Economic Resilience of Regions: A Longitudinal Study of the Australian Economy from 1986 to 2011

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ABSTRACT

Resilience is about addressing vulnerability, not only by surviving a shock to the system, but also thriving in an economic environment of change and uncertainty. A robust conceptual framework is required to navigate through underlining elements of vulnerability. An evolutionary model of regional adaptive cycles around four sequential phases in economic activity – reorganisation, exploitation, conservation and release – is adopted in this study as the framework for recognising such phase patterns. A data mining clustering method which utilises a k-means algorithm evaluates the impact of major shocks, notably economic recessions and drought, on four functional groups of regions (metropolitan, periphery, regional and rural). Applying this clustering method to the adaptive cycle model using census data from 1986, 1991, 1996, 2001, 2006 and 2011, the paper identifies patterns of economic resilience in regions by industry categories. Preliminary results show different resilience patterns and varied stability to this resilience for industry/functional regions ranging from non-resilient to very resilient regions.

> Resilience is about addressing vulnerability, not only by surviving a shock to the system under investigation, but also for the system to thrive in an environment of change and uncertainty. Recent severe economic and ecological crises raise questions about sustainable development and resilience of regions within different industries (Courvisanos *et al*, 2016, p. 630)

INTRODUCTION

Investigating the vulnerability of regional economic systems in Australia to economic and ecological crises has been the major research objective of this research team over a significant period of time. The quotation above appears in the first peer-reviewed research output in which a robust conceptual framework was developed to navigate through the underlining elements of vulnerability. This framework of regional adaptive cycles is based on a four sequential phase model of economic activity – reorganisation, exploitation, conservation and release – that was initially advocated by Simmie and Martin (2010). By adapting this generalised pattern into a framework for examination of Australian regions and industries, and their income generation capability during cycles and crises, patterns can emerge that enables resilience against crises to be investigated.

In Courvisanos *et al*. (2016), the data analysed was from the 2001, 2006 and 2011 Australian Bureau of Statistics (ABS) Census. A data mining clustering method called k-means provided an algorithm to evaluate the impact of major shocks, notably economic recession and drought,

on four functional groups of regions (metropolitan, periphery, regional and rural) across all 558 local government areas (LGAs) in Australia. These four functional groups of regions were allocated over the 19 ABS defined industry sectors, thus creating a total of 76 functional regional groups and their relevant industries. Two major limitations emerged from the investigation of the available three prior Census data sets. First is that 41 of the total 76 functional regional groups and their industries could not be allocated to the four-phase evolutionary pattern due to two or more non-separable (non-significant) periods being identified. Second is that only three periods with census data points 2001, 2006 and 2011 were available to be accessed in order to build the database for clustering. This is a limited time horizon with only two shocks (mid-2000s drought and 2008-09 Global Financial Crisis) in the snapshot data points with which to examine the adaptive resilience of regions by industry.

To overcome these two limitations, the research team undertook further investigation by extending back in time to cover census periods that take in the 1989-92 recession and the 1999-2001 dot com bubble crash. This required the statistical data from ABS to reach back across a further three Census periods, 1986, 1991 and 1996. Given the number of LGAs and their respective industrial sectors, preparation of the data concordance for six Census dates was a huge data setting task. The ABS officers informed the team that concordance going back prior to the 1986 Census was not possible due to lack of comparability of the data available. This paper summarises the salient results from this larger investigation, identifying patterns and determining the resilience of regions and their industries vis-à-vis vulnerability to ecological and economic shocks. The research question for this paper continues to be the same as Courvisanos et al. (2016) and can be stated as: What is the nature of economic resilience within the four functional groups of regions with respect to their industries as identified in the Local Government Areas of Australia, when evaluated longitudinally over a period of significant crises? In this paper the period covered is across all Census data from 1986 to 2011.

As noted in Courvisanos *et al*. (2016, p. 630):

> Analysis of Australia and the resilience of all its regions and its respective industries is a unique country-wide perspective in theory and application. Australia is usually ignored in the literature which generally focuses on the advanced economies of North America and Western Europe. As with other advanced economies, Australia is characterised by gradual loss of manufacturing and increasing reliance on mining and service industries. The Australian economy is based on a strong export-based primary sector, exposed by fluctuations in commodity prices. It is also underpinned by significant foreign direct investment in both these sectors and across this small open economy. The vagaries of the international economic environment coupled with public sector austerity, cyclical floods and droughts, and a volatile currency, play havoc with the Australian economy (Henry, 2013; Lim *et al*, 2014). Therefore, the resilience of regions in the context of this national economic environment is worth evaluating and studying in its own right as an advanced economy commodity producer.

Further, this investigation continues to apply k-means cluster analysis, an approach thus far not used in the evaluation of resilience. This cluster analysis is able to apply measures of employment and income change over time to find associations between industries and regions in a rigorous statistical manner. As with the aforementioned article by the same authors, all 558 LGAs in Australia are evaluated for their reaction to endogenous shock (the Global Financial Crisis) (Wettenhall, 2011) and exogenous shock (drought) (Horridge *et al*, 2005; Edwards *et al*, 2009). The approach adopted in this analysis is to have measures of employment and income change over time calculated in order to appreciate the nature of resilience in relation to regions and their industries. This understanding occurs by providing

an overall macroeconomic picture of resilience across the entire country and all industries. Resilience is categorised over six Census periods in conjunction with the regional geography of LGAs.

CONCEPTUAL FRAMEWORK BASED ON RELEVANT LITERATURE

Much academic attention has been given to the concept of resilience in the regional economics literature since 2008; most notably Pendall *et al*. (2008), Fingleton *et al*. (2012), Bristow and Healy (2013), Cellini and Torrisi (2014), and Holm and Østergaard (2015), as well as issues of two regional studies journals having been dedicated to regional resilience. In 2010 *Cambridge Journal of Regions, Economy and Society* had an issue called "The Resilient Region" (Volume, 3, Number 1) which introduced theoretical evolutionary models and their adaptability to regions, with applications to the USA. Then, more recently in 2016 *Regional Studies* released an issue called "Resilience Revisited" (Volume 50, Number 4) because it examined the empirical evidence across Europe, UK, Wales, Turkey, Malaysia, and the Australian study by the present authors, and also reconsidering the theoretical models. Despite all this research, the issue of how regions adapt to vulnerable events and circumstances that build crises by generating income and employment that is both viable in the longer term and sustainable both socially and ecologically is far from clear. The main reason, as identified by Bailey and Turok (2016, p. 557), is the "marked differences" in how the concept of resilience is defined and empirically applied. The advantage of this paper is that the same consistent framework already applied in Courvisanos *et al*. (2016) is adopted across a doubling of the previous time period with identical LGA functional industry groups.

