage of the bushfires also affected international tourism (Schweinsberg et al., 2020).

The COVID-19 pandemic following the bushfires further reduced economic activity and overshadowed the economic impacts from the bushfires. However, understanding the economic impacts and the inter-sectoral flow-on effects of the 2019-20 Australian bushfires remains important in 2021. Australia is prone to natural hazards, especially bushfires. The frequency and severity of fire weather in southern and eastern Australia has increased since 1950 (Royal Commission into National Natural Disaster Arrangements, 2020). Just more than a decade ago, the 2008-09 Victorian bushfires destroyed more than 3 500 buildings and more than 450 000 ha of land (2009 Victorian Bushfires Royal Commission, 2010). Understanding the economic impacts of bushfires and the inter-sectoral flow-on effects can inform policy responses for future natural hazards.

This study uses a dynamic version of The Enormous Regional Model (TERM) CGE model developed by the Centre of Policy Studies at Victoria University to examine the economic impacts of the 2019-20 bushfires on Victoria. The original TERM model provides a multi-regional representation of Australia that is useful for examining the regional impacts of shocks that are region specific (see Horridge, 2011). The dynamic version of this model, called the Dynamic VU TERM model, allows for the effects of ascribed impacts to be traced across time periods.

This study focuses on impacts the 2019-20 bushfires had on economic conditions in the regions that were most adversely affected by the fires (both directly and indirectly), as well as the implications for Victoria as a whole. We also analyse the impact of the bushfires on different industries. We consider the direct bushfire impacts via destruction of output, damage to capital along with the adverse effects of hazardous smoke on labour productivity. We also account for the indirect impact on international tourism through the damage to Australia and Victoria's attractiveness as a tourist destination. The assumptions in relation to the length and severity of weakness in international tourism is a key driver of the modelled economic impacts. We do not consider the broad costs arising from destruction of native forests and diminution of fauna and flora. In addition, losses in human life along with the broader costs of the excess health burden such as those associated with increased hospital admissions are not quantified in the model.

By simulating the model with a set of hypothetical shocks, we find that the impacts of the bushfires result in a 0.1 per cent fall in Victoria's real GSP in 2019-20 and that it takes more than five years to recover to its pre bushfire baseline levels. The overall welfare losses to Victoria are estimated to be $2.1 billion in net present value terms (at a discount rate of 2.5 per cent) over an 11-year simulation period covering 2019-20 to 2029-30. The study finds that the direct impacts of bushfires were vastly outweighed by the indirect impacts of assumed weaker international tourism demand, which had more widespread effects in Victoria and accounted for around 70 per cent of the net welfare losses. We find that the accommodation and food services and transport sectors suffer the largest losses due to their exposure to international tourism and these losses persist until the end of the simulation period. Additionally, the construction industry also suffers substantial losses due to its connection with investment, which declines in some regions due to depressed tourism demand.

Despite the lack of studies focusing specifically on the impacts to Victoria, other studies have examined the overall impacts on Australia. The Reserve Bank of Australia (2020) estimated that the direct effects of the bushfires would reduce national gross domestic product (GDP) growth across the December 2019 and March 2020 quarters by around 0.2 percentage points, with some recovery in the June quarter and beyond. Similarly, Westpac (2020) estimated that the bushfires would result in a 0.2 to 0.5 per cent reduction in annual GDP, and placed the total cost in terms of insured and uninsured losses at around $5 billion nationally.

This study, however, does not account for the financial cost of government responses to mitigate future bushfires and to support disaster recovery. Government responded at both the national and state levels. At the national level, the Commonwealth Government has committed more than $2 billion to various bushfire recovery programs (see National Bushfire Recovery Agency, 2020). At the Victorian state level, the Victorian Government has invested $250 million towards affected communities including the establishment of Bushfire Recovery Victoria (BRV), which is currently administering the clean up program in Victoria (Parliament of Victoria, 2020). There are also a range of financial support and relief programs targeting various affected individuals, families and businesses (see State Government of Victoria, 2020). All else equal, such schemes would be expected to expedite economic recovery by boosting the speed of capital recovery and cushioning the damaging impacts to employment in various affected regions and industries.

While the economic impacts of the bushfires have now been overwhelmed by the impacts of the COVID-19 pandemic, this study shows the impacts of bushfires alone. The pandemic would worsen outcomes in regions directly affected by bushfires by slowing building and property restoration and hindering a return to business-as-usual.

This study demonstrates an approach to understand how the impacts of localised bushfires flow through the economy and quantifies the impacts of bushfires on Victoria. This fills the gap in the existing 2019-20 bushfires analyses.

1. Methodology

This study uses the Dynamic VU-TERM multi-regional computable general equilibrium (CGE) model to measure the economic impacts of the 2019-20 bushfires on Victoria.

CGE models are large numerical models which combine economic theory with real economic data to computationally determine the impacts of policies or shocks to an economy. They provide a valuable modelling framework for conducting 'whole of economy' analysis due to their highly disaggregated conceptual architecture, enabling the inter-relationships of a wide range of economic agents and their interactions to be captured. Their whole of economy construct enables both the direct and indirect (secondary) effects of policies, events or projects to be considered. As such, they can give holistic insights into the estimated economic costs and benefits for an economy and its sectors. CGE models have been used to inform a wide range of policy debates at the state, national and global level.

The Dynamic VU-TERM model is an economy-wide model developed by the Centre of Policy Studies that can account for and represent various small regions within the economy (see Horridge, 2011). The model is regionally disaggregated to include the two Victorian regions impacted by the bushfires, namely North East Victoria (Wangaratta and Wodonga SA3 regions) and East Gippsland.

For the purposes of this study, the model database contains 26 sectors, including horticulture, wine grapes, livestock, broadacre crops and various downstream product industries for the agriculture sector. It also includes major tourism-related sectors, such as hotel and cafes, holidays by domestic residents and tourism exports.

Modelling strategy and input data

The Dynamic VU-TERM model traces the effects of ascribed shocks across time periods. The 11-year time horizon including the impact year (2019-20 to 2029-30) that we use in this study allows the short, medium and long-run impacts of the bushfires to be observed. A 'business as usual' forecast baseline is established over this horizon which allows the modelling results to be presented as deviations relative to this baseline. There are several broad types of economic costs arising from bushfires, including:

- destruction of capital, including houses, outbuildings, livestock, vineyards, other plantations, fencing, cars, powerlines, easements and telecommunications towers;
- destruction of current crops including the impact of smoke taint (mainly output loss in the Wine Grape and Wine industries);
- loss of labour productivity due to smoke;
- reduction in visitors to regions; and
- increased insurance premiums as a result of the insurance payouts.

All costs in this study are measured in 2017-18 monetary terms.

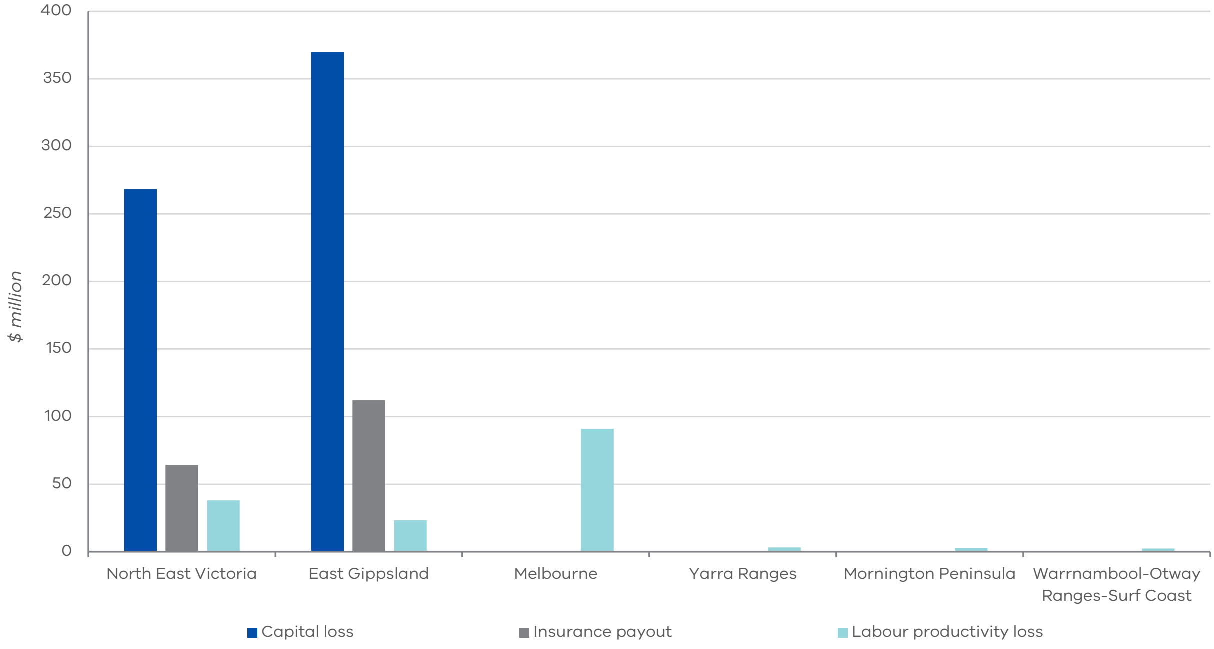
We estimate the direct and indirect impacts of the bushfires via shocks to capital, productivity, insurance premiums and tourism. These shocks are calibrated based on a range of sources including news media and government reports.

The direct capital loss nationwide is estimated to be a significant $3.2 billion.[3] In Victoria, the affected regions were North East Victoria ($268 million) and East Victoria including Gippsland ($370 million). Labour productivity losses are associated with hazardous smoke and poor air quality, which can exacerbate asthma and other respiratory conditions. Although the smoke was prolonged and hazardous in bushfire regions, the movement of smoke to major urban areas in Victoria was more limited and short-lived. In contrast, New South Wales suffered more than 35 days of hazardous smoke levels in 2019 (NSW Department of Planning, Industry and Environment, 2020). Figure 1 presents the estimated losses to capital and labour productivity and the increase in insurance payouts by region.[4]

3 Capital loss is calculated as the number of lost assets based on media reports multiplied by their estimated average replacement costs.

4 Loss of labour productivity is calculated based on the number of days with hazardous smoke levels and the cost of each hazardous day estimated by Terry Rawnsley in Irvine (2019), while the estimated increase in insurance premiums is based on published media reports.

Figure 1: Estimated direct losses in capital and labour productivity and insurance payout, Victoria, 2019-20

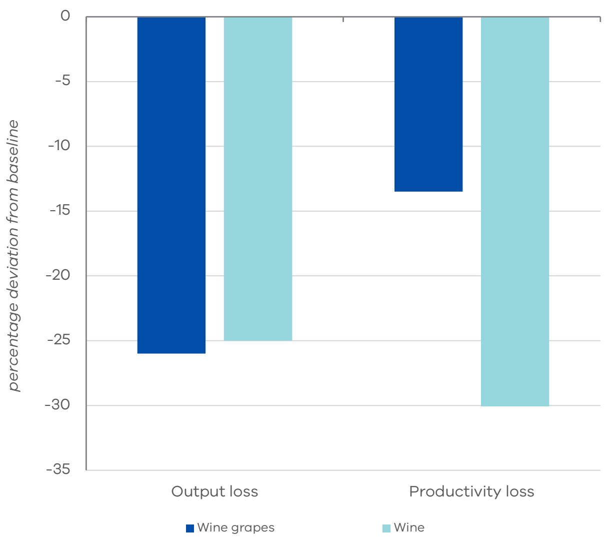


The destruction to capital in North East Victoria was primarily experienced in the Wine Grape and Wine industries.[5] These industries lost more than 25 per cent of output in 2019-20 due to the smoke damage to vineyards. Disruptions caused by the smoke also leads to loss in total factor productivity in these two industries (Figure 2).

The indirect effect of the bushfires on tourism is less certain and assumption driven. It is assumed that domestic tourism recovers quickly, with public campaigns playing a role in restoring regional demand. In addition, due to domestic visitors having better knowledge and access to information on local conditions, the negative perception-based impacts on domestic tourism can be quickly mitigated.[6] Based on this reasoning, no shock is imposed to domestic tourism for this study.

