

Dear Commissioner Lindwall,

In 2016, I completed a thesis, entitled 'Growth and resilience of Australian cities from 1971 to 2011', to meet the requirements of a Masters in Economic and Social History at the University of Oxford.

In the thesis I introduced a new historical dataset of Australian cities above 5 000 people. This included city-level data on employment, education, and industrial structure from 1971 to 2011.¹ This submission includes a brief summary of my analysis and conclusions followed by a more detailed appendix describing my data and methodology.

In my thesis, using descriptive analysis and a dynamic panel data model approach, I made two broad findings.

First, the growth of Australian cities, from 1971 to 2011, was correlated with city size, location, and industrial structure.

Second, cities, on average, returned to mean employment growth and unemployment rate following severe economic transition. However, they did not make up lost ground. Further, labour force participation decline showed signs of persistence indicating cities who experienced a negative employment shock from 1971 to 2011 could be left with a legacy of lower labour force participation.

In relation to the direct investigation conducted by the Productivity Commission my thesis has a number of implications. On average, Australian cities least likely to make a successful economic transition following a negative employment shock were:

- between 10 000 and 50 000 in population,
- non-coastal and distant from capital cities,
- less endowed with industries in government, tourism, and recreation, and
- unable to flex their populations according to economic demand.

Surprisingly, education levels were not correlated with a significant difference in city performance. This requires more investigation. However, it indicates increasing the skill base of a region may not have a corresponding impact on employment growth.

By implication, an analytical framework for assessing the scope for economic and social development in regions should consider:

- population size,
- proximity to markets and major trading routes,
- ability to attract tourism, recreation, and government services, and
- ability to facilitate out-migration.

¹ R. Tilleard. 'Growth and resilience of Australian cities 1971-2011', MPhil Thesis (University of Oxford, 2016)

Qualitative research revealed a role for local leadership and place-based policy aimed at restructuring a local economy during transitions. This included assistance through a short-term shock and longer term assistance to help adaption to the changing structure of national growth.

However, my research indicates cities rarely experience full employment recovery following a negative shock or severe economic transition. Regions and cities absorb employment decline through lower labour force participation or out-migration. Given the negative social impact and persistence of low labour force participation, out-migration is the preferred shock absorber. The challenge for government is to enact compassionate place-based policies whilst not losing sight of individual and community outcomes. To create a sustainable economic future for declining regions, government must mix (and experiment with) place-based policies alongside pragmatic options for out-migration and management of population decline.

This submission is intended as a brief introduction to the economic and social research that underpins my work. Please note I am currently revising my thesis for formal publication. As such, my conclusions are preliminary and analysis should be taken as work-in-progress. I would be happy to discuss the results of my thesis and the details of this submission further.

Many thanks,

Robert Tilleard
26 January, 2017

Summary: Australian city growth from 1971 to 2011

In my unpublished thesis, I considered the growth and resilience of Australian cities from 1971 to 2011. To do so, I constructed a new dataset of Australian cities, performed original archival research, and conducted a series of interviews with people impacted by severe employment decline.

Based on academic literature, I began with a simple model of city employment growth driven by productivity, quality of life, population size, and capital resources. Given the relative mobility of population and capital, it is commonly assumed differences between Australian cities are driven by productivity and quality of life forces such as agglomeration, access to markets, human capital, and available resources. In addition, a negative employment shock is generally seen to cause short-term damage to an economy. However, out-migration assists recovery in the long-run.

To test this model in the Australian context, I turned to the available historical data. A description of my constructed dataset and the econometric techniques used in my analysis can be found in the appendices. Testing productivity and quality of life forces, I came to the following conclusions:

- **city size, measured by population, caused large fixed effects**, however, as a city's population grows, employment growth slows,
- **distance to capital city and access to the coast appear important**, yet investigation of their causal effect is hindered by a requirement for fixed effects in analysis,
- **human capital levels have an ambiguous to negative impact on city growth**, and
- **tourism, recreation, and government sectors emerge as important contributors to employment growth.**

The key areas correlated with city-level success are size, access to markets, and industrial structure. In contrast to my initial model, empirical research indicated city-level employment growth was not significantly correlated with levels of human capital.

Summary: reaction of Australian cities to significant employment decline

From 1971 to 2011, fifty-one of Australia's largest 124 cities experienced at least one five-year period of significant employment decline represented by loss of 7 per cent of employment.

Econometric analysis, summarised in the appendix, found a city's employment growth and unemployment rate returned to trend following a negative shock. However, this did not allow for a recovery to levels of absolute employment expected prior to the shock. Cities did not make up lost ground.

Declines in labour participation, unlike employment growth, were sticky. Labour participation, on average, took longer to recover following a significant shock. Population was not inherently mobile.

Instead, out-migration emerged as a positive mechanism in the relative responses of cities to employment decline. Cities that could flex their populations according to economic demand escaped significant participation decline and its accompanying risks.