Already a seminal article, Simmie and Martin (2010) forms the basis of the framework developed in this investigation to identify regional resilience patterns, in which regional economic resilience is seen in terms of "adaptive ability". Simmie and Martin (2010, p. 28) define this adaptive ability as "the differential ability of a region's or locality's firms to conditions that shape the evolutionary dynamics and trajectories of that regional or local economy over time". In the context of regional economies, dynamic resilience means the ability of the regional economy not just to recover after an economic or ecological downturn, but also to adapt, innovate and grow. Regional economic systems need to co-evolve with other regional systems and the surrounding social and physical environment (Sotaruata and Srinivas, 2006).

Basic to this approach, regions are "resilient" in an economic sense when they are shock resistant such that "resilient regions avoid being locked into restrictive low income level equilibria" (Hill *et al*, 2008, p. 4). Thus, resilient regions resist a situation where the shock resets the same equilibrium or results in the equilibrium (path) developing a downwards trajectory of economic development (Christopherson *et al*, 2010). Applying this regional resilience in economics to industry sector-based activity, Holm and Østergaard (2015, p. 13) explain that "regional industrial resilience is a population concept on the adaptive capacity of a regional industry to make changes in response to a shock". Taking adaptive into account, Boschma (2015) suggests a comprehensive view of resilience that incorporates industrial change, strong but loose networks, and coherent but flexible institutions. As far back as North (1992) evolutionary economics has seen industries in regions as playing a significant role as institutions which need to build adaptive economic resilience. Thus, the role of industry-based activity in the conceptual framework applied in this investigation.

The same conceptual framework applied by Courvisanos *et al*. (2016) is adopted in this paper in order to frame the quantitative assessment from the ABS Census data. This framework is grounded in Simmie and Martin's (2010) "panarchy" model of regional resilience which

resides within the stream of evolutionary adaptive economic theory (Hodgson, 2004). "Panarchy" is a state in which there are complex interactions between institutions, industry, ecosystems and society. This panarchy state describes the resilience of the system as it interacts through the different phases of the adaptive cycle. For Simmie and Martin (2010, p. 34), resilience of a region "depends both on the longer term, region wide processes and on shorter term microscale processes and how these interact". All of these interactions occur in different spatial and time frames, adding complexity to the understanding and analysis of these processes. Such complexity of adaptive systems depends on extent of self-organisation and learning that occurs in the nominated space in which the system exists (Folke *et al*., 2002); in this study it is a regional space as defined by LGA. With such systems being in a constant state of flux through self-organisation and learning, adaptation and change occurs that makes mainstream equilibrium economics an approach that is totally irrelevant.

The adaptive ability framework applied in this investigation is able to recognise how regions can differ in their ability to adapt to changes and shocks of any description and magnitude. This approach, as specified by Martin *et al*. (2016), enables resilience to be viewed either as the ability to respond to a shock after the crisis ("hysteretic shift to a new path") or to react to signs of upcoming crisis by first resisting the shock and then addressing it prior to any potential crash (set up a "pre-recession path"). Some regions make take a long time to organise a new path after crisis (e.g. Pittsburgh, USA; Giarratani and Houston, 1989), or remain in resistance to an upcoming shock that delays crisis but does not bring change (e.g. Stanhope, Australia; Courvisanos, 2007). Both such paths are slow and weak in adaptive capacity. Other regions can anticipate future shock and alter their development path (e.g. Qitaihe, China; Ke, Song and He, 2009) or quickly address the crisis that happens and move to a new path (e.g. Sheffield metals cluster, UK; Potter and Watts, 2012). Thus, resilience means both degree of resistance to shock (potential or actual) and then the ability to respond to the shock.

Responding to shock has its theoretical roots in the innovation model by Schumpeter (1942) with its shift to either industrial mutation or creative destruction. Thus, underlying the building of resilience in a regional system is innovation. This innovation needs to be able to create an adaptable industrial structure of sustainable development that can secure a regional development economic trajectory that broadly addresses financial, social, and ecological crises affecting the region (Courvisanos, 2012, pp. 224-50). Examples of successful innovation in the face of shocks are New York city women's garment district (Rantisi, 2002), North Staffordshire external ties with Castellon, Spain and Sassoulo, Italy (Hervas-Oliver *et al*, 2011), and 17 Spanish new service intensive regions (Navarro-Espigares *et al*, 2012). In this paper, the aim is to identify adaptability within Australia of an LGA region, as one of four functional groups, in respect to different industry sectors. This possible adaptability is specified by the length of time across Census period data that an industry remains static or changes in relation to a crisis.

The conceptual framework, using Simmie and Martin (2010)'s panarchy model, has four phases of regional resilience that aim to explain adaptability of a region. The panarchy model is an adaptive cycle that evolves over time through four phases: conservation, release, reorganisation and exploitation. Since it is a cycle model, the analysis can begin at any of the four phases, but needs to proceed through these phases in the specified evolutionary sequence. The "conservation phase" has high connectedness and reflects a relatively stable pathway. This stable phase coincides with the "resistance" dimension in Martin *et al*. (2016) in which the region resists change due to shock (or impending shock). Over time a region may overcome resistance and evolve into the "release phase" which has high but declining connectedness and low but increasing resilience. This is a pathway that can be more easily

disrupted by external forces when connectedness decreases between the components within the system, forcing some change however reluctantly. Martin *et al*. (2016) see this as the "recovery" dimension in which actions are placed in the system to address the shock. Eraydin (2016) highlights these two phases together as a region's "ability to respond" to shock (or potential shock). In essence, the issue in these two phases is increased vulnerability and the consequent response by the regional community.

With increased vulnerability, the region can respond by registering a level of innovation with increases connectedness that is called the "reorganisation phase". In this phase, Martin *et al*. (2016) identify a dimension of "reorientation" in which innovation takes root as a niche activity. Finally, the "exploitation phase" evolves in which there is low connectedness but increasing resilience and strong seizing of opportunities. This permits the internalisation of external forces for the good of the region and thus Martin *et al*. (2016) identify this as the "renewal" dimension. Eraydin (2016) highlights these next two phases together as a region's "adaptability and adaptive capacity" to shock (or potential shock). In essence, the issue in these two phases is the consequent response by the regional community to change and how much innovation is brought about by this change.

To assess regional resilience in the context of the four phases framework, this paper follows Courvisanos *et al*. (2016) by evaluating economic activity (or income contribution) of industries within regions over periods in which shocks have occurred or threatened to occur on a national basis. As with Fingleton *et al*. (2012), Courvisanos *et al*. (2016) analyses resilience of regions to employment shocks and significance to regional variations in recovery from employment shock, by (i) using broad quantitative assessment of the industry structure from ABS Census data and (ii) identifying relevant income generation impacts within different regional groupings. The groupings are four functional groups called Metropolitan-Core, Metropolitan-Periphery, Regional Cities, and Rural. What underlies this potential income generation is that (Courvisanos *et al*, 2016, p. 632):

> Regions that have access to endogenous knowledge and innovation in the manner of strong established regional innovation systems tend to do well in the face of adversity… On the other hand, regions that rely on one principal industry or activity or group exclusively tend to be less resilient…Further, those regions which enjoy vertical and horizontal linkages in their industries and institutions are considered more likely to be resilient.