On the other hand, it is assumed that there is a persistent impact on international visitors due to perceived risks of bushfires during their stay in Australia and other reputational damages. The magnitude of the negative impact is assumed to be a 20 per cent decline in tourism exports during the second half of 2019-20.[7] This decline in tourism exports is widespread across multiple regions and impacts not just those in the directly affected areas. A notable reduction in international travel underpins this profile, with international visitors assumed to form long-lasting impressions of the risks of travelling to Australia. Tourism exports are assumed to improve slightly during the following two years, improving to a 10 per cent decline from the baseline in 2020-21 and 2021-22. It is assumed that by 2022-23, tourism exports recover back to baseline levels.[8]

Figure 2: Loss of output and productivity in Wine Grape and Wine industries (North East Victoria)



5 There is lack of information on capital destruction and insurance payout in the regions outside North East Victoria and East Gippsland as there was no material bushfire in those regions.
6 This is consistent with academic evidence such as Walters and Clulow (2010) who find that the negative tourism perception following the 2009 Victorian bushfires persists longer in markets that are more distant from Victoria.
7 Based on estimate by the Australian Tourism Export Council in Carruthers (2020) along with subjective judgement.
8 This assumed decline in tourism accounts for $1.4 billion welfare loss at net present value. This welfare loss is approximately scalable for sensitivity analysis.

This study does not consider the entire range of health and wellbeing effects on affected individuals and communities. For example, aside from the adverse health impacts of smoke inhalation on various respiratory and cardiovascular conditions, the bushfires are also likely to escalate the incidence of posttraumatic stress disorder (PTSD) among professional and voluntary firefighters. As a result, this study likely underestimates the impacts associated with time off work and labour productivity losses. Also, the broader costs associated with the excess health burden such as increased hospital admissions are not measured. Moreover, the loss of human life both directly in the bushfires along with smoke-related deaths such as those estimated by Arriagada *et al.* (2020) are not quantified. In addition, the costs arising from destruction of native forests and diminution of fauna and flora are also not considered.

Finally, this study has excluded the impact of government policies and community initiatives that would mitigate the economic impacts of the bushfires in this analysis. Specifically, the various financial support programs provided to small businesses and primary industries, along with taxation relief measures for businesses, families and individuals in affected regions (see State Government of Victoria, 2020) can be expected to expedite economic recovery.

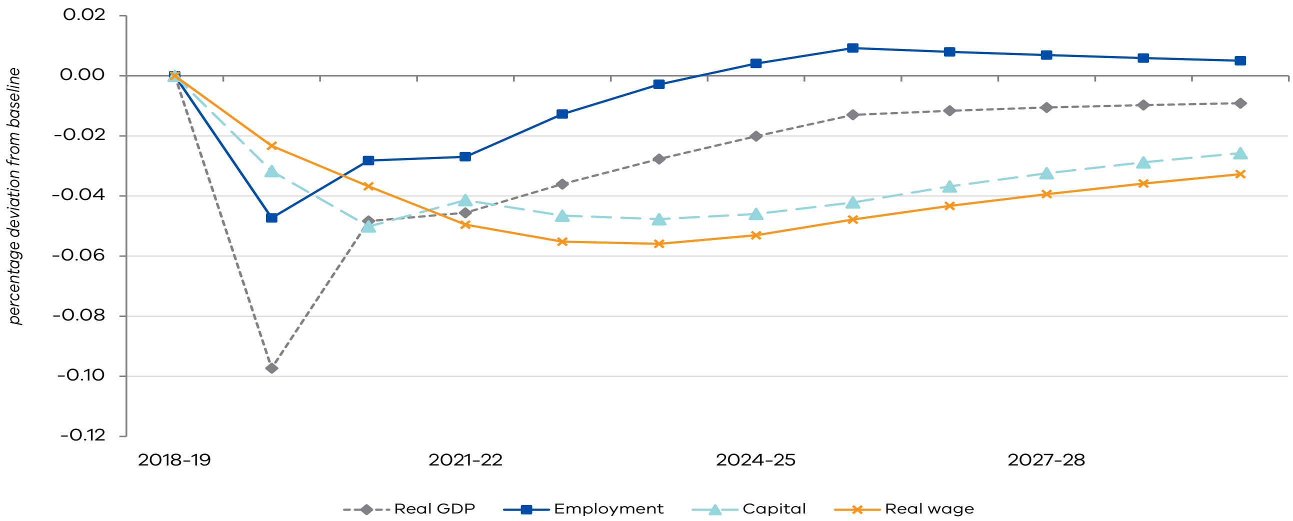
2. Results and discussion

This section discusses the modelled economic impacts of the bushfires on Victoria, selected regions and industries. It considers the regions directly impacted by the bushfires (i.e. North East Victoria and East Gippsland) as well as the regions indirectly affected by ongoing reductions in international tourism (i.e. Melbourne, Yarra Ranges, Mornington Peninsula and Great Ocean Road regions of Warrnambool-Otway Ranges-Surf Coast). The estimated impacts on all economic indicators are reported as percentage deviations relative to baseline business as usual levels.

2.1 Statewide impacts

During the 2019-20 event year (year 0), we estimate that Victoria suffered a 0.1 per cent loss in GSP brought about by the impacts of capital destruction and employment and productivity losses. Figure 3 shows the impact and recovery path for GSP, employment, real wages and capital.

Figure 3: Real GSP and factor inputs, Victoria (per cent deviations from business-as-usual base)

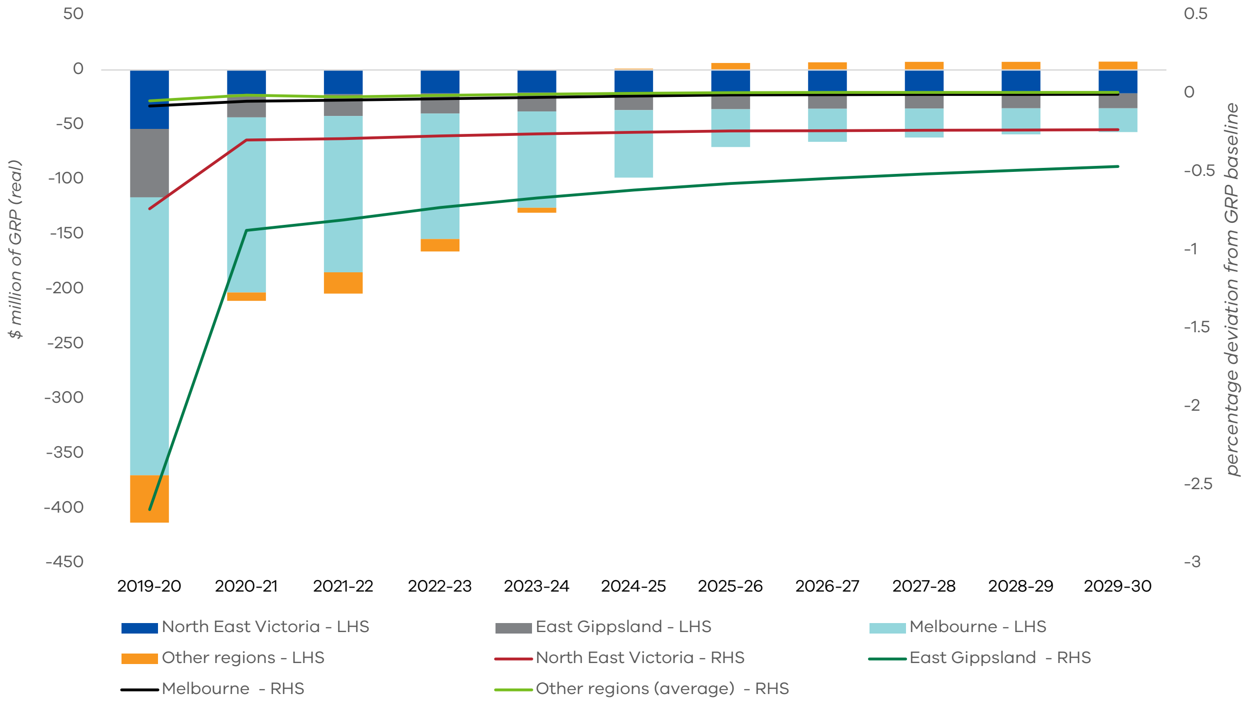


It takes more than five years for real GSP to return to near pre-bushfire baseline levels. Although the direct bushfire impacts are concentrated in North East Victoria and East Gippsland, their contribution to statewide GSP losses are small as these regions only account for a small proportion (around 2.2 per cent) of Victoria's GSP. This vast majority of losses in state GSP are attributed to the disruption to international tourism in non-bushfire areas. Being an important economic driver for the State, international tourism contributed around $4.7 billion to Victoria's gross value add in 2018-19 (Business Victoria, 2020).

The losses in capital in North East Victoria and East Gippsland in 2019-20 is estimated to be 0.03 per cent of the State's total capital stock. The destruction of capital coupled with the decrease in international tourism demand weaken the labour market in Victoria, with employment falling by 0.04 per cent during 2019-20. The negative impacts to international tourism are expected to persist and do not recover fully until 2023-24. This leads to temporary decrease in investment across Victoria and lower capital stock as a result. Diminished capital stock, coupled with increased insurance premiums for the two fireaffected regions, result in persistently lower real wages and consumption throughout the simulation period. Employment levels fall in the event year and employment falls are most pronounced in the fire-affected regions of North East Victoria and East Gippsland due to the direct effects of capital destruction and productivity losses. By the end of the simulation period in year 10, employment levels return to base levels in all regions.

Real GSP persists below pre-bushfire baseline levels throughout the simulation period due to the diminished capital stock. Figure 4 summarises the impact on real gross regional product (GRP) for regions throughout the simulation period. The bar chart shows each region's contribution to the total monetary impact (measured in millions of dollars) during each year, and the line graphs show each region's percentage deviation from their baseline levels. The chart shows that most of the total monetary impact is attributed to Melbourne due to its substantial base level of GRP. However, it is East Gippsland and North East Victoria that sustain the greatest percentage deviations from their base levels. Around 30 per cent of real GSP losses in the event year can be attributed to the two fire-affected regions, and around 70 per cent of losses can be attributed to other regions.

Figure 4: Summary impact to real GRP ($m) and percentage deviation from baseline by region



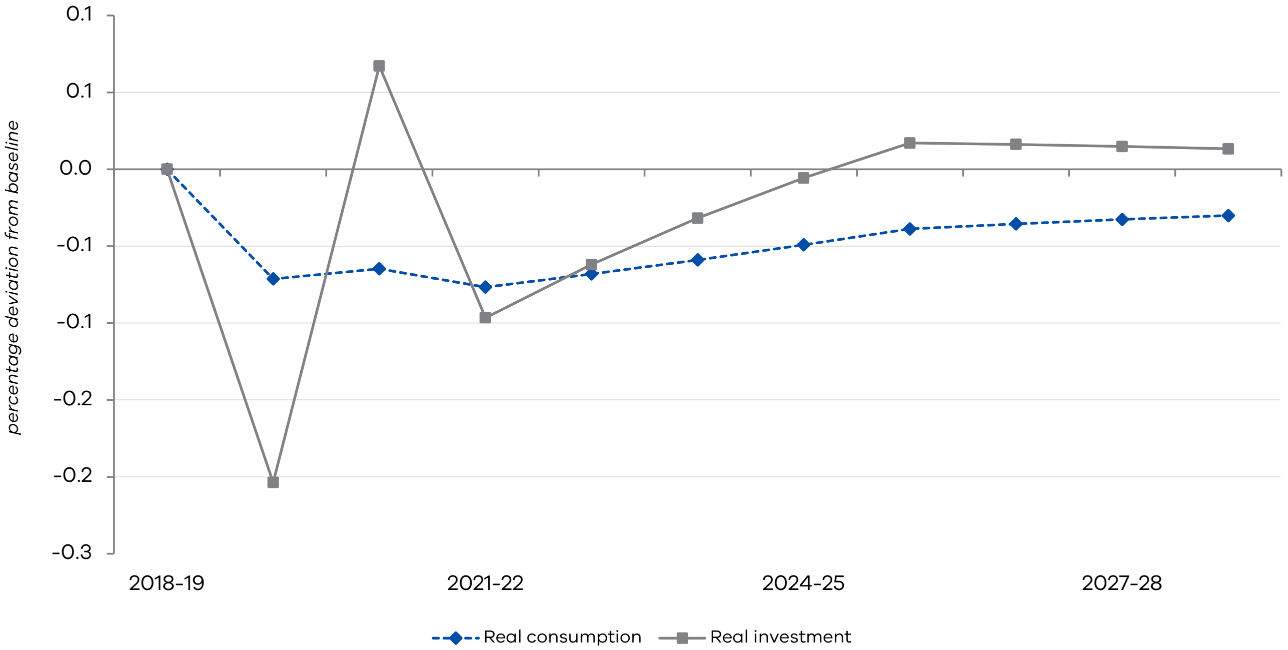
The decline in international tourism demand has a damaging impact towards investment in 2019-20. As shown in Figure 5, Victoria's real investment is 0.2 per cent lower than the base during 2019-20 as a result of the impact of the bushfires, largely driven by a reduction in international tourism. As part of rebuilding efforts, accelerated investment takes place the following year in 2020-21 in the fire-affected regions of North East Victoria and East Gippsland, and propels real investment levels 0.07 per cent above base. Consequently, there is an upturn in capital stock in 2021-22 (see Figure 3). However, as the temporary surge in investment for rebuild wears off after 2020-21, real investment levels drop back below base in 2021-22 before following a gradual recovery path.