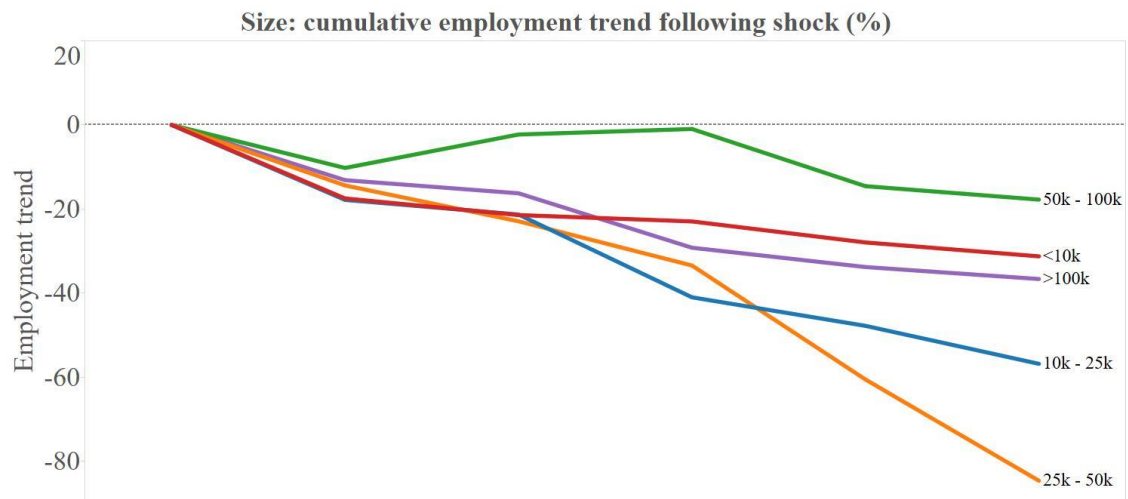
Figure 1 shows cumulative city growth, relative to the national average, of cities who experienced a negative employment shock. All initial city-level shocks in my sample have been fitted to the same first period. The zero line represents the national average of employment growth relative to all cities after their shock. Generally, it shows cities recovered growth in the period following a shock. Most did not enter into continuing decline. However, nearly all were left permanently impacted and behind the national average.

Cities between 10 000 and 50 000 at the time of the shock entered into 20 years, or four periods, of decline compared to national performance. Large, and the very smallest, cities show signs of recovery and stability. Coastal cities recovered whilst inland and satellite (cities less than 150km from the nearest state capital) cities struggled. Government and construction cities made general recoveries whilst diverse and coastal cities did not lose further ground. Mining, manufacturing, utility, and wholesale and retail trade cities appear particularly impacted by a shock.

Cities that recovered following significant employment decline include Gladstone, Murray Bridge, Bowen, Bundaberg, and Kalgoorlie. Cities that continued to decline following significant employment decline include Broken Hill, Moe, Morwell, Whyalla, Cootamundra, and Maryborough.

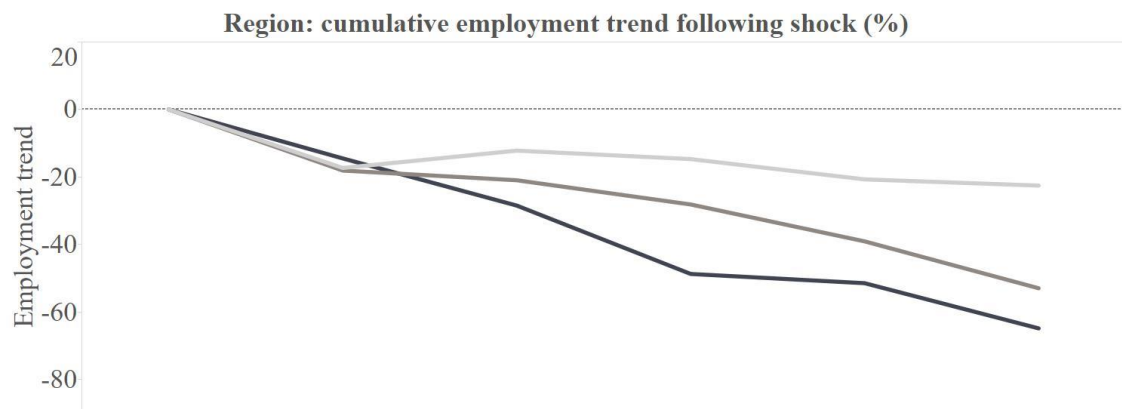
Analysis indicates cities that were large (or very small), well-located on traditional trade routes or close to resources, and with significant government and tourism sectors found it easier to recover from 1971 to 2011. The absence of these fundamentals resulted in a difficult recovery.

Figure 1: Cumulative employment trend, relative to the national average, following employment shock



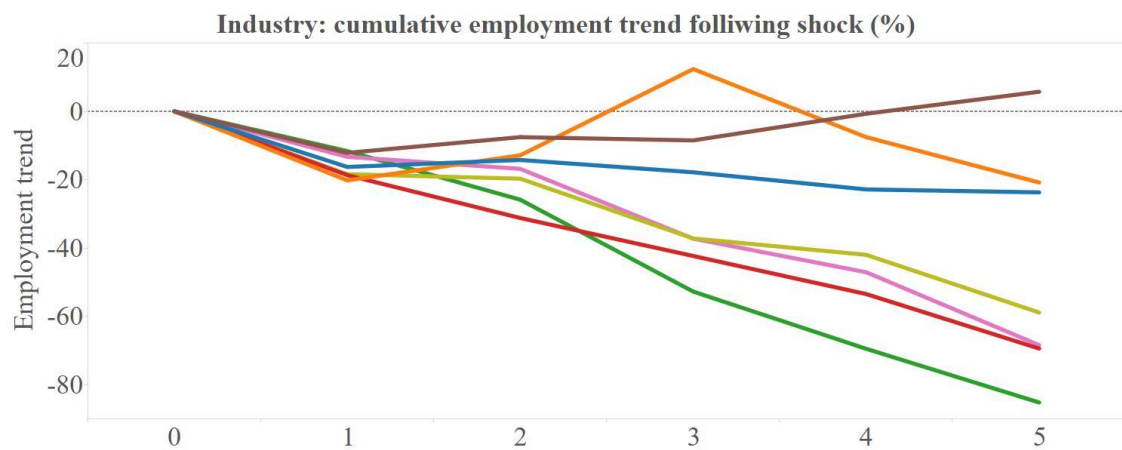
City size at shock

- <10k
- 10k - 25k
- 25k - 50k
- 50k - 100k
- >100k



Region

- Coastal
- Inland
- Satellite



Industry concentration

- Construction
- Diverse
- Government
- Manufacturing
- Mining
- Retail trade
- Utilities