Thus, income generation effects identified through five year Census data collection data can reveal strong or weak regional innovation systems.

With the four functional groups as different Australian regional economies set up, Courvisanos (2016) and this paper follow Martin (2012) by using employment level data to evaluate regional economies. In the UK study by Martin (2012) across three major recessions in 1979-83, 1990-93 and 2008-10, the conclusion is that the three recessionary shocks were different in nature and impact, yet after all three recessionary shocks employment recovery lagged behind output recovery. This indicates different levels of resilience which can be placed within specific resilience evolutionary phases. In this paper, same as in Courvisanos *et al*. (2016, p. 632):

> …the measure of adaptability in the long term is evaluated by the changes in industry structure of the four functional groups of regions. An adaptable resilient region will demonstrate change in the nature of industry over time without significant reduction in employment or income despite shocks (or perturbations).

Once the measures are established, assessment of regional economic resilience is difficult for two reasons. First, there are no well-defined parameters. Han and Goetz (2015, p. 133) note two approaches commonly used to measure regional economic resilience. "One examines

regional properties or characteristics that reflect economic resilience…The other approach …analyzes changes to a region's representative measure in response to a shock." The first approach is relevant to specific issue analysis (e.g. resource use, Matarrita-Cascante and Trejos, 2013; local knowledge networks, Crespo, Suire, and Vicente, 2014; and income equality, Augustine *et al*., 2013). This investigation is along the lines of the second approach in which employment is used as a representative measure (as in Martin, 2012 and Han and Goetz, 2015). Whereas Martin (2012) uses a sensitivity index to gauge the extent of employment loss in a region compared with the nation, Han and Goetz (2015) uses a "drop and rebound" measure the employment effect of a shock. Both reflect a strictly economistic measure.

This raises the second difficulty in measuring resilience where the measure adopted reflects an ontology specific to researchers' discipline training. In this investigation the measure exhibits an interdisciplinary ontology in which different discipline fields are used to identify appropriate epistemological tools (Miller *et al*, 2008). The discipline fields are regional development (spatial groupings), economics (industrial activity, income, and factor endowment), public policy (initiatives and incentives), and information systems (data mining and clustering algorithm). From the previous study by Courvisanos *et al*. (2016), this represents the complex reality of diverse regions in which self-organising and learning evolve based on different experiences across the vast number of functional regional groups and industries. As Han and Goetz (2015, p. 133) note, such diversity is crucial because: "Even if most counties [regions] experience economic recession, some local areas may grow even during a downturn and exhibit different economic patterns." The contribution of Courvisanos *et al*. (2016) is to recognise that, despite the one country study with homogenous laws and one socio-political system, each region has unique characteristics which define its economic development trajectory, emergence and resilience. The four functional groups of regions allows this diversity across 558 LGAs to be reflected in 19 industrial sectors.

METHODOLOGY

The methodological research paradigm adopted in this study is positivist. The strength of this paradigm is in exploring a terrain with a very large data set requiring deep data mining (Saunders *et al*, 2009). Based on a strong framework developed from the literature discussed in the previous section, this large quantitative study with a deductive approach is used to rigorously apply evolutionary theories and models in regional resilience to all LGA regions in Australia. With various adaptive resilience cycle patterns identified across the four functional groups, this positivist study, being an extension to Courvisanos *et al*. (2016) by double the data sets, opens the door for deep qualitative studies to understand the causal mechanisms that lie in the patterns (Elder-Vass, 2010).

Epistemological Approach

The epistemological approach taken to this study is not the standard hypotheses testing. The panarchy model has been well tested positively, as described in the literature reviewed in the previous section. The approach here is to use the panarchy model with functional groups of regions on an industry base as the conceptual framework, to which a data mining pattern matching algorithm (El-Ramly *et al*, 2002) is applied to identify configurations of resilience across Australian regions. These patterns are set alongside the BASE case of the national adaptive cycle model as the reference cycle.

In Australia over the period 1986-2011, there have been a number of major shocks that affected the national economy. Table 1 sets out the Australian economic history of his period and incorporates the panarchy adaptive cycle model as it relates to this economic history. In

this way a national adaptive cycle pattern is established as the reference cycle to the pattern-matching for every industry sector within the four functional regional groups. At the national level, when there is a strong economic boom, then an assumption is made that overall employment across all industries, as a proportion income, is high. This is labeled as 'H' in Table 1, and reflects the high income generation capability of the national economy at that economic historical period and its positive role in providing employment in the national economy. On the other hand, when there is an economic recession or severe economic downturn, then an assumption is made that overall employment across all industries, as a proportion income, is low. This is labelled as 'L' in Table 1, and reflects the low income generation capability of the national economy at that economic historical period and its negative role in providing employment in the national economy.

Table 1: Period 1986-2011 and General National Adaptive Cycle Model

Boom 1986 **H**	Release	*Recession* 1991 **L**	Reorgnisation	*Expansion* 1996 **H**	Exploitation	*Out of Downturn* 2001 **L**	Conservation	*Boom* 2006 **H**	Release	*Out of Downturn* 2011 **L**

In Table 1 by the 1986 Census the national economy had reached a strong economic boom identified as **H**, on the back of a "social wage" accord with the trade unions. Out of the late 1970s/early 1980s stagflation, there was a strong financial boom that a strong flow-on effect to the rest of the economy. This ended with the first shock – the "Black Tuesday" stock market crash of 20 October, 1987 (due to time zone difference, throughout the rest of the Western world it is called "Black Monday") – when 25 per cent of stock value was wiped out in one day (Sykes, 2012). Although short-lived, it sowed the seeds for "…a recession that lasted until the September quarter of 1991, over which period:

> …GDP [Gross Domestic Product] fell by 1.7 per cent, employment by 3.4 per cent and the unemployment rate rose to 10.8 per cent. Like all recessions, it was a period of disruption and economic distress. It was particularly deep in Victoria, where a disproportionate share of the financial failure occurred. Victorian employment fell by 8.5 per cent compared with a fall of 2.1 per cent for the rest of Australia. (Macfarlane, 2006a)

Thus, by the time of the August 1991 Census, the economy had been in recession for nearly a year, identified as **L** in Table 1. From the adaptive cycle perspective, the period between the 1986 and 1991 Census can be considered as the "release phase" in which the economy can be very susceptible (with low connectedness) to external forces in negatively disrupting the economy. With low resilience, Simmie and Martin (2010, p. 33) call 1986-1991 a "Period of decline and destruction".