The net welfare losses for Victoria over the entire simulation period between 2019-20 to 2029-30 is estimated to be $2.1 billion in net present value terms, at a 2.5 per cent discount rate. This comprises the following breakdown:

- $663 million of destroyed capital costs offset by $167 million in insurance payouts;
- $183 million of labour productivity losses;
- $16 million of total factor productivity losses; and
- $1.4 billion in international tourism losses.

The decrease in international tourism is the major contributor to the output loss in Victoria, representing around 70 per cent of total losses. An explanation on the calculation of welfare loss is given in Appendix D. This calculation accounts for the reduction in real net foreign liabilities in the final year of the simulation, softening welfare losses. Such a reduction arises from the trade surplus due to the rebound in tourism exports along with the reduction in real wages, making exports cheaper than before.

Figure 5: Real Investment and Consumption, Victoria (per cent deviations from business-as-usual base)



2.2 Regional impacts

Regions directly affected by bushfires

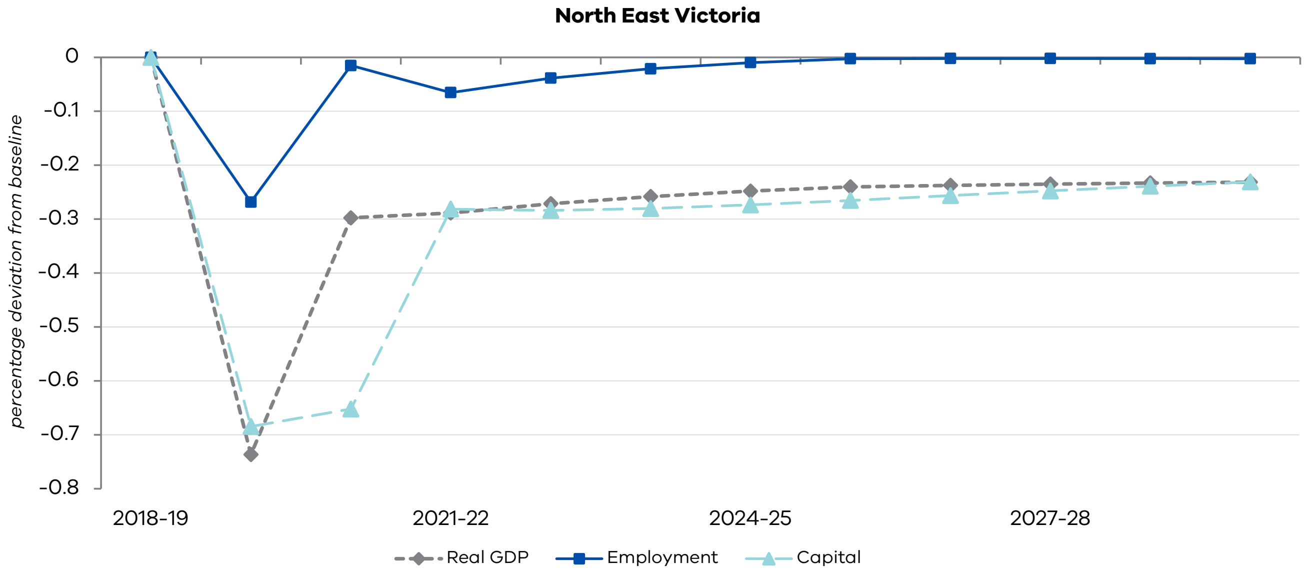
The direct impacts of the bushfires were concentrated in North East Victoria (comprising Wangaratta and Wodonga SA3 regions) and East Gippsland. As of July 2019, these fire-affected regions had an estimated population of around 69 000 for North East Victoria and 47 000 for East Gippsland.[9] Together, these two regions account for around 1.8 per cent of Victoria's total population and 2.2 per cent of Victoria's GSP.

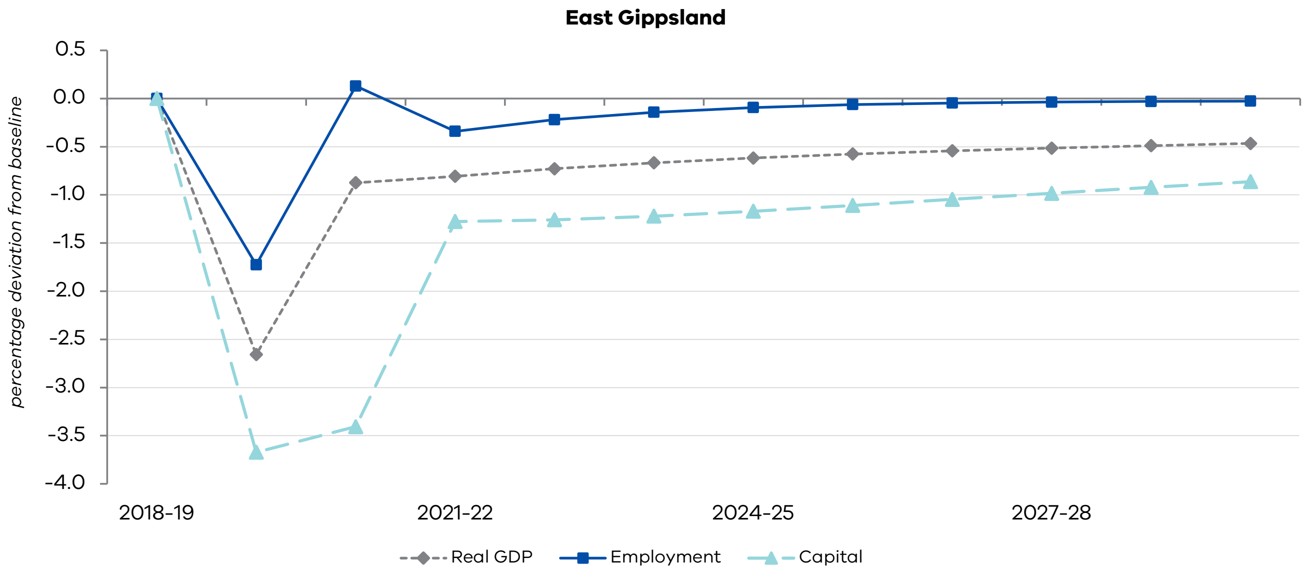
The panels in Figure 6 depict the impact of bushfires on output, measured by real GRP and input factors (i.e. capital and employment) in North East Victoria and East Gippsland. The figures show the immediate and significant reduction in capital and output in these regions, with losses in East Gippsland proportionately greater than in North East Victoria due to being more heavily hit by the bushfires. The insurance payout and the rebuilding process ensures a considerable recovery in capital level in 2021-22.

With capital in the form of infrastructure, machinery and equipment no longer available for production, demand for labour decreases resulting in a reduction in employment relative to baseline levels. Additionally, labour productivity falls as a result of the adverse effects of the hazardous smoke. As a result, we observe sharp falls in real GRP in 2019-20.

9 From idcommunity, an organisation delivering suburb-based community profiles to councils across Australia and New Zealand, https://profile.id.com.au/.

Figure 6: Real GRP and factor inputs, North East Victoria and East Gippsland (per cent deviations from business-as-usual base)

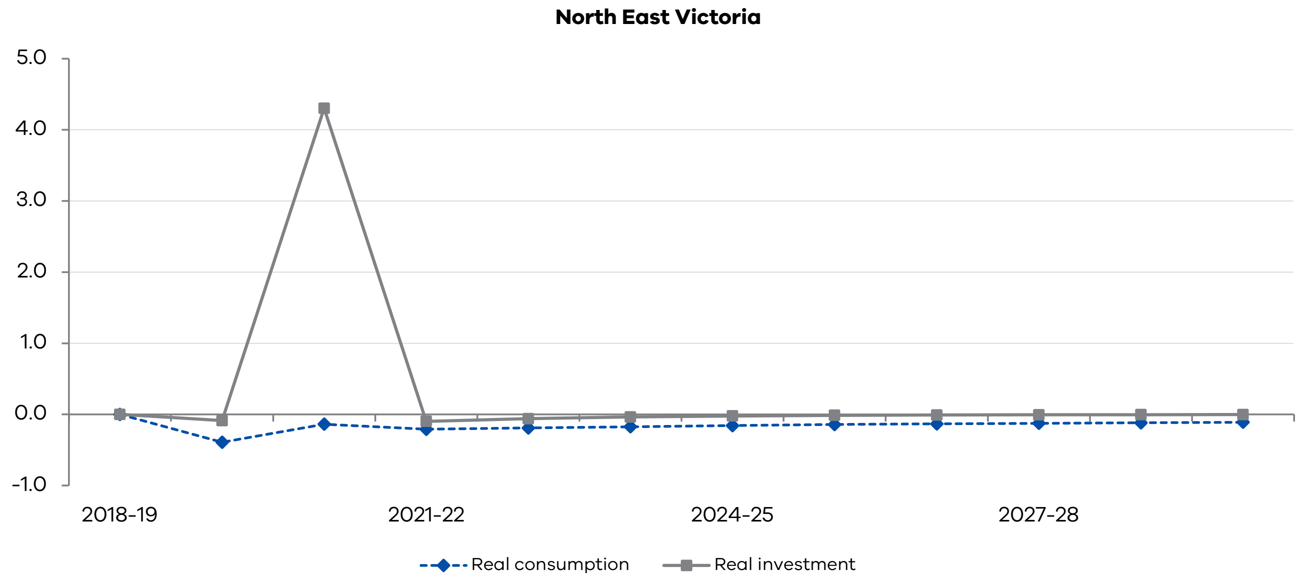




There is accelerated investment in these regions in 2020-21 to restore capital destroyed by bushfires in the previous year (Figure 7). Real investment is projected to climb by 4.5 per cent above base in North East Victoria and by 22 per cent in East Gippsland, resulting in a recovery in capital stock in 2021-22 as seen in Figure 6. However, there is a permanent increase in insurance premiums in these two regions, leading to higher production costs. Consequently, capital remains around 0.3 per cent below base in North East Victoria and around 1 per cent below base in East Gippsland in the final year of the simulation period. It is worth noting that this spike in real investment does not include the various government bushfire recovery programs, which would further expedite the recovery process.

Capital destruction in fire-affected regions and the resulting declines in employment have flow-through effects for labour market dynamics in these regions. Workers respond to reduced employment opportunities in these regions by adjusting their labour supply, as shown in Figure 8. While real wages adjust lower in this environment, the model assumes that real wages are sticky and the adjustment is therefore sluggish. The rapid recovery in employment the following year in 2020-21 is driven by the restoration of destroyed capital brought by real investment. This recovery eventually leads to a strengthening of real wages from 2023-24. Although employment returns to baseline, both the diminished levels of capital along with the permanent increase in insurance premiums pushes down real wages and ensures that they persist below base levels throughout the simulation period. The reduction in employment and real wages triggers a modest decline in consumption levels, falling by 0.4 per cent and 2.5 per cent in North East Victoria and East Gippsland respectively during 2019-20 (Figure 7).