Appendix A: About the author

In 2016, I completed an MPhil in Economic and Social History (Distinction) at the University of Oxford focused on the growth and resilience of Australian cities from 1971 to 2011. This included specific research on how cities recover from severe economic shocks. The research was inspired by my experiences growing up in Sale, Gippsland and a deep concern about regional inequality.

As a management consultant, I have advised state and federal governments on regional development and how to increase economic growth. I have also helped private sector companies transform their businesses in the wake of severe disruption caused by technology change. I have written for The Guardian, Business Spectator, and BuzzFeed.

The views expressed in this submission are my own and do not reflect the views or experience of organisations where I have been, or are, employed.

Appendix B: Corrections, data description, and econometric analysis

My thesis remains a work-in-progress and requires corrections and amendments. It is important the reader is aware of these if considering the policy implications of my results.

First, use of an exogenous definition of shocks would yield greater insight into how cities react and recover from severe employment decline. Unfortunately, I was only able to compile an incomplete list of negative employment shocks by Australian city. As such, I was forced to rely on a somewhat arbitrary definition of a shock rather than anything exogenous.

Second, I am conducting further analysis on spatial correlation and the impact of nearby cities on employment growth. At present, my thesis does not deal with issues generated by migration, spatial spill overs, and spatial correlations adequately.

Third, my data is incomplete. More frequent data points and complete census data would aid my empirical analysis.

These amendments and corrections may not change the overall thrust of my conclusions. However, these and some other minor corrections would improve the robustness of my econometric analysis and confidence in my results.

Given the relevance of my work to the Productivity Commission's study I believe even my incomplete analysis and conclusions could be useful. In this appendix, I attempt to explain my data collection and current status of econometric analysis for the Productivity Commissions reference.

Data description

To consider factors that led to the growth and resilience of Australian cities from 1971 to 2011 my thesis applies a mixed-methods approach. I compile a new panel dataset of 124 Australian cities over five-yearly census periods from 1971 to 2011. I test a model of city growth against empirical observations of city performance. Finally, not included in this submission, I examine case studies of cities that succeeded and failed to work through economic transitions in order to understand any details not captured by city-level data.

Statistical techniques in urban economics traditionally examine long-differences in the growth of cities over time and test for correlations with measures of initial conditions in a city.² Recently, studies of urban growth have incorporated the use of dynamic panel models.³ In my case, this allows the estimation of dynamic forces related to size, education, and industry. Panel data has well-known advantages related to 'more accurate inference of model parameters, greater capacity for capturing the complexity of city changes, and simplifying computation and statistical inference'.⁴ My application has weaknesses, which will be discussed, related to a requirement for fixed effects, the heterogeneity of city experience, and identification limitations of my data. However, as far as I am aware a panel data approach to city development has not occurred in the Australian literature. Even limited application of panel techniques yields new insights into the growth and resilience of Australian city labour markets.⁵

My dataset was chosen for its comprehensiveness and timeframe. My focus is on performance across the full range of Australian cities. My approach allows estimation of general patterns. The 40-year timeframe reveals the shifting sources of prosperity for Australian cities and leads to general conclusions about their long-term development. The heterogeneity of cities presents issues for analysis. Alternative approaches to general statistical methods in urban economics focus on overcoming identification issues by concentrating on specific, and similar, regions.⁶ In Australia,

² E. L. Glaeser *et al.*, 'Growth in Cities', *Journal of Political Economy*, 100/6 (1992), 1126-52, W. Hanlon and A. Miscio, 'Agglomeration: A long-run panel data approach', (2016) <http://www.econ.ucla.edu/whanlon/papers/hanlon_miscio_draft.pdf>, accessed April 17 2016, p.1

³ W. Hanlon, *Temporary Shocks and Persistent Effects in the Urban System: Evidence from British Cities after the U.S. Civil War*, (79: Society for Economic Dynamics, 2015), D. Yagan, 'The enduring employment impact of your great recession location', (2016) <<https://sites.google.com/site/dannyyagan/greatrecession>>, accessed online 23 April 2016, A. Foote, M. Grosz, and A. Stevens, 'Locate Your Nearest Exit: Mass Layoffs and Local Labor Market Response', (2015) <<http://www.nber.org/papers/w21618>>, accessed 20 April 2016

⁴ C. Hsiao, 'Panel data analysis— advantages and challenges', *An Official Journal of the Spanish Society of Statistics and Operations Research*, 16/1 (2007), 1-22.

⁵ Hanlon and Miscio, 'Agglomeration: A long-run panel data approach', Hanlon, *Temporary Shocks and Persistent Effects in the Urban System: Evidence from British Cities after the U.S. Civil War* are examples of new applications of panel models to the study of urban growth and agglomeration effects. Their complexity goes beyond the models presented in this dissertation.

⁶ Hanlon and Miscio, 'Agglomeration: A long-run panel data approach', p.5

studies are often limited to case studies or small samples. These have the advantage of clear causal identification of changes to city economic activity.⁷ My approach combines these methods through both statistical analysis and the use of case studies. This allows general findings and potential use in broad policy analysis alongside identification advantages of considering specific local economic shocks.