When the 1996 Census came along, the economic narrative had moved on. There had been slow but rising economic growth from the low economic trough of 1991, right up to the next Census date, thus identified as **H** in Table 1. The economic reforms of the Hawke/Keating governments set the scene for major neoliberal economic restructuring of the Australian economy (privatisation, deregulation, labour market reforms and monetary stability), freeing up economic forces which during the 1990s allowed it take advantage of the growing economies of Asia, especially China, feeding their construction booms with Australian coal and steel exports (Macfarlane, 2006b). Thus, the period between the 1991 and 1996 Census, from the adaptive cycle perspective, can be considered as the "reorganisation phase" in which the economy is developing new connectedness and increasing resilience to negative external

forces while benefiting from growing networks. Simmie and Martin (2010, p. 33) call 1991-1996 a "Period of innovation and restructuring".

The Australian economy prospered strongly through the late 1990s, giving the period sustained growth (Macfarlane, 2006b). The first signs of financial stress in the global economy occurred in July 1997 with the Asian Financial Crisis (AFC) that was caused by credit bubbles in booming Asian "tiger" economies and fixed currency exchange rates (Delhaise, 1998). This was followed quickly with the global "dot.com" collapse in which most new start-up internet-based companies that had become overinflated in stock value crashed to zero. This collapse slowly began to undermine stock values in very late 1999, but reached its nadir with the 11 September 2001 New York/Pentagon attacks (Lowenstein, 2004). The August 2001 Census in Australia reflected the low point of the early 2000s global recession, most notably in the USA where most of the "action" took place. Australia itself avoided a recession, but encountered a low and slow growth in 2001, thus identified as **L** in Table 1, noting this point as the Australian economy in a significant but not deep downturn. The period between the 1996 and 2001 Census, from the adaptive cycle perspective, can be considered as the "exploitation phase" in which the economy, having develop strong connectedness and high resilience, maximised its growth potential, but with darkening clouds. Simmie and Martin (2010, p. 33) call 1996-2001 a "Period of growth and seizing of opportunities", but connectedness was now becoming low, with growing susceptibility to shocks.

Despite the 'gray clouds' amassing on the horizon, the Australian economy was being buoyed by massive commodity mining exports for the Chinese economic boom. The 2006 Census was held in the last full boom year before mid-2007 experiences of global bank failures (first was Northern Rock in UK) that led to the September 2009 Global Financial Crisis (GFC) implosion (Rohit, 2013). Census 2006 was also midway through a 13-year drought affecting the whole Australian rural economy, which is reflected in the first signs of a drought shock in rural communities (Horridge *et al*, 2005; Edwards *et al*, 2009). Thus, overall this Census in Table 1 is identified as H, the last boom the capitalist world, and Australia in particular, has experienced at the time of writing. The period between the 2001 and 2006 Census, from the adaptive cycle perspective, can be considered as the "conservation phase" in which the economy maintains its recently developed strong connectedness but with resilience declining from its 2001 peak. Resilience is lowering quickly with the normal drought cycle for the rural regions shifting into a major unfamiliar and unknowable continuing crisis for the whole economy and financial boom ready to be unravelled. Simmie and Martin (2010, p. 33) call 2001-2006 a "Period of stability and increasing rigidity" in systems that delivered strong prior growth.

By the time of the next Census in 2011 the world had turned, and the Australian economy consequently faced serious 'stormy headwinds'. In early 2010 the 13-year drought ended with severe floods across the Eastern seaboard (Courvisanos and Richardson, 2011). This shock slowly accumulated over the years as the extent of the drought intensified and transferring more effects to first to regional cities, and then to periphery and core metropolitan regions. The other major national shock was the short sharp GFC shock in late 2009, which saw revival by mid-2010 unto a subdued growth trajectory into 2012 (Courvisanos, 2012, p. 84 Figure 3.2). As noted in Courvisanos *et al*. (2016, p. 633):

> The GFC in macroeconomic quantitative terms was negotiated quickly and effectively so that economic activity could resume, but it had major structural change as some industries and regions were particularly heavily affected, such that many firms (especially in regional and rural communities) folded and some industries (especially manufacturing and tourism) suffered significant declines in activity through into 2011 (Stimson, 2011, p. 38).

The 2011 Census reflected the lowest point of an economic business cycle since the early 1990 recession. Australia avoided "The Great Recession" encountered by the rest of the developed capitalist economies (Rohit, 2013), but slow overall growth entailed through to the present. Thus, Table 1 has identified as **L** the 2011 Census, noting this point as the Australian economy coming out of a deep downturn. The period between the 2006 and 2011 Census, from the adaptive cycle perspective, can be considered as another "release phase" in which the economy from a boom, became highly susceptible (with low connectedness) to external forces (drought and GFC) in negatively disrupting the economy. With low resilience, Simmie and Martin (2010, p. 33) call 2006-2011 a "Period of decline and destruction".

Method and Data Analysis

Having set out the national adaptive cycle in Table 1 as the reference to pattern-matching, the research question can be restated for data analysis as: How resilient have the 19 industries within the four functional groups of regions in Australia been to the shocks encountered since the 1986 Census as outlined above in Table 1?

Data mining is the general method adopted in this study. It facilitates the identification of useful information within data reservoirs and involves the application of discovery algorithms to the data. Cluster analysis (or "clustering") is an important data mining tool with a process of pattern recognition which simplifies understanding of large data sets (Mardaneh, 2012). Clustering is the task of assigning a set of objects into groups (called clusters) so that objects in the same cluster are more similar (in some sense or another) to each other than to those in other clusters (Bagirov, 2008). Cluster analysis is used by contemporary researchers when the number of observations is very large, comprising a myriad of economic and social variables (Freestone *et al*, 2003).

Cluster analysis, although developed as a data mining tool in information technology, it has also been used in other disciplines like marketing (Schaninger et al., 1980). Different algorithms can be used for cluster analysis, including the k-means algorithm. The k-means algorithm has only recently been used in regional studies (Mardaneh, 2012). It considers each sample (LGAs in this study) in a dataset as a point in n-dimensional space (nR) and chooses k centres (also called Centroids) and assigns each point to the cluster nearest the centre. The centre is the average of all the points in the cluster; i.e. its coordinates are the arithmetic mean for each dimension separately over all the points in the cluster. This algorithm is sensitive to the choice of starting points. These points can converge on local minima and these local minima may be significantly different from global solutions as the number of clusters increases (Bagirov, 2008; Bagirov and Mardaneh, 2006).

Using the *k*-means clustering algorithm, this study addresses the gap in understanding the combined role of location, industry structure, and income level in the longitudinal analysis of the economic resilience of Australian regions. Data for this study is obtained from the six consecutive ABS *Census of Population and Housing* 1986, 1991, 1996, 2001, 2006 and 2011 (data from the recently conducted 2016 Census was not available as at the time of writing). This Census data was sourced as industry of employment (19 categories) and individual weekly income (12 categories). National Economics (2013) *State of the Regions Report* classifies LGAs under different regions as dispersed metro, independent city, knowledge base, lifestyle, resourced based, rural. Using these regions with an index of LGAs, each LGA was allocated into one of four functional groups as per National Economics (2002) categories: Metro-Core, Metro-Periphery, Regional Cities, and Rural. This study clusters the data using the k-means clustering algorithm to examine in combination location, income levels, and industry categories for economic resilience of each LGA within the four functional groups.