Figure 7: Real Investment and Consumption, North East Victoria and East Gippsland (per cent deviations from business-as-usual base)



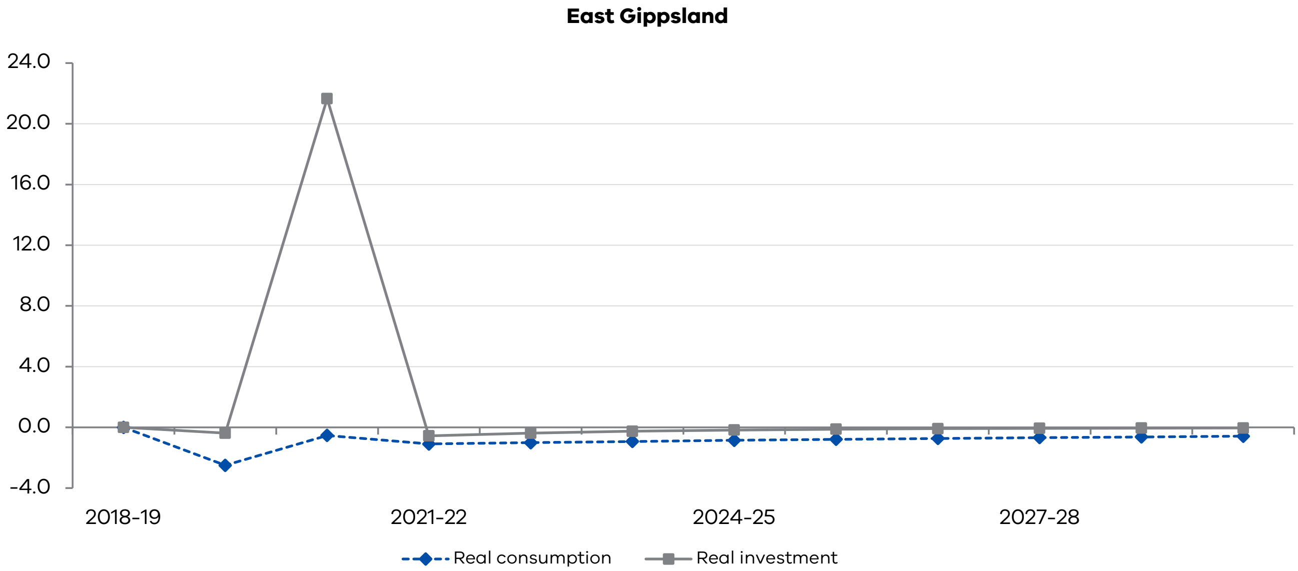
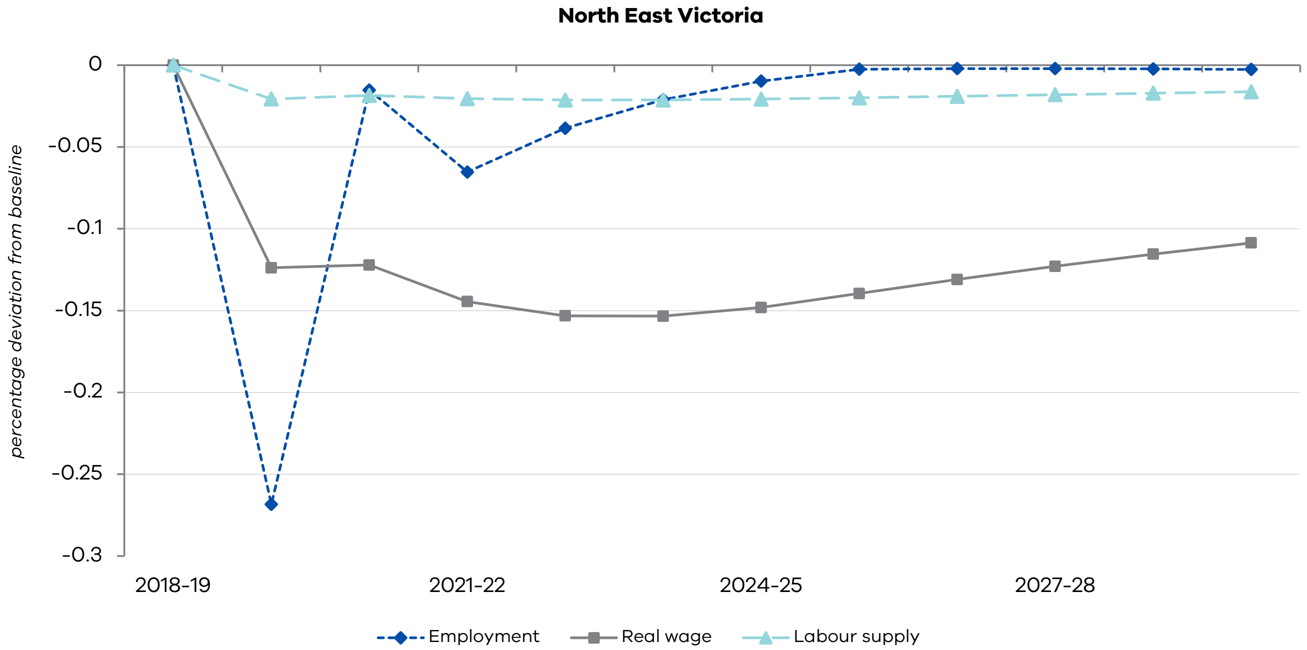
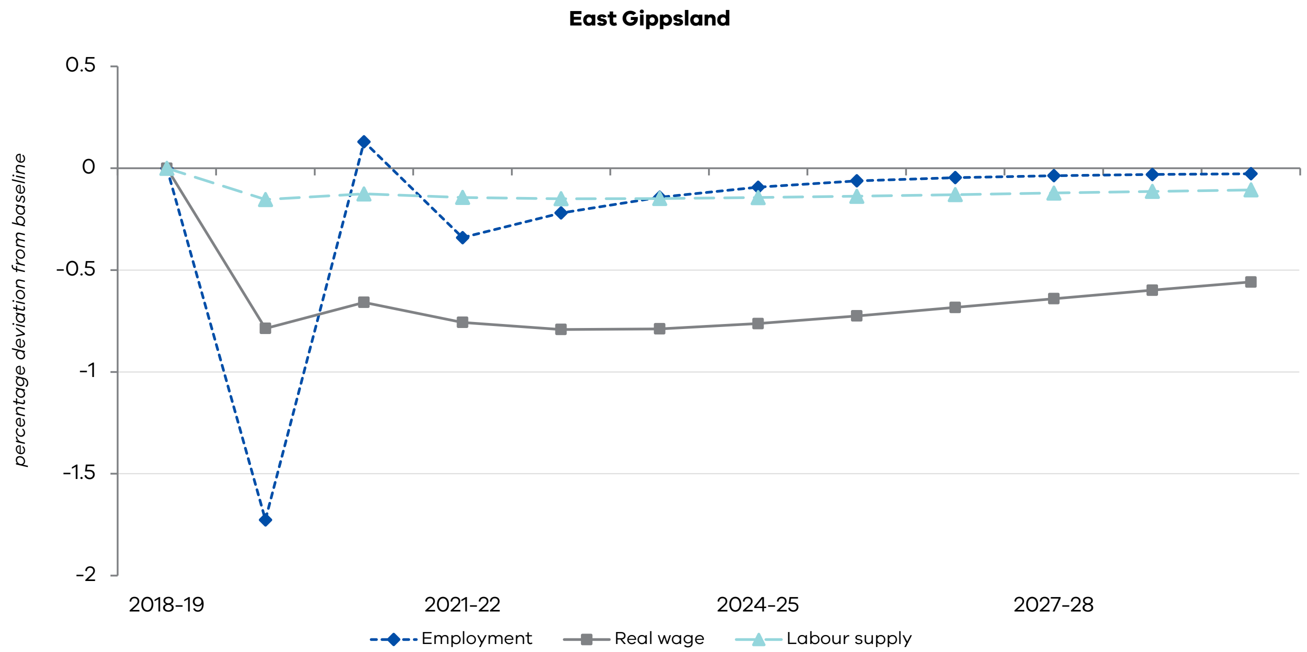


Figure 8: Labour market, North East Victoria and East Gippsland (per cent deviations from business-as-usual base)



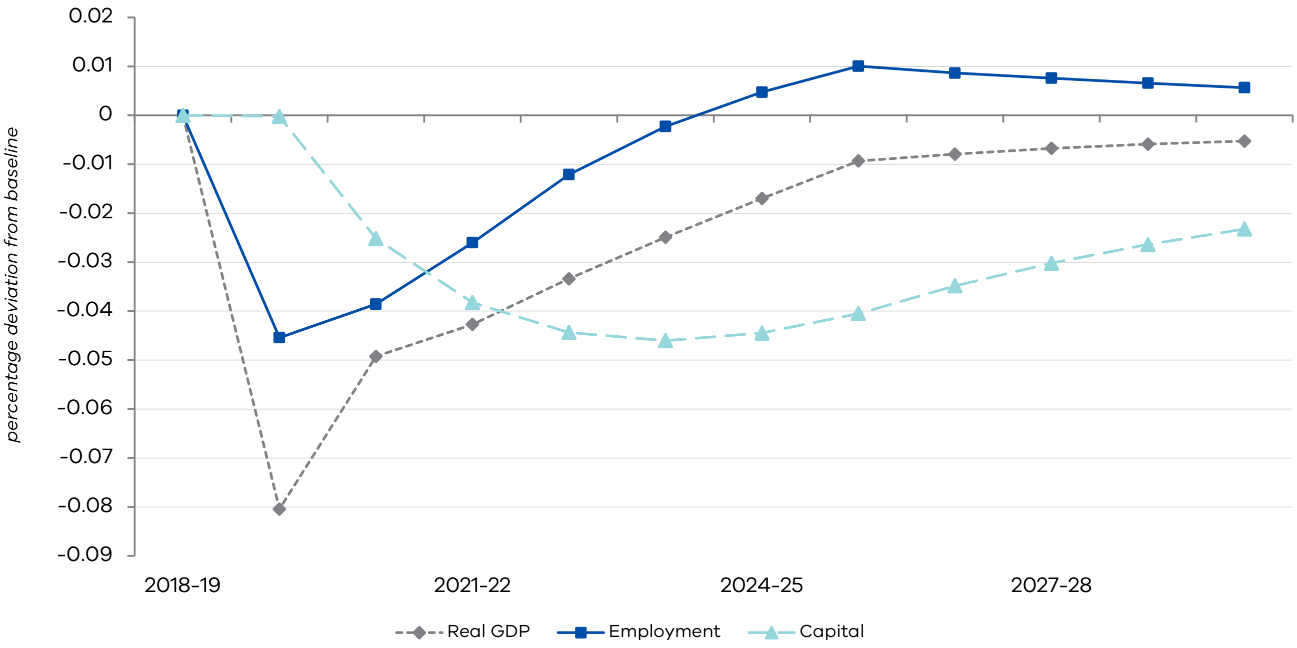


Regions not directly affected by the bushfires

The bushfires have a more widespread impact on Victorian regions via the effects on international tourism. While the local government areas of Melbourne, Yarra Ranges, Mornington Peninsula as well as the Greater Ocean Road regions of Warrnambool-Otway Ranges-Surf Coast were not directly affected by bushfires, they are indirectly affected by losses in international tourism.