A new historical dataset

Previous statistical analyses of the economic performance of cities in Australia are restricted by available data.⁸ Because of changing statistical boundaries, papers on the subject are limited to a single ten-year timeframe or broad statistical regions that cover an area beyond a single city.⁹

My research and discussions revealed a method to seek comparison of Australian cities over 40 years.¹⁰ Data on Urban Centres and Localities (UCLs) have been collected in accessible, but unpublished, format since 1971.¹¹ UCLs are a geographical unit that describes Australian population centres exceeding 200 persons. They are designed for the release of data related to the five-yearly Australian Census of Population and Housing conducted by the Australian Bureau of Statistics (ABS).

UCLs are constructed by clustering urban areas based on various amenities and indicators of a single urban space. The ABS ensures the clustered area, or UCL, is a distinct and singular city. Administrative borders do not play a role in this definition. Instead, it is defined by the continuity and density of urban development. Therefore, I define a city, using the ABS methodology, as a distinct urban space. The definition is dynamic. Cities grow, absorb nearby centres or decline. The regions from which they are built change with the settlement patterns of the population. Due to availability of data, I further define cities as urban clusters with a population of 5 000 and above across my entire period.

I sourced my data through consultations with ABS experts and a thorough search of the Australian Data Archive. The data has not been used across the full length of my period and appears to be a

⁷ Hanlon and Miscio, 'Agglomeration: A long-run panel data approach', p.5

⁸ R. Stimson, A. Robson, and T.-K. Shyy, 'Modeling regional endogenous growth: an application to the non-metropolitan regions of Australia', *An International Journal of Urban, Regional and Environmental Research and Policy*, 43/2 (2009), 379-98.

⁹ Ibid., R. Stimson, S. Baum, and K. O'Connor, 'The Social and Economic Performance of Australia's Large Regional Cities and Towns: Implications for Rural and Regional Policy', *Australian Geographical Studies*, 41/2 (2003), 131-47., J. Lawson and J. Dwyer, 'Labour market adjustment in regional Australia', *Reserve Bank of Australia* (Sydney, 2002).

¹⁰ D. Hossack, ABS Officer, Interviewed by the author, Canberra via email, 9 July 2015

¹¹ Australian Bureau of Statistics, 'Australian Statistical Geography Standard', (2012) <<http://abs.gov.au/AUSSTATS/abs@.nsf/Lookup/1270.0.55.004Main+Features1July%202011?OpenDocument>>, accessed 3 December 2015

defensible method to compare city performance over time. I plan to make the dataset public sometime in 2017. I can provide it upon request.

The UCL data

I use four sources to construct my dataset.¹² First, four previously unpublished datasets were purchased from the ABS for the years 1971, 1976, 1986 and 1991. Second, a dataset for 1981 was found in the Australian Data Archive (ADA) at the Australian National University (ANU). This data suffers from the non-exclusion of overseas visitors and visitors from within Australia. In order to match other sourced databases, it was adjusted to ensure it reflects only persons enumerated at home on Census night.¹³ Third, 2001 UCL data is available online but not in an aggregated format. The data is only accessible by individual UCL. I scraped the data from the ABS site. The final source for data was ABS's Table Builder tool for 2006 and 2011 UCLs. This is a tool provided by the ABS to access public census data.

Table 1 summarises the available data. Measures for the year 1996 were unavailable. This limits the flexibility of the model and gives some concern about the later specification of a dynamic panel model. However, given there are 124 cities and communities in the sample and eight time periods, I believe sufficient data exists to make conclusions. Because 1996 data is unavailable, I use yearly averages of growth to allow for the difference in years from 1991 to 2001.

Table 1: Sourced data from ABS on UCLs

Available data	1971	1976	1981	1986	1991	1996	2001	2006	2011
Employment	x	x	x	x	x		x	x	x
Unemployment	x	x	x	x	x		x	x	x
Age distribution	x	x	x	x	x		x	x	x
Education	x	x	x	x	x		x	x	x
Industry of employment	x	x	x	x	x		x	x	x
Population	x	x	x	x	x		x	x	x

x indicates sourced data

¹² Australian Bureau of Statistics, *1981 Census of Population and Housing by UCL*, Australian Bureau of Statistics, *Australian Census Data 1971, 1976, 1986, 1991*, (2016), Australian Bureau of Statistics, *Australian Census Data - UCLs - 2001*, (2016), <<http://www.abs.gov.au/census>>, accessed 12 December 2014, Australian Bureau of Statistics, *Australian Census Data - UCLs - 2006, 2011*, (2016), <<http://www.abs.gov.au/census>>, accessed 12 December 2014

¹³ Explanation of this adjustment is found in full thesis

Adjustments and limitations of the data

Selection issues in my data have been addressed or acknowledged.

First, some satellite cities were absorbed into capital and larger cities over the period. Cities that leave the sample due to absorption are added into their absorbing city.

Second, approximately five cities drop out of the 5 000 range during my period. These cities were already small and did not experience an extreme decline. In turn, some cities entered the sample over my period. For simplicity, these cities were excluded from my sample. None experienced levels of growth or decline to influence my results.

Third, definitions of industry and education change over the period. The Australian Standard Industrial Classification changed in 1978 and 1983.¹⁴ In 1996 and 2001, the industry variable was coded using the first edition of the Australian and New Zealand Standard Industry Classification, released in 1993.