The study examines whether (for example) people earning relatively high incomes are associated with any particular industries within LGAs of the specified four functional groups.

Across the six census data periods, individual weekly income is used as a proxy for economic activity. In this paper, same as in Courvisanos *et al*. (2016, p. 634):

> Income was initially used to separate LGAs into high and low-income LGAs and not to indicate resilience. To indicate resilience, the study linked the 'income level' with the industries present in a particular LGA and the employment proportion change across the three census data periods.

Table 2: Percentage of People within Income Categories in each Functional Group: 1986-2011

Functional Group	Median for Percentage of People within the Income Category			Number of People with the Income Category		
Income Category			**$1,000 - $1,499**			
Census Year	**1986**	**1991**	**1996**	**1986**	**1991**	**1996**
Metro-Core	98.3	4.7	7.8	2,465,389	120,145	215,623
Metro-Periphery	99.2	2.8	5.1	1,656.686	67,726	128,882
Regional Cities	99.0	2.3	4.8	740,572	27,386	50,210
Rural Areas	98.8	1.9	3.5	1,345,878	43,843	78,434
Income Category			**$1,500 and More**			
Census Year	**1986**	**1991**	**1996**	**1986**	**1991**	**1996**
Metro-Core	1.7	2.5	3.5	52,983	78,643	124,839
Metro-Periphery	0.8	0.9	1.3	22,956	33,971	53,780
Regional Cities	1.0	1.2	4.8	7,699	10,257	17,301
Rural Areas	1.2	1.1	1.8	18,329	22,364	37,781
Income Category			**$1,000 - $1,999**			
Census Year	**2001**	**2006**	**2011**	**2001**	**2006**	**2011**
Metro-Core	8.3	16.9	21.8	4,948	10,833	15,300
Metro-Periphery	6.4	15.0	21.4	5,173	11,990	19,368
Regional Cities	5.8	12.5	18.0	2,736	5,855	9,283
Rural Areas	4.4	9.8	15.3	545	896	1,657
Income Category			**$1,499 and More**			
Census Year	**2001**	**2006**	**2011**	**2001**	**2006**	**2011**
Metro-Core	4.6	4.7	7.9	3,462	3,386	6,096
Metro-Periphery	2.1	2.3	4.8	2,474	2,334	4,979
Regional Cities	2.0	1.8	3.7	1,043	978	2,264
Rural Areas	2.0	1.5	3.1	283	158	446

ANALYSIS OF THE RESULTS

With the clustering method and accompanying data sets developed, this section undertakes an analysis of the results by the four functional regional groups. Initially, Table 2 on the previous page shows the percentage of people within income categories in each of the four functional groups of regions over the six Census periods. For example, in the Metro-Core LGAs of the 1996 Census, the medians of people within income levels 'AU$1000-$1499' and 'AU$1500 and over' are 7.8% and 3.5% respectively, whereas in the Metro-Periphery LGAs this same two income groupings medians are 5.1% and 1.3% respectively.

Table 3 indicates that for the Metro-Core in the 1996 Census, six industries show higher employment proportion within a high cluster. All these industries have lower employment proportions within a low cluster. As opposed to this, for the Metro-Periphery in the same 1996 Census (Table 4) there are only four 'higher' industries with a high employment proportion in a high cluster. For the Metro-Core (Table 3), the 'higher' industries are Information Media; Finance; Rental, Hiring and Real Estate Services; Professional, Scientific and Technical Services; Education and Training; and Health Care and Social Assistance Services. For the Metro-Periphery (Table 4), the 'higher' industries are Information Media; Finance; Professional, Scientific and Technical Services; and Education and Training. In the 1996 Census pattern, there are some similarities and differences between the Metro-Core and Metro-Periphery functional regional groups regarding employment proportion of industries in their LGAs, as evidenced when comparing Tables 3 and 4. Professional, Scientific and Technical Services have a high employment proportion within a high cluster in both regional groups; magnitude of which being higher in the Metro-Core as opposed to the Metro-Periphery. In contrast, Manufacturing, in both regional groups have a significantly higher level of employment proportion within a low cluster.

Table 3: Employment Level of Industries Within, Above and Below Median Income Clusters: Metro-Core LGAs, 1996

Industry	Cluster Category		Test of Independence	
	1	2		
	Cluster Centroids		*t*	*Df*
Higher Industries (given their high employment proportion in above median income cluster)				
Information Media and Telecommunications	3.9	2.8	4.1	50.7***
Financial and Insurance Services	5.8	4.4	4.0	65.8***
Rental Hiring and Real Estate Services	2.2	1.5	4.3	69.2***
Professional, Scientific and Technical Services	12.4	6.3	10.2	68.4***
Education and Training	9.6	7.6	3.8	68.6***
Health Care and Social Assistance	12.4	10.7	2.7	68.9**
Lower Industries (given their high employment proportion in below median income cluster)				
Manufacturing	7.5	13.1	-7.0	50.7***
Electricity, Gas, Water and Waste Services	0.5	0.7	-3.7	65.6***
Construction	4.1	6.3	-5.9	70.9***
Retail Trade	9.1	10.3	-4.8	67.7***
Transport Postal and Warehousing	3.4	4.9	-4.2	69.4***
Public Administration and Safety	5.6	7.0	-2.1	66.4*
Other Services	3.8	4.8	-7.2	70.6***
Non-separable Industries (non-significant difference employment proportion in either above or below median income clusters)				
Mining	0.6	0.5	1.0	63.5
Accommodation and Food Services	7.0	6.5	1.4	69.7
Administrative and Support Services	3.4	3.2	1.7	70.8
Arts and Recreation Services	2.1	1.8	1.7	70.7
Agriculture, Forestry and Fishing	0.6	1.1	-1.6	38.8
Wholesale Trade	5.4	5.7	-1.2	70.9

Table 4: Employment Level of Industries Within, Above and Below Median Income Clusters: Metro-Periphery, 1996