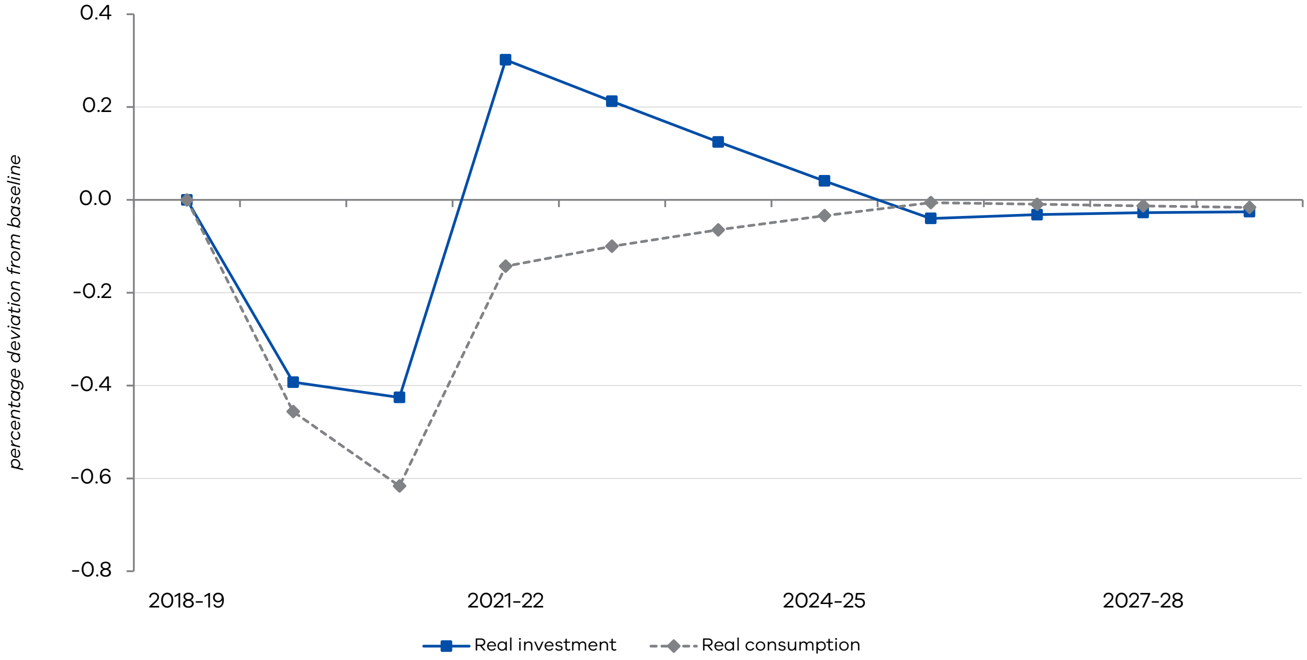
To illustrate these impacts, Figure 9 below depicts the dynamic profile of GRP and factor inputs for Melbourne in response to the bushfires. As shown, no capital losses are incurred during the event year, hence, capital remains at base levels during 2019-20. However, the downturn in international tourism weakens labour markets, pushing down employment close to 0.05 per cent below base levels. This causes the fall in real GRP, declining 0.08 per cent below base levels. The ongoing impacts to international tourism persist and do not recover fully until 2023-24 when employment returns to base levels.

Figure 9: Real GRP and factor inputs, Melbourne (per cent deviations from business-as-usual base)



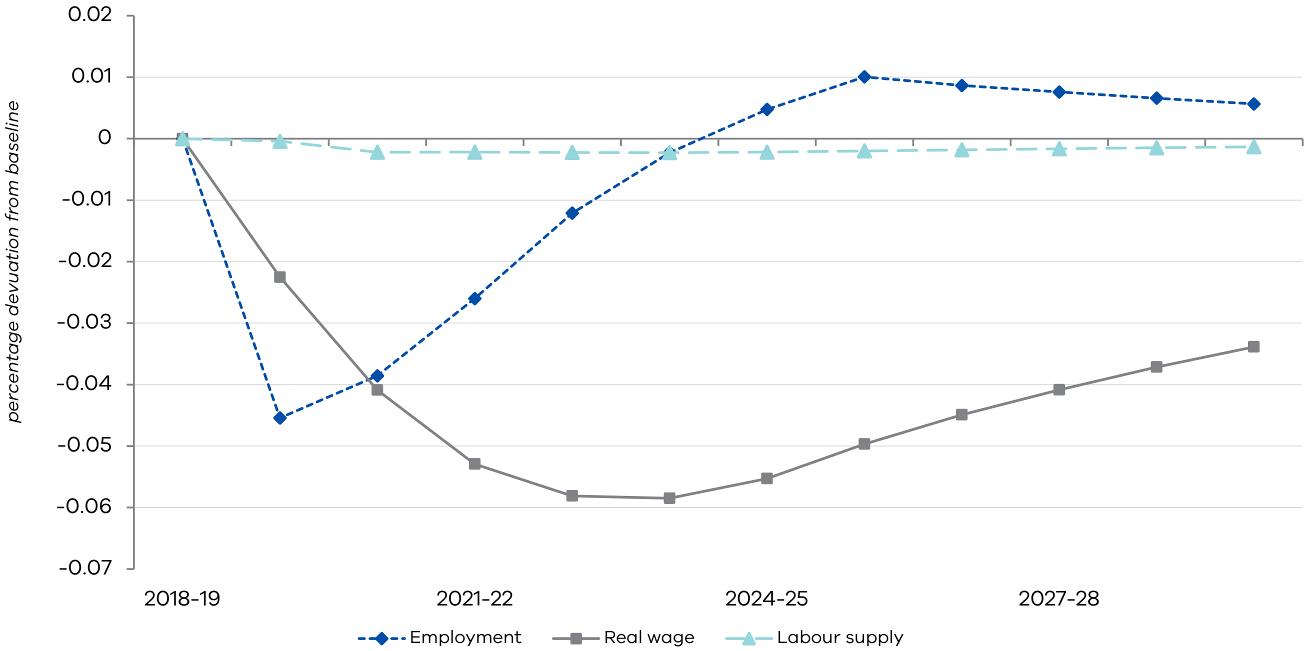
As shown in Figure 10, the downturn in tourism pushes down investment activity in Melbourne relative to its base levels in 2019-20. This contrasts with the directly affected regions (Figure 7 above) where investment is supported by recovery of capital stock destroyed by bushfires. The reduction in investment means that the annual erosion in capital stock arising from depreciation is not sufficiently restored by new capital. As a result, capital falls below base levels in 2020-21. In addition, real consumption falls due to diminished employment and real wages and persists below base levels due to lower capital levels.

Figure 10: Real Investment and Consumption, Melbourne (per cent deviations from business-as-usual base)



The labour market adjustment profile for Melbourne is given in Figure 11. The adjustment in real wages lags employment due to the assumption of sticky wages. A marked recovery in the tourism industry is assumed for the following year in 2020-21, resulting in a bounceback in employment. Although employment climbs back to base, diminished capital relative to base pushes down real wages relative to base and ensures that they persist at these levels throughout the simulation period. The persistence of lower wages also pushes down real consumption below base levels throughout the simulation period (Figure 10).

Figure 11: Labour market, Melbourne (per cent deviations from business-as-usual base)



A similar story is observed for the economies in other tourism regions of the Yarra Ranges, Mornington Peninsula and Warrnambool-Otway Ranges-Surf Coast. Their simulation results along with those for the rest of Victoria are presented in Appendices A to C.

2.3 Sectoral and industry impacts

This section summarises the modelling results for sectors and industries. Table 1 presents the output changes in the relevant state sectors and industries, measured in millions of dollars in deviation from base.

As observed, many directly-affected industries in the agriculture and manufacturing sectors experience losses in output during 2019-20 and for the two or three subsequent years, for instance agriculture, forestry and support services, meat and dairy manufacturing, and wine manufacturing. This can be attributed to the destruction in industry production and capital, along with the negative impacts to industry employment. As discussed earlier, these direct impacts are mostly attributed to the fire-affected regions of North East Victoria and East Gippsland.

On the other hand, industries indirectly affected by the downturn in international tourism suffer more than those industries directly affected. Notably, the accommodation and food services and transport sectors suffer the largest losses due to their exposure to international tourism and these losses persist throughout the simulation period. The construction industry also suffers substantial losses due to its connection with investment, which falls for some regions due to depressed tourism demand. Unaffected industries such as education and other manufacturing experience an increase in real wages and higher employment.

Figure 12 shows the changes in real industry output for tourism-related industries, namely hospitality (hotels and cafes), transport and other services, and compares them with the net changes for all nontourism industries (measured in millions of dollars). The net losses to industry in 2019-20 totalled $323 million.

Figure 12: Changes in output for tourism-related industries versus other industries ($m deviations)

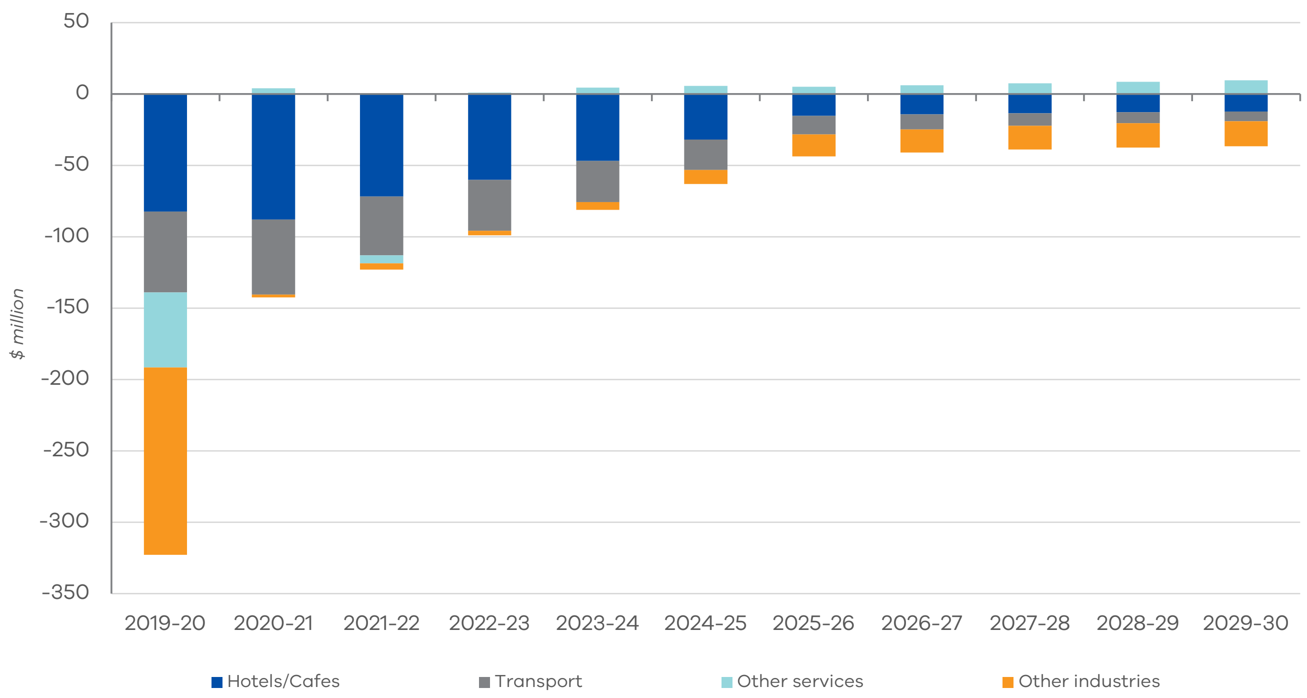


Table 1: Changes to State industry and sector outputs ($m deviation from base)

	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30
Horticulture	5	11	7	6	6	5	5	4	4	4	3
Wine grape growing	1	0	0	0	0	0	0	0	0	0	0
Livestock	-3	7	5	5	5	5	5	5	5	4	4
Broadacre cropping	0	1	1	1	1	1	1	1	1	1	1
Agriculture, forestry and fishing support services	-10	-8	-1	-1	-1	-1	-1	-1	-1	-1	-1
Mining	0	2	3	3	3	2	2	2	2	1	1
Meat and dairy danufacturing	-8	-9	-3	-3	-2	-2	-1	-1	-1	-1	-1
Wine manufacturing	-7	0	1	1	1	2	2	2	3	3	3
Other food and drink manufacturing	-9	-10	-5	-5	-4	-3	-3	-2	-2	-2	-2
Textile, clothing and footwear manufacturing	1	3	5	5	4	3	2	2	1	1	1
Wood and paper product manufacturing	0	2	3	3	3	2	1	1	1	1	1
Other manufacturing	5	24	27	25	21	16	10	9	8	7	6
Utilities	-3	-1	-1	-1	-1	0	0	0	0	0	0
Construction	-36	8	-24	-18	-12	-6	0	1	1	1	2
Trade	-38	-12	-8	-4	-2	0	1	1	1	1	1
Accommodation and food services	-82	-88	-72	-60	-47	-32	-15	-14	-13	-13	-12
Transport	-57	-52	-41	-36	-29	-21	-13	-11	-9	-8	-7
Other services	-53	4	-6	1	4	6	5	6	7	9	10
Owner dwelling	-21	-21	-19	-22	-25	-27	-28	-28	-28	-28	-27
Public administration and safety	6	-6	-10	-10	-9	-8	-7	-7	-6	-6	-6
Education and training	7	25	34	29	22	15	8	7	6	6	5
Health	-14	-10	-12	-10	-9	-8	-6	-6	-6	-5	-5
Child care	-9	-8	-9	-8	-7	-6	-4	-4	-4	-4	-3

3. Conclusion

This study utilises the Dynamic VU-TERM CGE model to estimate the economic impacts of the 2019-20 Australia bushfires on Victoria, absent any government responses.