¹⁵ This variable changed again in 2006 to the Australian and New Zealand Standard Industry Classification 2006.¹⁶ This data has been matched using the ABS standard. Data pre-1996 has no formal matching method. I follow methods outlined in later years. This could produce some measurement error within the industry data if industries do not properly align over time. However, given matching measures have been followed and carefully applied to previous years I consider the industry data is defensible in use. Similar changes occurred over the period in the Australian Standard Classification of Education (ASCED). To mitigate the effect of these changes I treated all degrees and diplomas as 'Tertiary-level qualifications' and all trade-based education as 'Trade-based certificates'. This allows comparison over time. However, it does make the variable a blunt instrument, perhaps contributing to its ambiguous effect in my models. Unfortunately, due to comparative issues, little can be done to alleviate this problem.

The available historical data has limitations. Data that act as proxies for culture, demographics, local entrepreneurial ability and leadership could not be found or accessed for the entire period. Incomes, productivity, and housing supply data are not available at a city-level across my entire period. In urban economics, these variables are used to capture the complex dynamics of city behaviour. However, as

¹⁴ Australian Bureau of Statistics, '1292.0 - Australian and New Zealand Standard Industrial Classification (ANZSIC), (Revision 2.0)', (2013)
<<http://www.abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/D249EC2A7DC203BACA257B9500133E91?opendocument>>, accessed 4 December 2015

¹⁵ Ibid.

¹⁶ Ibid.

studies by Hanlon and Bradley and Gans have shown, it is possible to examine general correlations in their absence.¹⁷

There are areas of difference between the sample and real national trends. The sample, on average, picks up 75 per cent of the Australian population but consistently records slightly higher unemployment rates than the actual nationwide average.¹⁸ The weighted sample does follow the general employment and labour force trend of the nation. Overall, I acknowledge further data points and less variation between my sample and actual national trends would be useful.¹⁹ However, the dataset captures, on average, the trend and magnitude of national statistics.

Key variables

Table 2 shows the key variables constructed from the dataset. The nature of my data means labour markets are the key measure of city performance. Employment growth is the main dependent variable used to measure city performance. Labour force growth, unemployment rate, and participation rate are further indicators of healthy local labour markets.

Note a modified Herfindahl index derived from Bradley and Gans and Bostic is used to indicate the specialisation level of industry in a city.²⁰

$$SPEC_{i,t} = \sum_{j=1}^J \left(\frac{L_{j,t}}{L_{i,t}} \right)^2$$

Where $L_{i,t}$ is the population level in city i at time t and $L_{j,t}$ is the population working in each industry in the city at time t . As $SPEC_{i,t}$ approaches one, the city is increasingly specialised in one industry.

I found no satisfactory variable to measure institutional strength in Australia over my period. A city age variable was constructed. It had a positive correlation with city performance but the effect was small and the mechanism unclear. As such, case studies are important for understanding the role of institutions and leadership.

¹⁷ Hanlon and Miscio, 'Agglomeration: A long-run panel data approach', , Hanlon, *Temporary Shocks and Persistent Effects in the Urban System: Evidence from British Cities after the U.S. Civil War*, Bradley and Gans, 'Growth in Australian Cities'.

¹⁸ Sample is weighted by population for comparisons

¹⁹ Not all data could be collected due to unavailability or expense. This leaves open the possibility of further work and research as data and budget become available.

²⁰ R. Bradley and J. S. Gans, 'Growth in Australian Cities', *Economic Record*, 74/226 (1998), 266-78., p. 270

Table 2: Key variables for city performance

Variables	Description
<i>City performance indicators</i>	
Annual employment and labour force growth (log)	Measures changes in labour market size and employment.
Unemployment rate	Unemployment rate illustrates how much of labour force is in employment.
Participation rate	Participation rate calculated from size of labour force compared to population aged 15 to 65.
<i>Size and location</i>	
Size (population, log)	Measured by population. Size of city may impact labour market due to positive impact of agglomeration and built infrastructure or negative effect of congestion and convergence
Distance from state capital (km, log)	Measured in kilometres, as the bird flies. Distance to capital acts as a proxy for infrastructure and accessibility of markets. It is imperfect as regional hubs exist but relevant in the Australian context given dominance of capitals
Coastal	Dummy variable for whether a city is directly adjacent to a coastline. Associated with generally better amenity and connection to trade and transport
<i>Education and industry</i>	
Tertiary-level qualification	Proportion of city population aged over 15 who have completed three-year university-level education or vocational education of more than one year
Trade-based certificate	Proportion of city population over 15 with up to one year of post-secondary education in practical and specific skill
Over 65s	Proportion of population aged over 65
Specialisation	Measure of industry specialisation of a city. Indicates reliance on single industry for employment
Industry employment variables	Proportion employed in manufacturing, mining, tourism, recreation, utilities, construction, wholesale and retail trade, financial, professional, and business services, and government

City performance: baseline panel data regression

I apply two approaches to my dataset of 124 Australian cities. First, I consider what leads cities to have strong growth and performance. A general panel model with fixed effects is estimated correcting for autocorrelation of the errors. I use employment growth as my key measure of performance. Second, I explore how cities respond to shocks. With my full dataset, I estimate a difference-generalized methods of moment (GMM) dynamic panel data model. This aims to understand the dynamic factors at play in city performance and examine the persistence of employment shocks over time.

To understand city-level growth, I estimate a panel model with fixed effects. This has three advantages. First, it means information from all years can be combined without losing period to period variation. Second, it allows tests of, and controls for, persistent unobserved city differences. Third, lagged variables can be introduced to study adjustment dynamics in response to significant employment decline.