Industry	Cluster Category		Test of Independence	
	1	2		
	Cluster Centroids		*t*	*Df*
Higher Industries (given their high employment proportion in above median income cluster)				
Information Media and Telecommunications	2.6	2.1	3.5	33.3***
Financial and Insurance Services	4.5	3.6	2.5	33.6*
Professional, Scientific and Technical Services	7.0	4.5	5.0	21.8***
Education and Training	8.1	5.8	5.4	27.5***
Lower Industries (given their high employment proportion in below median income cluster)				
Manufacturing	13.3	17.5	-3.2	42.3**
Electricity, Gas, Water and Waste Services	0.8	0.9	-2.1	43.0**
Transport Postal and Warehousing	4.6	6.0	-3.5	31.6***
Administrative and Support Services	2.8	3.1	-2.1	43.0*
Non-separable Industries (non-significant difference employment proportion in either above or below median income clusters)				
Construction	7.4	7.2	0.5	38.8
Wholesale Trade	6.9	6.8	0.2	35.3
Rental Hiring and Real Estate Services	1.6	1.4	1.7	31.9
Health Care and Social Assistance	9.4	8.9	1.0	41.8
Arts and Recreation Services	1.4	1.3	0.9	41.2
Agriculture, Forestry and Fishing	1.5	1.7	-0.3	43.6
Mining	0.6	0.7	-0.2	34.5
Retail Trade	11.0	11.1	-0.4	28.6
Accommodation and Food Services	5.1	5.3	-0.7	32.9
Public Administration and Safety	5.5	6.1	-1.3	40.6
Other Services	4.9	5.1	-1.1	41.4

From Table 2, Regional Cities in 1996 have medians of people within both income levels 'AU$1000–1499' and 'AU$1500 and over' are 4.8%. For the same 1996 Census, Table 5 indicates that the Regional Cities have four industries with a higher employment proportion, of which all industries have a significantly higher level of employment within a high cluster. These are Mining; Construction; Professional, Scientific and Technical Services; and Administrative and Support Services.

For Rural in 1996 (Table 2), the medians of people within income levels of 'AU$1000-$1499' and 'AU$1500 and over' are 3.5% and 1.8% respectively. For the same 1996 Census, Table 6 indicates that the Rural includes three industries with higher employment proportion, of which all industries have a significantly higher level of employment within a high cluster. These are Mining; Construction; Public Administration and Safety Services. For Rural, the magnitude of the employment in Public Administration and Safety Services within a high cluster is much stronger than Construction.

Overall, a decrease in the median for the percentage of people within the income categories from 1986 to 2011 is clearly evident progressing down the list of the four functional groups by industry in Table 2, from Metro-Core (highest) to Rural (lowest), particularly for 1991 and 1996. The Appendix with the supplementary data presents a detailed summary over the six census data sets of the average employment proportion within high and low clusters for each industry, as they apply across the four functional regional groupings. In the Appendix, the first set of census date columns indicate the average of employment proportions under high and low clusters obtained from Tables 3 to 6 (for 1996 data), and similar data calculations for the other five Census data sets. For example, for the Mining industry in 1996 (as evident in Table 6) the employment proportion in the high cluster for the Rural LGAs is 6.5, while in the

low cluster it is 0.8; thus the 1996 average of the two cluster centroids is 3.6 (as evident in the Appendix table). This average figure provides an indication of the proportion of economic activity and employment under each industry and their respective functional groups across the six census data periods. The second set of census date columns in the Appendix table labels each industry/functional region group with '**H**' when the industry is located in the 'higher' industries section of Tables 3–6 (for 1996) and with '**L**' when the industry is located in the 'lower' industries section. This labelling is also conducted for the remaining five Census data sets to produce the H and L contributions to income across the 76 functional regional groups.

Table 5: Employment Level of Industries Within, Above and Below Median Income Clusters: Regional LGAs, 1996

Industry	Cluster Category		Test of Independence	
	1	2		
	Cluster Centroids		*t*	*Df*
Higher Industries (given their high employment proportion in above median income cluster)				
Mining	5.5	0.4	2.8	11.1*
Construction	7.8	6.5	1.9	16.8*
Professional, Scientific and Technical Services	4.3	3.4	2.8	13.3*
Administrative and Support Services	2.6	2.2	3.2	24.9**
Lower Industries (given their high employment proportion in below median income cluster)				
Agriculture, Forestry and Fishing	1.8	6.1	-3.8	26.4***
Information Media and Telecommunications	1.8	2.2	-1.8	28.7*
Non-separable Industries (non-significant difference employment proportion in either above or below median income clusters)				
Electricity, Gas, Water and Waste Services	1.3	1.0	1.7	20.0
Transport Postal and Warehousing	4.5	4.3	0.5	27.4
Rental Hiring and Real Estate Services	1.6	1.5	0.6	23.3
Manufacturing	13.1	13.3	-0.1	20.1
Wholesale Trade	5.0	5.1	-0.3	26.1
Retail Trade	12.0	12.8	-1.4	22.0
Accommodation and Food Services	7.2	7.3	-0.1	28.3
Financial and Insurance Services	2.5	2.6	-0.2	17.2
Public Administration and Safety	4.8	5.2	-0.5	26.2
Education and Training	7.6	8.2	-1.2	23.2
Health Care and Social Assistance	10.2	11.2	-1.5	21.0
Arts and Recreation Services	1.0	1.1	-0.5	26.3
Other Services	4.7	4.8	-0.7	28.8

PATTERNS OF RESILIENCE

Based on the analysis of census data sets presented in the previous section, an appreciation of resilience pathways of industries in LGAs within the four functional regional groups can now be made based on the four phase adaptive cycle resilience model (as per Simmie and Martin, of the functional group of regions and their industries in the context of the shocks to the national economy as set out in Table 1. The Appendix is used to conduct this analysis in the second set of census date columns. Functional groups and the industries with a higher employment proportion within an above median income cluster (of LGAs) are marked as '**H**' for a high cluster and the ones with a higher employment proportion within a below-median income cluster (of LGAs) are marked as '**L**' for low clusters. Four functional groups of regions with 19 industry sectors for each grouping create a total of 76 functional regional groups and their relevant industries, which make up this analysis. Based on the Appendix, Table 7 summarises the six combinations of contributions across the six periods (1986 to 2011) that are observed. These combination patterns can be interpreted using the four-phase model:

Table 6: Employment Level of Industries Within, Above and Below Median Income Clusters: Rural LGAs, 1996

Industry	Cluster Category		Test of Independence	
	1	2		
	Cluster Centroids		*t*	*Df*
Higher Industries (given their high employment proportion in above median income cluster)				
Mining	6.5	0.8	6.0	98.1***
Construction	5.7	5.0	1.9	144.1*
Public Administration and Safety	7.0	5.3	2.9	110.9**
Lower Industries (given their high employment proportion in below median income cluster)				
Manufacturing	6.1	8.3	-3.2	191.7***
Wholesale Trade	3.5	4.0	-2.5	174.9*
Retail Trade	7.0	8.7	-4.7	182.5***
Financial and Insurance Services	1.4	1.7	-3.1	150.3**
Health Care and Social Assistance	6.9	8.3	-3.0	171.2**
Other Services	2.7	3.4	-4.8	162.5***
Non-separable Industries (non-significant difference employment proportion in either above or below median income clusters)				
Accommodation and Food Services	6.0	5.8	0.5	147.4
Transport Postal and Warehousing	4.0	3.9	0.4	143.9
Rental Hiring and Real Estate Services	0.8	0.7	0.1	167.4
Professional, Scientific and Technical Services	2.4	2.3	0.8	146.0
Administrative and Support Services	1.6	1.4	1.7	146.9
Agriculture, Forestry and Fishing	28.1	29.4	-0.5	156.3
Electricity, Gas, Water and Waste Services	0.9	1.0	-0.4	148.7
Information Media and Telecommunications	1.0	1.1	-1.1	159.6
Education and Training	6.9	7.3	-1.7	172.5
Arts and Recreation Services	0.6	0.7	-0.7	173.3