This study considers both the direct bushfire impacts of capital destruction and labour productivity losses, as well as the negative impacts on international tourism.

Modelling results were presented for (i) individual regions, including the fire-affected regions of North East Victoria and East Gippsland, as well as impacted tourism regions, (ii) sectors and industries and (iii) the entire State.

Overall, the economic losses to Victoria are estimated to be $2.1 billion in net present value terms (at a discount rate of 2.5 per cent) over a 11-year simulation period covering 2019-20 to 2029-30. The study found that the direct impacts of bushfires were outweighed by the indirect impacts of assumed weaker international tourism demand, which had more widespread effects in Victoria.

Around 30 per cent of real GSP losses during the event year in 2019-20 can be attributed to the fire-affected regions of North East Victoria and East Gippsland, while the remaining 70 per cent of losses can be attributed by losses in other tourism dependent regions. Long-term negative impacts are observed for capital stock, real wages and real consumption in both the fire-affected regions as well as tourism dependent regions, with these indicators persisting below base levels throughout the simulation period.

The industries most affected include accommodation and food services (-$450 million over 10 years) and transportation (-$283 million over 10 years), due to their exposure to international tourism. Additionally, the construction industry also suffers considerable losses (-$84 million over 10 years) due to its connection with investment, which declines in some regions due to depressed tourism demand.

This study has excluded the impact of government policies and initiatives that would mitigate the economic impacts of the bushfires in this analysis. Specifically, the various financial support programs provided to small businesses and primary industries, along with taxation relief measures for businesses, families and individuals in affected regions (see State Government of Victoria, 2020) can be expected to expedite economic recovery. In addition, the loss of flora and fauna and the loss of human life is not quantified in this study.

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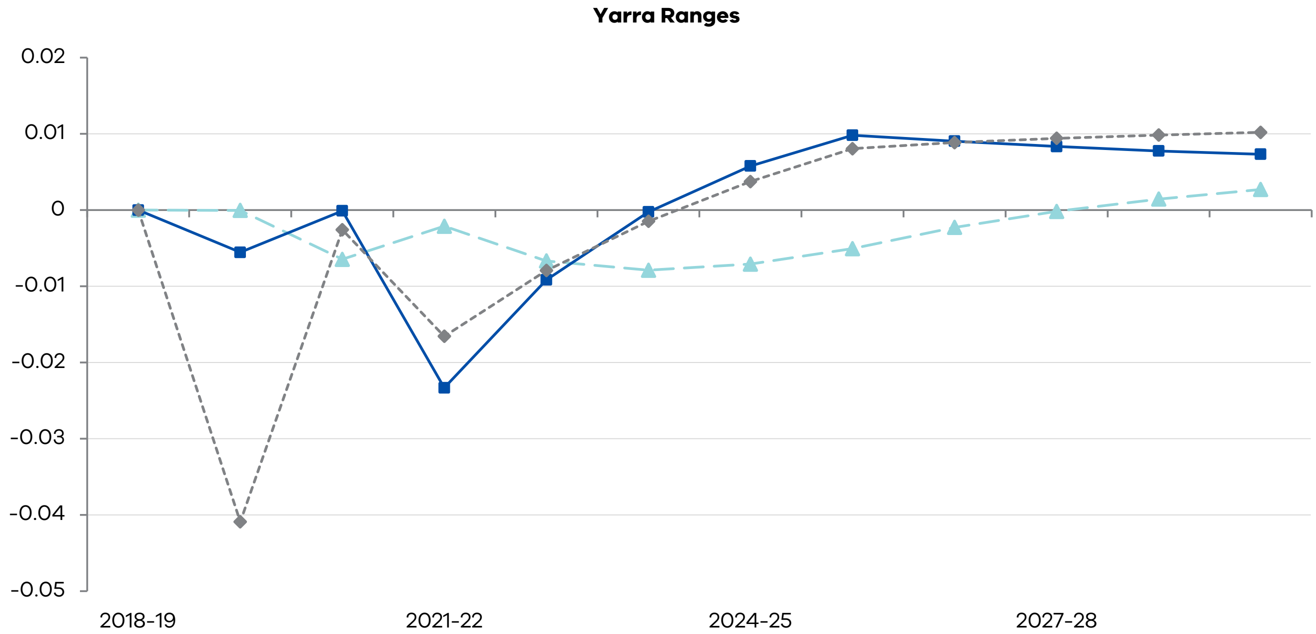
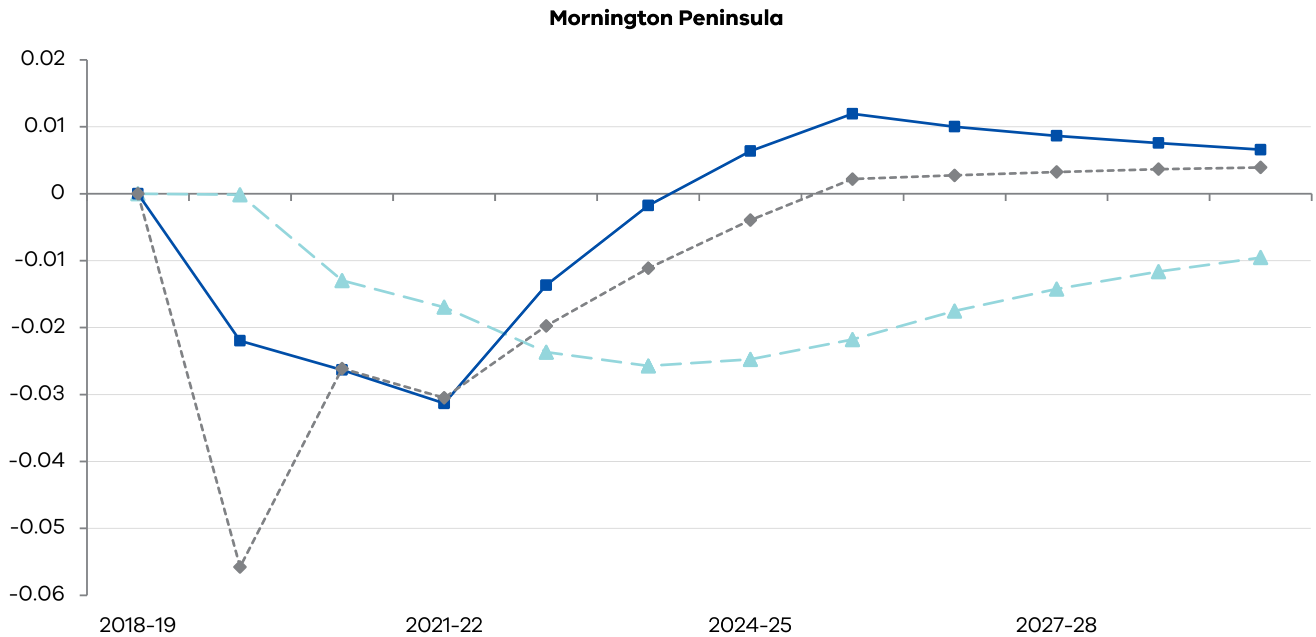
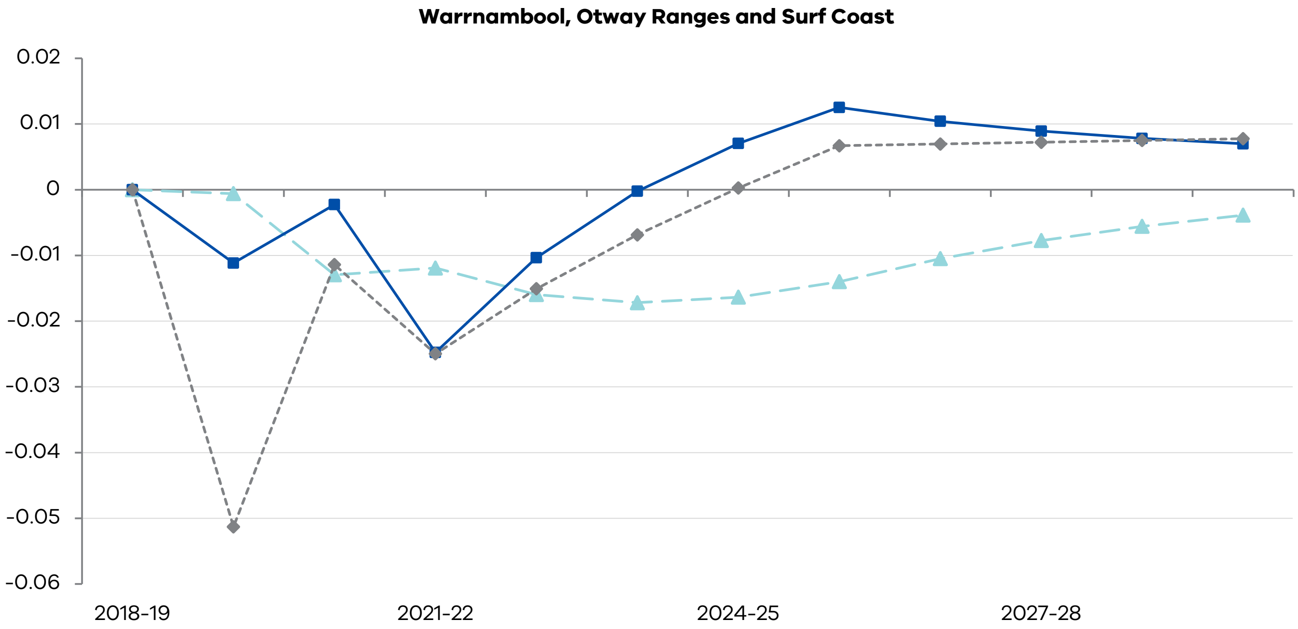
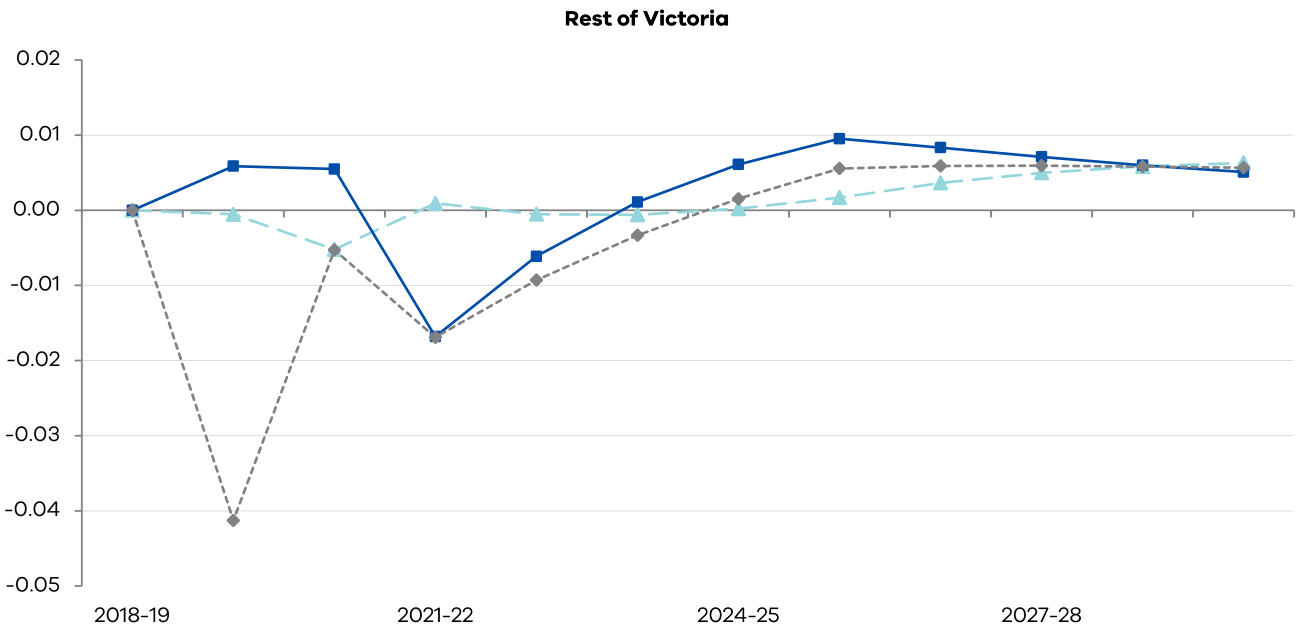
Appendix A: Real GRP and factor inputs, other tourism regions and rest of Victoria (per cent deviations from business-as-usual base)