First, I must deal with some preliminaries. In a cross-section model, I found errors for individual cities to be systematic and large, indicating persistent, unobserved city-specific heterogeneity. As a result, I include city fixed effects in my model. Their inclusion implies coastal and distance variables, which do not change over time, must be omitted. I also observe the presence of heteroscedasticity based on population. To address this concern, I calculate robust standard errors and, where possible, estimate the model using the square root of population to weight observations. This is appropriate if the variance of the error is inversely proportional to the population. Initial tests of the panel model confirm the presence of systematic city-specific differences.²¹ Nulls of no year and no city fixed effects are strongly rejected.²² Tests indicate the presence of first-order autocorrelation and spatial correlation.²³ I estimate standard errors robust to both.

With the preliminaries concluded, the starting point for the panel regression is the following model:

$$y_{it} = \alpha + \beta'X_{it} + \varphi_i + \theta_t + \varepsilon_{it} \quad (1)$$

where y_{it} is the dependent variable of interest (for example - employment growth, from the current to the next period) X_{it} is a set exogenous and/or predetermined variables of the current period, φ_i

²¹ The Hausman test finds a random effects model is inconsistent with the data

²² I control for year effects in my models. I considered using deviations from national mean as my dependent variable. However, the year effects capture the same movements

²³ I apply the Woolridge and Moran I tests. In my estimates, I experiment with allowing correlation over different distances and limited serial correlation based on S. M. Hsiang, 'Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America', *Proceedings of the National Academy of Sciences of the United States of America*, 107/35 (2010), 15367. and W. K. Newey and K. D. West, 'A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix', *Econometrica*, 55/3 (1987), 703-08. Neither substantially impacts my results.

is a (time-invariant) city-specific effect, θ_t are period effects, α is the intercept term, ε_{it} is the error term and subscript t indicates the time periods under consideration. Equation (1) can be written as:

$$y_{it} = \alpha_i + \beta' X_{it} + \theta_t + \varepsilon_{it} \quad (2)$$

where

$$\alpha_i = \alpha + \varphi_i$$

Given panel data, I can estimate β' if I treat the α_i as parameters to be estimated. I apply the 'within' transformation. Estimated effects of the strictly exogenous period dummies, the $\hat{\theta}_t$, are not reported to save space. Thus, the panel data model with fixed effects is equivalent to estimating:

$$(y_{it} - \bar{y}_i) = \beta'(X_{it} - \bar{X}_i) + (\varepsilon_{it} - \bar{\varepsilon}_i) \quad (3)$$

The value of the fixed effects can be estimated directly in (2) or recovered from (3). For robustness, I also estimated the model in first differences. The results broadly confirm the within estimates. For simplicity, I first run the employment growth regression. Table 3 shows the results of an initial panel regression with fixed effects corrected for first-order autocorrelation. I progressively add explanatory variables to observe any changing effects.

Table 3: Employment growth panel estimates²⁴

	(a)	(b)	(c)	(d)	(e)
<i>Dependent: Annual employment growth (log)</i>					
Size (population, log)	-0.030*** (-1.638)	-0.033*** (-1.818)	-0.034*** (-1.853)	-0.032*** (-1.754)	-0.032*** (-1.739)
Tertiary-level qualification		-0.005 (-0.011)	-0.004 (-0.009)	-0.013 (-0.029)	-0.012 (-0.028)
Trade-based certificate		-0.104** (-0.133)	-0.103** (-0.131)	-0.134*** (-0.170)	-0.135*** (-0.172)
Over 65		-0.107* (-0.207)	-0.107* (-0.207)	-0.193*** (-0.375)	-0.193*** (-0.373)
Specialisation			0.018 (0.017)		-0.014 (-0.012)
Manufacturing				-0.044 (-0.146)	-0.041 (-0.135)
Mining				0.035 (0.095)	0.039 (0.103)
Tourism and recreation				0.229*** (0.284)	0.229*** (0.285)
Utilities				-0.041 (-0.070)	-0.038 (-0.064)
Construction				-0.161*** (-0.177)	-0.161*** (-0.177)
Wholesale and retail trade				0.063 (0.106)	0.066 (0.109)
FPBS				-0.010 (-0.013)	-0.010 (-0.013)
Government				0.143*** (0.386)	0.145*** (0.391)
Observations	744	744	744	744	744
Number of Cities	124	124	124	124	124
City fixed effects	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES
Autocorrelation coefficient	0.0917	0.0948	0.0977	0.151	0.150

Note: Robust normalized beta coefficients in parentheses; *** p<0.01, ** p<0.05, * p<0.1; model not able to be weighted, regular panel model w/weights and clustered by city shows similar results; I also estimate standard errors robust to spatial correlation, no significant change; fixed effects applied at city-level; model corrected for autocorrelation; variables hold for robustness with introduction of a national growth control and - with the exception of size - a control for city-level growth

²⁴ FPBS = Financial, Professional, and Business Services

I find size is negatively correlated with employment growth. Trade-based certificates, proportion over 65, and share employed in construction are negatively correlated and statistically significant. Tourism, recreation and government employment are positively correlated and statistically significant. The estimated autocorrelation coefficient of the final regression (column e) is 0.150. The positive sign suggests a persistent, but small, effect of the previous period. This indicates some negative or positive growth in the previous period will carry to the next.

Concerned the model may differ for different types of cities, I estimate panel models restricting cities to specific characteristics such as industrially diverse and coastal cities. The results illustrate similar effect sizes if not always significance. This may be because of severely limited sample sizes. However, the effect sizes increase confidence in the broad conclusions.