- Functional groups of regions and industries almost match the national economic pattern observed throughout the six periods as per Table 1. Also, the almost reverse of this pattern and labelled as ‘close to base’ and ‘close to reverse of base’ have only one each industry/functional group that exhibits such patterns.
- Functional groups of regions and industries which present high level of stability despite the economic shocks and are labelled as ‘stable high’ (SH1, SH2 and SH3). Twenty industry/functional groups of regions exhibit such patterns.
- Functional groups of regions and industries which present degrees of resilience (these are labelled resilient, very resilient, strongly resilient). Only five industry/ functional group of regions exhibit such patterns, all five were affected by the 1991 recession with an ‘**L**’.
- Functional groups of regions and industries which present low resilience with different levels. These are called low resilient with four slightly different patterns labelled LR1 to LR3. Eleven industry/functional group of regions exhibit such patterns. All these 11 regions had difficulty emerging from the 1996 recession, till remaining as ‘**L**’ in 1996 Census.
- Functional groups of regions and industries which are ‘non-resilient’ (NR). These are labelled non-resilient NR1 to NR 3. Sixteen industry/functional group of regions exhibit such patterns. All these 16 regions still remained in ‘**L**’ through both the 1996 and 2001 Census.

Table 7: Summary Patterns of Resilience based on Appendix

Rank		1986	1991	1996	2001	2006	2011	Industry/ Functional Region Patterns	Colouring/marking in the Appendix
1	BASE	H	L	H	L	H	L	0	
2	Closest to BASE	H	H	H	L	H	L	1	*Italic & Underlined*
3	REVERSE OF BASE	L	H	L	H	L	H	0	
4	Close to REVERSE OF BASE	H	L	L	H	H	L	1	Grey
1	SH1 (stable high 1)	H	H	H	H	H	H	14	Green
2	SH2 (stable high 2)	H	H	H	H	H	L	4	Brown
3	SH3 (stable high 3)	L	H	H	H	H	H	2	**Bold**
1	Strongly resilient	H	L	H	H	H	H	1	Light blue
2	Very resilient	L	L	H	H	H	H	2	Dark blue
3	Resilient	H	L	L	H	H	H	2	Lightest blue
1	LR1 (low resilient 1)	H	L	L	L	H	L	3	*White italic*
2	LR2A (low resilient 2)	L	L	L	L	H	H	3	***Bold & Italic***
3	LR2B (low resilient 2)	L	L	L	L	H	L	4	Purple
4	LR3 (low resilient 3)	L	H	L	L	L	L	1	Light pink
1	NR1 (non-resilient 1)	H	H	L	L	L	L	1	Light yellow
2	NR2 (non-resilient 2)	H	L	L	L	L	L	2	Orange
3	NR3 (non-resilient 3)	L	L	L	L	L	L	13	Red
1	Cannot discuss with two NAs	NA	NA	-	-	-	-	8	Not coloured/marked
1	Irregular patterns	-	-	-	-	-	-	14	Identified 'IR'

- Functional groups of regions and industries which do not have data available for the 1986 and 1991 census are labelled as 'NA' in the table. Due to the data not being available for the periods mentioned, it is not possible to identify any meaningful pattern or draw any conclusions. Eight industry/functional group of regions are in this category.
- Functional groups of regions and industries which present patchy patterns. These are labelled as 'Irregular' regions (IR). These regions have irregular patterns that cannot at this stage of the research be identified in any consistent approach. Fourteen industry/functional group of regions s exhibit such irregular patterns.

DISCUSSION

The pattern and distribution of industrial resilience identified provides an insight into the resilience of functional regions where these industries operate. Strong innovation allows industries to remain resilient and withstand both endogenous and exogenous shocks with impunity. Functional groups where such innovation is lacking demonstrate low resilience as evidenced by clusters with many '**L**' periods identified. This lack of innovation is more prevalent in the Rural functional groups overall.

Preliminary evaluation of the data demonstrates that the overall aggregate relationship of all industry/functional groups with **H** and **L** clusters follows the national economic cycle (base) as set out in Table 1. To start off with the 1986 data, during the economic boom of 1986 there were 29**H** and 25**L** clusters (as can be seen by adding up for 1986 vertically all the **H** and L across the number on industry/functional regional groups in Table 7). This was followed by a recession in 1991, reflected by the increase to 31**L** clusters (+6) and a decrease to 23**H** (-2) clusters. Thus, the number of total **H** clusters was now less than the **L** clusters compared to 1986. This recession was followed in 1996 by a slow upswing in the economy from the deep 1991 trough, resulting in equal **H** and **L** clusters of 30 each (+7**H** and -1**L**). In fact, the 1996, 2001 and 2006 Census dates were characterised by continued upswing in economy. This is exhibited by an increase in **H** clusters to 34 in 2001 (+4) and then to 37 in 2006 (+3). This was accompanied by no reduction in the **L** clusters in 2001 due to a weak downturn after the dot.com collapse to 30 (no change), but then as the boom built strongly there was a reduction in L clusters to 25 (-5). The GFC followed in 2008-9 resulting in a severe global downturn, to be followed by a gradual weak upturn resulting in 25**H** (-12) and 38**L** (+13) clusters in 2011 (compared to 2006). From the national pattern, economic recovery is associated with a gradual increase in **H** clusters, with the number of **H** clusters outnumbering **L** clusters in boom times.

Despite the positive association between the national economic cycle and the number of clusters in **H** and **L** as set out in the previous paragraph, there is no single industry/functional group that mirrors the national average. The cluster of Accommodation & Food Services in the Metro-Core region is the closest to this cycle, with the only aberration being that it has an **H** cluster in 1991 as opposed to the national **L**, which would have reflected the national economic cycle. Accommodation & Food Services at Metro is a significant industry sector that closely tracks the national business cycle due to the high level of discretionary spending involved in this sector (Courvisanos, 1996), particularly in Metro areas of Australia that attract large number of tourists and locals who eat out great deal. There is also no industry/functional group that is exact opposite to the national cycle (or reverse of base national). The industry/functional group of Arts & Recreational Services in the Regional Cities is the closest to this reverse of base cycle, with reversal of the expected cluster category in 1986 and 1991 from **L**/**H** to **H**/**L**; and an additional **H** rating in 2001 instead of **L**. This

indicates the relatively small arts sector in Australia has artistic and cultural dimensions that drive the industry, especially in Regional Cities away from the major cultural centres.