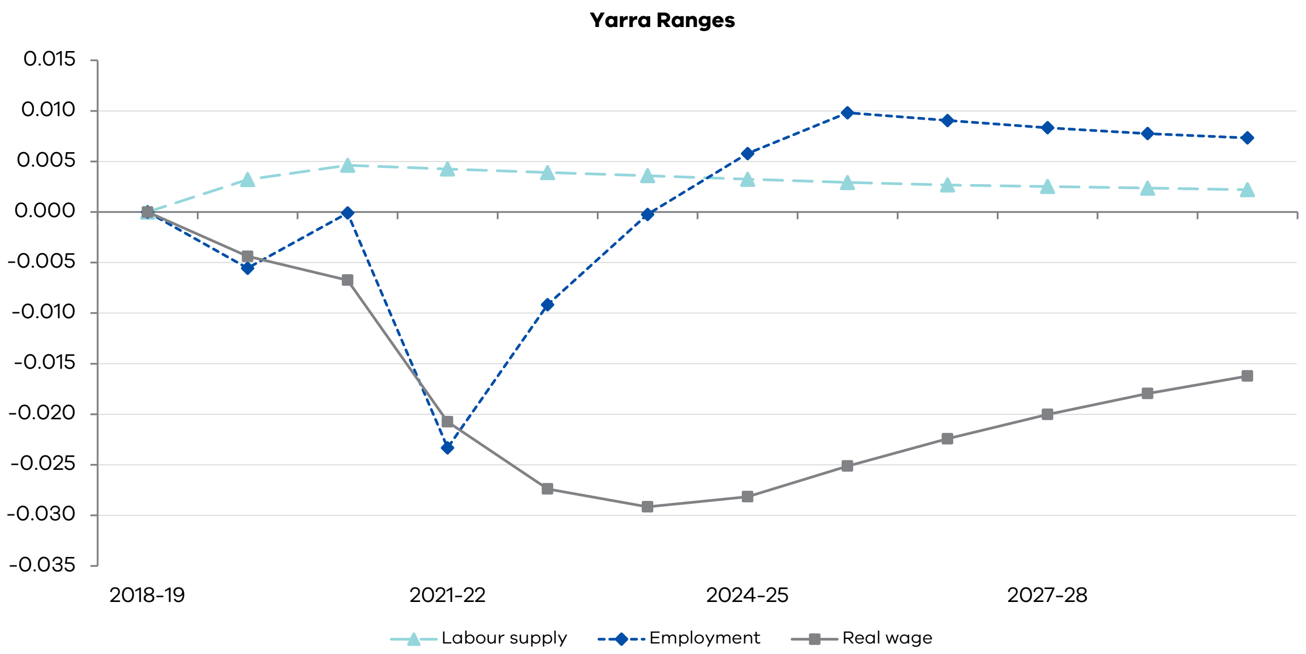


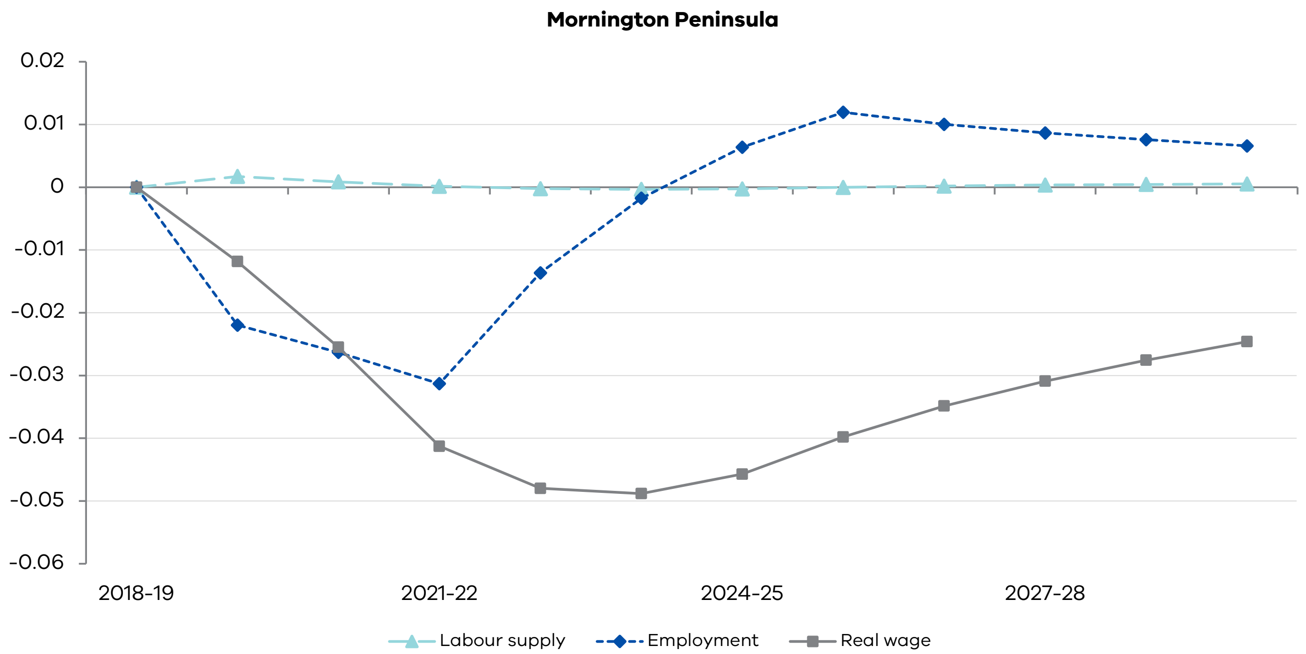


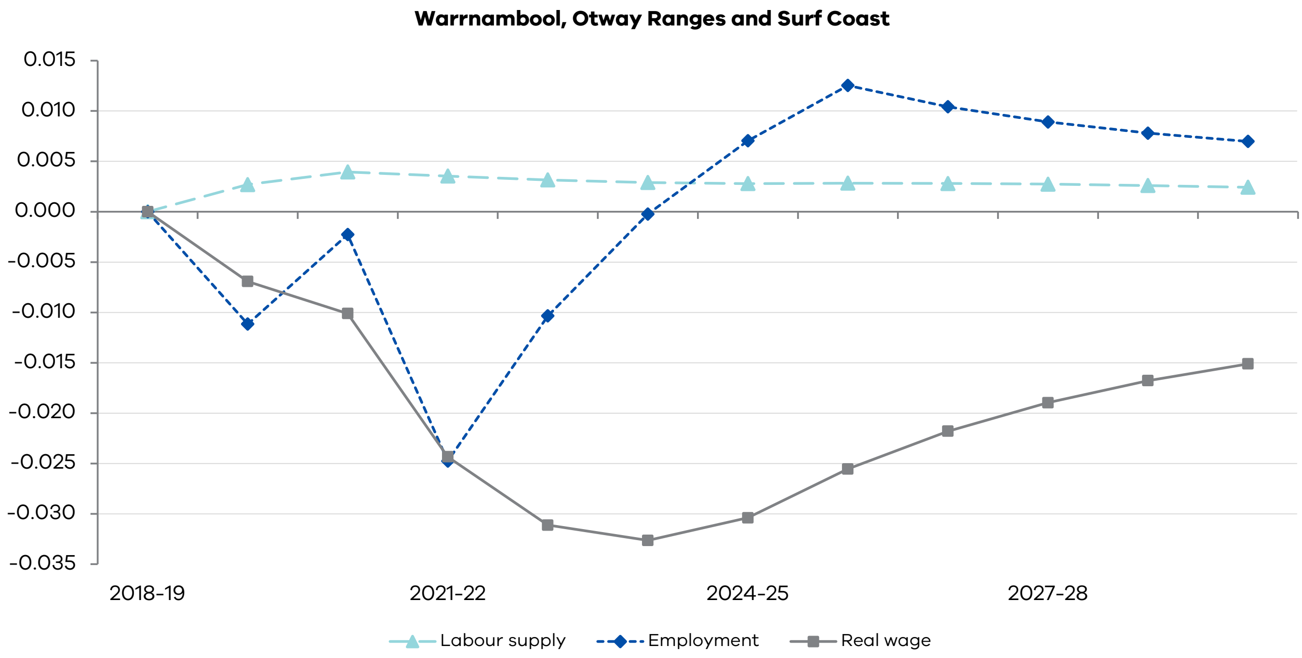

Warrnambool, Otway Ranges and Surf Coast
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
2018-19
2021-22
2024-25
2027-28

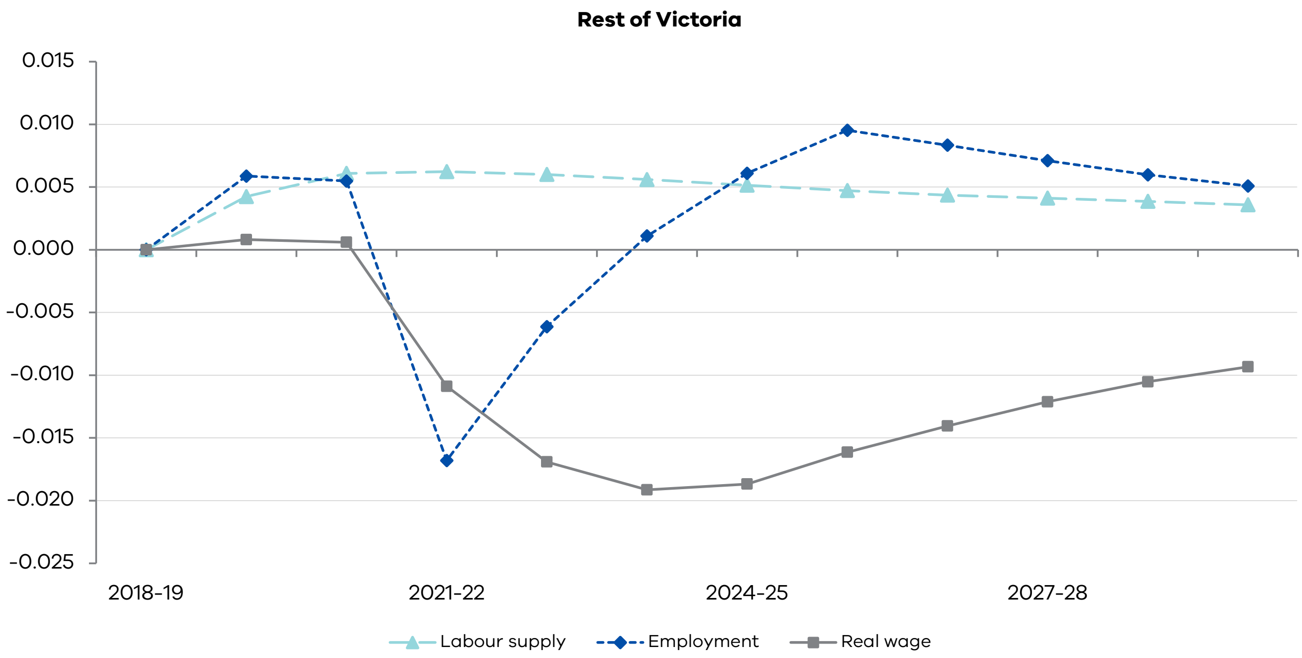

Rest of Victoria
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
2018-19
2021-22
2024-25
2027-28

Appendix B: Labour market, additional tourism regions and rest of Victoria (per cent deviations from business-as-usual base)