My main specification of panel model (e) with fixed effects controls for unobservable city-specific factors. These city-specific factors are of interest, especially for their possible correlation with time-invariant geographic variables that are lost in the panel model. Fixed effects shows the value added to a city's growth variable in every period due to unobservable factors estimated using dummies in the panel model. My priors are cities distant from capitals, and inland, faced disadvantages due to physical geography, distance from administrative centres, and poorer access to markets.²⁵ Negative mean fixed effects for such cities suggest this was true. Capital cities had large fixed effects. This confirms the importance of size.²⁶ Similarly, small cities had negative fixed effects on average compared to large positive fixed effects for large cities. The fixed effects of mining, utility, wholesale and retail trade, and government cities are negative whilst diverse, manufacturing, tourism and recreation, and construction are positive.

City resilience: dynamic panel data model

The results of the simple panel model reveal significant effects of size and industrial structure. The autocorrelation of each regressions' residuals is of substantive interest. I do not know if this is the result of a persistent shock or a slow adjustment process. For instance, a factory could shed jobs over a number of periods. This would be a persistent shock. Alternatively, a factory may shed jobs all at once but the city could take some time to adjust. A difference-GMM dynamic panel model means this effect can be tested alongside previous period changes having a persistent effect on a city.²⁷ The

²⁵ M. Bosker *et al.*, 'Ports, plagues and politics: explaining Italian city growth 1300–1861', *European Review of Economic History*, 12/1 (2008), 97-131.

²⁶ The panel model estimate is a within effect. Therefore, as cities got bigger, their growth tended to slow. However, growth in a capital could still be faster than growth in small or medium cities. This is indicated by their large fixed effects.

²⁷ Nickell finds an issue when lags are introduced to panel models related to bias in the estimate of the coefficient of the lagged dependent variable which is not mitigated by increasing N, the number of individual

starting point for the dynamic panel estimation is a variant of the initial simple panel data model from equation (1):

$$y_{i,t} = \alpha + \omega y_{i,t-1} + \beta' X_{i,t} + \varphi_i + \theta_t + \varepsilon_{i,t} \quad (4)$$

which means,

$$y_{i,t-1} = \alpha + \omega y_{i,t-2} + \beta' X_{i,t-1} + \varphi_i + \theta_{t-1} + \varepsilon_{i,t-1} \quad (5)$$

Therefore, to eliminate city-specific effects, φ_i , the equation can be formulated in first differences. The difference in year dummies is omitted for simplicity.

$$y_{i,t} - y_{i,t-1} = \omega(y_{i,t-1} - y_{i,t-2}) + \beta'(X_{i,t} - X_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad (6)$$

Equation (6) shows the difficulty in estimating the model.

First, the lagged change variable is endogenous, as $y_{i,t-1}$ depends on $\varepsilon_{i,t-1}$. Second, the new composite error will be autocorrelated, even if the underlying ε is not, since successive realisations each share a common term.²⁸ However, the formulation is useful as it allows me to test for persistence using ω and account for endogeneity. A detailed econometric discussion can be found in Roodman and Bond *et al.*²⁹

Table 4 summarises the dynamic panel model results reporting only the coefficients on the lagged dependent variable. I control for period, city-level fixed effects, and include the same explanatory variables as in Table 3.

I report the p-values from a formal test of first-order autocorrelation (AR(1)) and second-order autocorrelation (AR(2)). Recall that if the underlying errors are uncorrelated – an assumption on which the Arellano-Bond estimator depends – the first differenced errors in Equation 6 will be a moving average with a correlation of -0.5. The expectation is thus of first-order autocorrelation, but no higher-order persistence. The test results are consistent with this prediction for labour force growth and the rates of unemployment and labour force participation. In the case of employment growth, it was

units. First differences and instruments are proposed as a potential solution. S. Nickell, 'Biases in Dynamic Models with Fixed Effects', *Econometrica*, 49/6 (1981), 1417-26.

²⁸ D. Holtz-Eakin, W. Newey, and H. S. Rosen, 'Estimating Vector Autoregressions with Panel Data', *ibid.* 56 (1988), 1371-95, M. Arellano and O. Bover, 'Another look at the instrumental variable estimation of error-components models', *Journal of Econometrics*, 68/1 (1995), 29-51, M. Arellano and S. Bond, 'Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations', *The Review of Economic Studies*, 58/2 (1991), 277-97, R. Blundell and S. Bond, 'Initial conditions and moment restrictions in dynamic panel data models', *Journal of Econometrics*, 87/1 (1998), 115-43.

²⁹ D. Roodman, 'How to do xtabond2: An introduction to difference and system GMM in Stata', *Stata Journal*, 09/1 (2009), D. Roodman, 'A Note on the Theme of Too Many Instruments *', *Oxford Bulletin of Economics and Statistics*, 71/1 (2009), 135-58, Arellano and Bond, 'Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations', J. Temple, 'GMM Estimation of Empirical Growth Models', (3048: C.E.P.R. Discussion Papers, 2001).

necessary to add an additional lag to capture more complicated dynamics and eliminate higher-order autocorrelation. This brings my observations down to six periods. This seems small. However, Arellano and Bond used a similar number of observations, albeit annual, when introducing the estimator, which is meant for situations in which there are many cross sectional units and few observations over time.³⁰ As such, I continue with the estimation but with some caution over the robustness of results.

The results show employment growth and labour force growth experience a small, insignificant, dampening effect. All being equal, a city will have a slight recovery following a negative employment or labour force shock. Cities largely return to trend within five years. The unemployment rate has no significant lagged effect. This broadly mirrors the findings of Blanchard and Katz, who found US states rapidly return to mean employment growth and unemployment rates following a shock.

Participation shows a significant lagged effect. The magnitude of the effect is small and it returns to mean after two periods (ten years). However, the result is an indication cities take time to escape from a decline in participation. To illustrate my results, Figure 2 stimulates a shock in employment growth over the full sample. I use the example of a negative shock (results are mirror image for a positive shock). The figure shows cities experience a very small rebound. However, they generally return to their former employment growth after five years. As suggested by my descriptive analysis, cities returned to growth but along a permanently lower employment path.

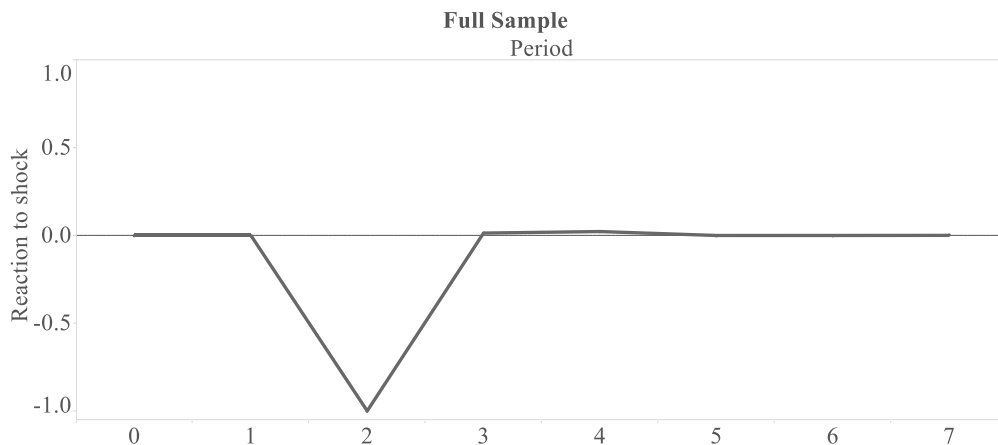
³⁰ Arellano and Bond, 'Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations'.

Table 4: Results of dynamic panel model

	(a)	(b)	(c)	(d)
<i>Dependent variables:</i>	Employment growth	Labour force growth	Unemployment rate	Participation rate
Coefficient on lagged variable				
One lag	-0.038 (-0.042)	-0.031 (-0.030)	-0.005 (-0.006)	0.221*** (0.214)
Two lags	-0.069 (-0.077)			
<i>Implied impulse responses</i>				
Period 1	-1.000	-1.000	-1.000	-1.000
Period 2	0.038	0.031	0.005	-0.221
Period 3	0.068	-0.001	0.000	-0.049
Period 4	-0.005	0.000	0.000	-0.011
Period 5	-0.004	0.000	0.000	-0.002
Observations	496	620	744	744
Number of Cities	124	124	124	124
City fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
City controls	YES	YES	YES	YES
Hansen	0.115	0.235	0.123	0.257
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.623	0.592	0.173	0.597
Instruments	99	109	117	117

Note: Robust normalized beta coefficients in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Hansen test null that overidentifying restrictions are valid. P-values are shown. Null is not rejected; city controls include size, education, specialisation, over 65s and industry variables used in previous models; model weighted by square root of population; year and city fixed effects applied but not reported; I use the xtabond2 routine in Stata developed by Roodman; nolevleq specified for difference GMM; twostep specified to better assess error variance-covariance and ensure heteroscedasticity robust; noconstant as differenced regression; default artests; lag of employment growth treated as endogenous; year dummies and employment shares treated as exogenous justified by general inertia of industrial structure; tested with construction, WRT, and tourism as endogenous, model fails; population, higher degrees, technical certificates, and population over 65 treated as predetermined/weakly exogenous as all could vary in response to earlier shocks; two lags required for employment change as one lag fails AR(1) requirement to reject the null; model is estimated with subsequent periods despite absence of 1996, otherwise too few periods are available for estimation, model is forced into periods 1-8; Instruments required for model to pass Hansen, and closeness of failure to reject null, suggests some fragility

Figure 2: Example response of city employment growth to a negative employment shock³¹



³¹ The dynamic panel model does not pass specifications when limited to specific city characteristics preventing investigation of different levels of persistence between city types.

The dynamic panel data model also gives an opportunity to further test the robustness of the simple panel findings. Figure 3 summarises the beta coefficients of both models. The grey marks represent the values of beta coefficients from the baseline panel model. Dark grey is significant, light grey is not significant. Similarly, dark blue is significant and light blue insignificant for the dynamic panel model. Size, government, tourism, and recreation are the only variables with strong and robust results across the models. Generally, they are significant and their effect size is always relatively large. The effect size and statistical significance of other variables are inconsistent. Thus, statistical results only find robust results for size, tourism, recreation, government, and construction. Construction is difficult to explain. It is negatively correlated with growth but also correlated with low unemployment. Potentially, the cause is related to the migratory behaviour of the industry, but I do not have a full explanation. Other effects are of interest, but variable.

In summary, cities generally return to previous performance following a shock to the labour market. Though employment and labour force growth rates recover, their levels do not: time paths are permanently lower (or higher). In addition, the adjustment of participation back to equilibrium is protracted, requiring at least five years. This suggests one mechanism for city labour markets dealing with shocks is people exiting the labour force. In my thesis, I consider this mechanism, alongside out-migration, in more detail but have not included the discussion here.

Figure 3: Beta coefficients of baseline (circle) and dynamic panel model (cross)