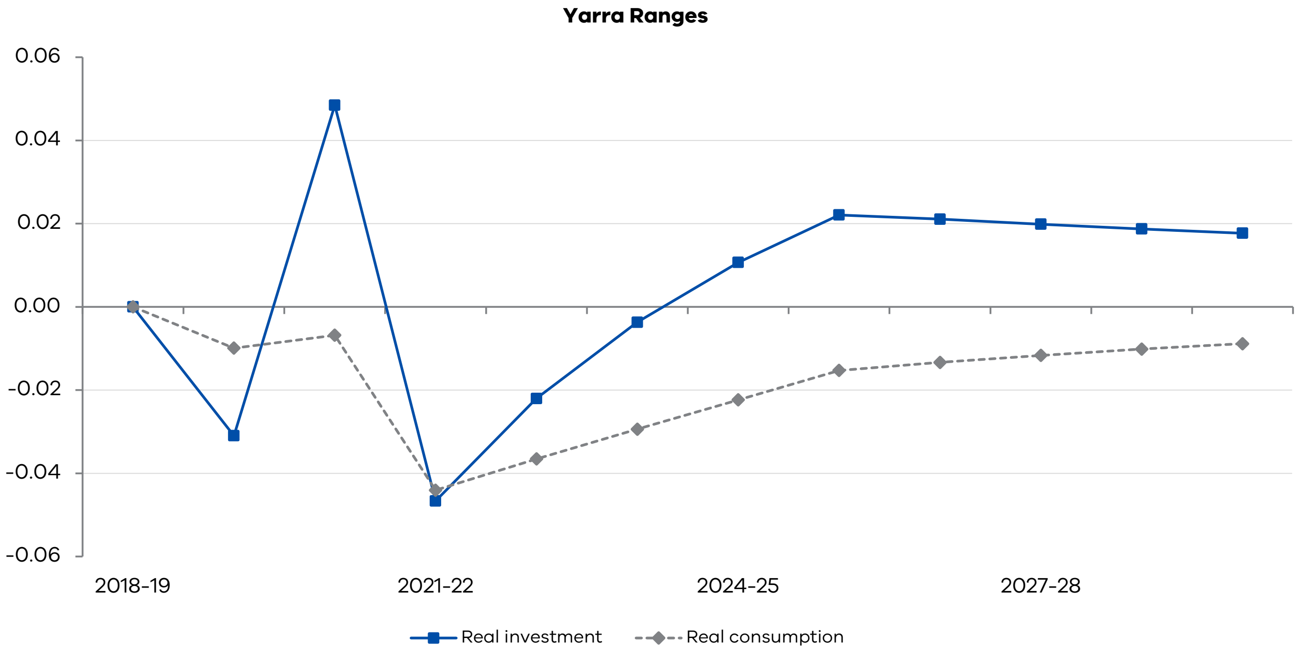


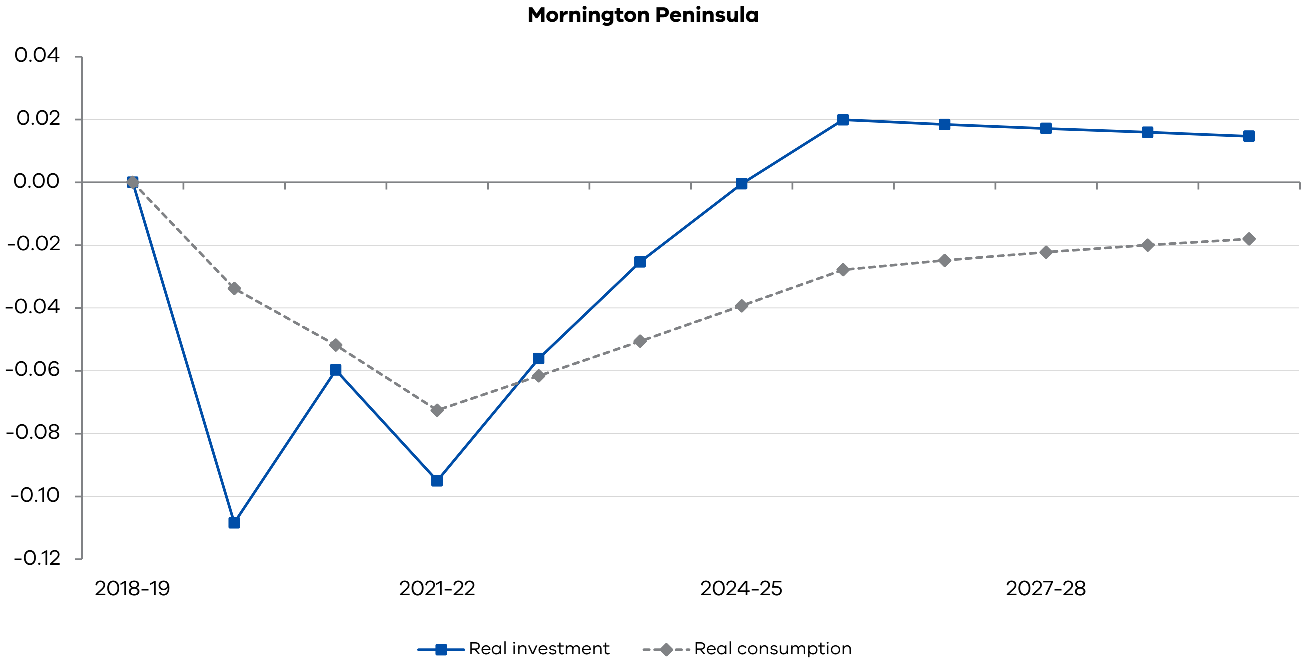


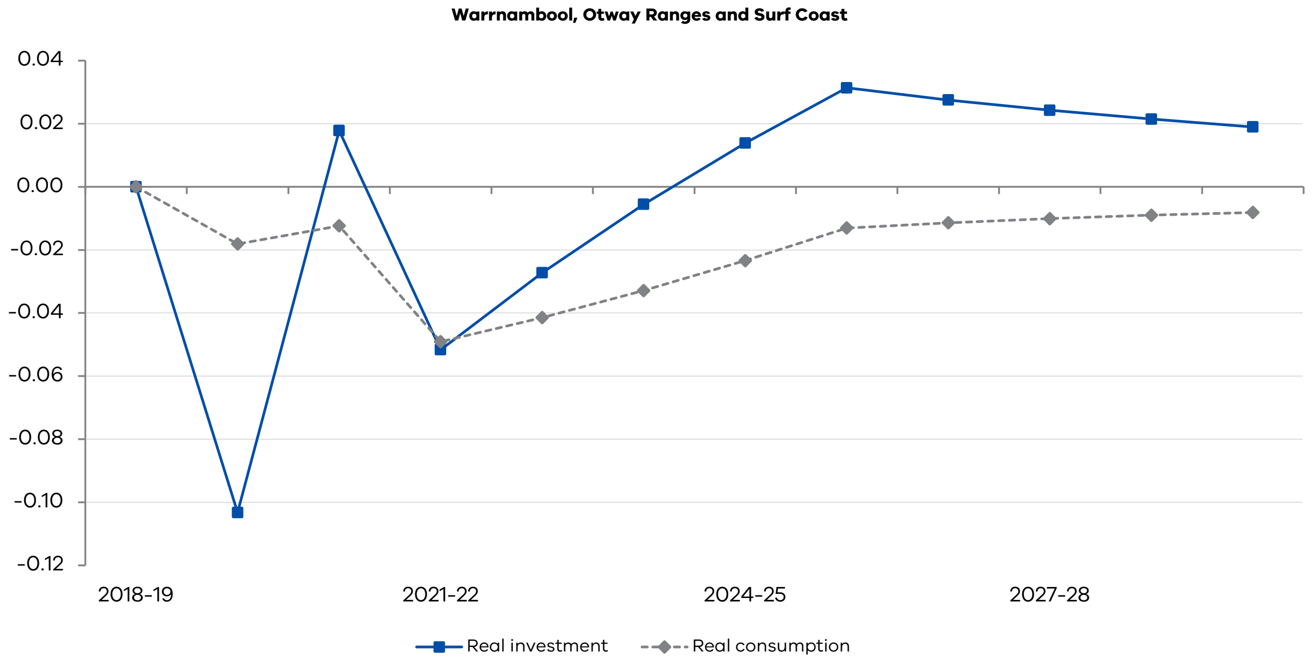

Warrnambool, Otway Ranges and Surf Coast
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
2018-19
2021-22
2024-25
2027-28
Labour supply
Employment
Real wage

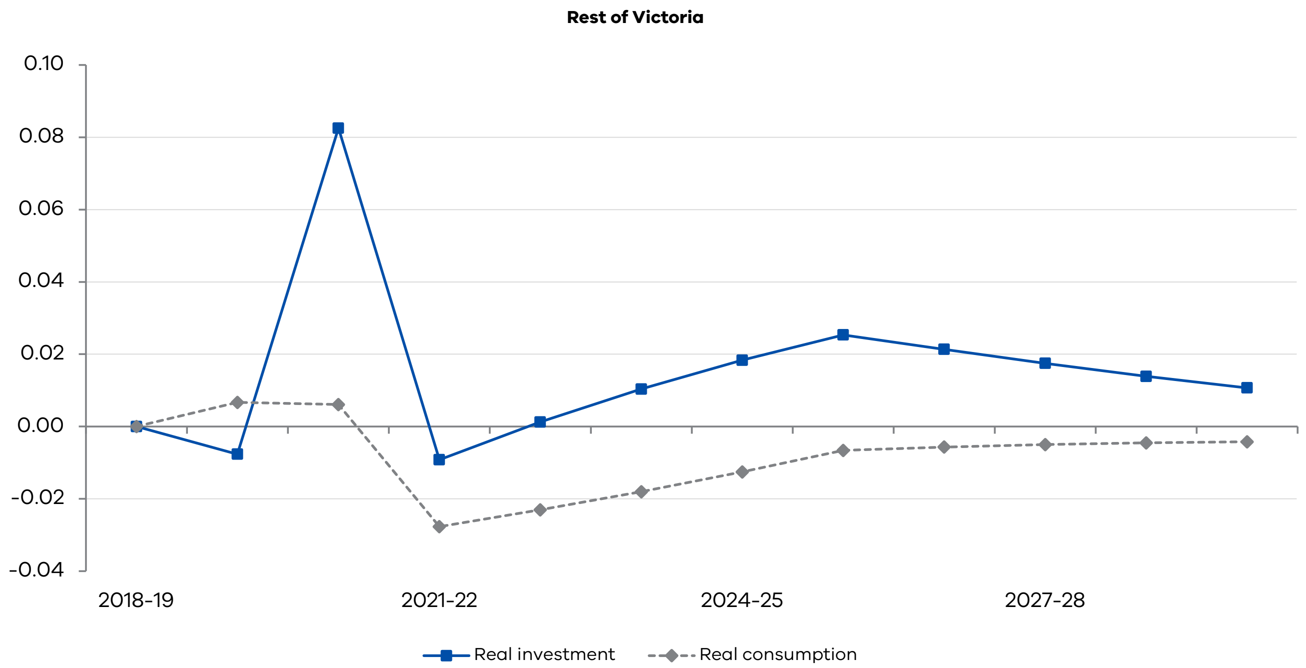

Rest of Victoria
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
2018-19
2021-22
2024-25
2027-28
Labour supply
Employment
Real wage

Appendix C: Real investment and consumption, additional tourism regions and rest of Victoria (per cent deviations from business-as-usual base)






Warrnambool, Otway Ranges and Surf Coast
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
2018-19
2021-22
2024-25
2027-28
Real investment
Real consumption


Rest of Victoria
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
2018-19
2021-22
2024-25
2027-28
Real investment
Real consumption

Appendix D: Calculation of welfare

In measuring the welfare impacts, we account for the policy impacts on net foreign liabilities and net change in capital with a terminal calculation. The deviation in welfare (dWELF) is calculated by:

$$\mathrm{dWELF} = \sum_{d}\sum_{t}\frac{dCON(d,t) + dGOV(d,t)}{(1+r)^{t}} - \frac{dNFL(z)}{(1+r)^{z}} + \frac{dCAP(z)}{(1+r)^{z}}$$

where dCON, dGOV are the deviations in real household and government spending in region d and year t;

- dNFL is the deviation in real net foreign liabilities in the final year (z) of the simulation; dCAP is the deviation in real capital stock; and
- r is the discount rate.

The annualised version of this calculation is $r \times \mathrm{dWELF}$.

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Government

Treasury
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