Functional clusters that are stable independent of the economic cycle include Mining in the Metro-Core, Regional and Rural regions; Construction in the Metro-Periphery, Regional and Rural regions; Wholesale Trade, Health Care & Social Assistance, Financial & Insurance Services, Arts & Recreational Services, and Education &Training in the Metro-Core and Metro-Periphery regions; Rental Hiring & Real Estate in Metro-Core, Metro-periphery and Regional Cities; Public Administration in Regional Cities. It is clear that the majority of these functional groups are in the Metro-Core (7) and Metro-Periphery (7) regions. These industry

and functional groups demonstrated sustained 'shockproof' resilience over the study period, weathering the boom/bust cycle of the national economy due to their innovation (Education &Training) or alternatively because their products/services are essential (e.g. Health Care & Social Assistance in the Metro-Core and Metro-Periphery regions). It is also not unexpected that these industry clusters which require a higher proportion of the creative classes (Florida, 2002), access to finances, major transport and government support thrive in Metro areas. This is also in keeping with nearly 90 per cent of the population residing in Metro-Core and Metro-Periphery regions (Courvisanos et al., 2016).

At the same time it is important to review the functional groups that demonstrate this level of sustainability in the Regional and Rural Areas: Mining and Construction, both presumably on the back of the sustained demand for commodities from China and the accompanying mining boom. Similarly in Regional Cities, Rental Hiring & Real Estate and Public Administration are perhaps sustained due to decentralisation by government transfer of services to these sites, for example the Australian Taxation Office to Albury.

Other resilient patterns can be noted. Accommodation & Food Services in Rural regions is strongly resilient; Information Media & Telecommunications in Metro-Core areas as well as Rental Hiring & Real Estate Services in Regional Cities are considered resilient, with Financial & Insurance Services and Information Media & Telecommunications both in Regional Cities being resilient in this model. Resilient Information Technology in Metro and Regional Cities reflects the new information economy at the centre of major cities (Zagler, 2002), while financial services in major regional centres and tourism-based activity in rural areas provide strategic areas for regional development activity (Courvisanos, 2012, pp. 224-50).

The functional groups that demonstrate low resilience include LR1: Electricity Gas Water & Waste Services in Metro-Periphery, Wholesale Trade and Education & Training in Regional Cities; LR2: Retail Trade in Metro-Periphery and Rural, Financial & Insurance Services, Manufacturing, Education & Training in Rural, Public Administration & Safety in Metro-Periphery, and, Accommodation & Food Services in Regional Cities. It is of note that no Metro-Core appear in this list, while the Regional Cities and Rural dominate these low resilience clusters; importantly noting that most of these Regional/Rural industry clusters rely on a critical mass of population for resilience, a resource in scarcity in these regions. The functional groups in this low resilience grouping from Metro-Periphery are likely to be due to weak spillover effects from linked industries from Metro-Core.

For obvious reasons, Agriculture, Forestry & Fishing are non-resilient in Metro-Core, Metro-Periphery and Regional Cities. Surprisingly Public Administration & Safety in Metro-Core was also non-resilient. The non-resilience of manufacturing in Metro-Core, Metro-Periphery and Regional Cities is no surprise given the weak nature of manufacturing across the whole Australian Economy (Lim et al., 2014). Other functional groups with this non-resilient result

include Electricity Gas Water & Sanitation, and Construction in Metro-Core; Retail trade in Metro-Core and Regional Cities; Transport, Postal & Warehousing in Metro-Core and Metro-Periphery; Health Care & Social Assistance in Regional Cities and Rural; and Other Services in Metro-Core. Most of these functional groups are in the Metro-Core areas suggesting that Metro-Core has extremes of clusters, i.e. a higher proportion of stable high as well as non-resilient Clusters as opposed to other regions.

The industrial clusters of Professional Scientific & Technical Services and Administrative and Support Services have incomplete data, therefore could not be evaluated. The other industrial groups had patchy irregular resilience patterns that defy classification into any of the categories described above at this stage of the research.

CONCLUSION

This discussion makes it clear that first, there is no industry group that demonstrates stable high resilience for all functional groups through this period. Second, Metro-Core regions have extremes of resilience clusters: stable high and non-resilient; more than any other functional region. Third, industry/functional groups with low resilience are commonest in the Rural regions followed by Regional Cities. Fourth, Mining, Rental Hiring & Real Estate Services, Education & Training, Health Care & Social Assistance, and Arts & Recreational Services have the highest resilience across all regions. Fifth, Manufacturing and Transport Postal & Warehousing demonstrate lower resilience, both of which go hand-in-hand. Sixth, there was a stark disparity between the Health Care & Social Assistance services resilience, and by proxy availability, in Metro-Core and Metro-Periphery as opposed to Regional Cities and Rural. Seventh, Regional Cities demonstrate much higher resilience in Public Administration & Safety most likely due to shifting of State and Federal government services to Regional Cities as part of their decentralisation activities.

The insights produced from this research study potentially permits more accurate allocation of resources by all levels of government to try and invest in industry groups in appropriate functional regions to ensure ongoing resilience of the economy. A national (in this case Australian) economy is only as resilient as the industry-based functional regions within that country. Each industry/functional group is an economy itself, with its own resilient properties. Further implications for public policy need to be carefully thought through and presented in a coherent manner which is practical and possible to ensure best long term outcomes.

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Appendix: Detailed Summary of the Average Employment Proportion within High and Low Clusters (1986-2011)

Industry	Functional Group	Average % of categories 1 & 2						High (H); Low (L) contribution to the income						Irregulars
		1986	1991	1996	2001	2006	2011	1986	1991	1996	2001	2006	2011	
Agriculture, Forestry and Fishing	Metro-Core	0.9	0.8	0.8	2.3	0.7	0.5	L	L	L	L	L	L	
	Metro-periphery	2.0	1.6	1.6	2.1	0.3	1.1	H	H	L	L	L	L	
	Regional	5.7	4.3	4.0	4.0	1.3	2.3	H	L	L	L	L	L	
	Rural	35.5	31.4	28.7	23.6	9.8	18.6	H	H	L	L	H	L	IR
Mining	Metro-Core	0.9	0.5	0.5	0.7	0.5	1.6	H	H	H	H	H	H	
	Metro-periphery	0.6	0.6	0.6	0.6	0.5	1.6	L	H	L	L	H	H	IR
	Regional	3.5	4.0	2.9	4.0	1.5	4.5	H	H	H	H	H	H	
	Rural	2.4	2.7	3.6	4.2	2.0	6.0	H	H	H	H	H	H	
Manufacturing	Metro-Core	15.0	12.6	10.3	9.4	3.6	6.4	L	L	L	L	L	L	
	Metro-periphery	18.5	16.9	15.4	14.5	6.0	10.7	L	L	L	L	L	L	
	Regional	15.1	14.2	13.2	11.8	4.6	9.5	L	L	L	L	L	L	
	Rural	6.5	6.7	7.2	6.8	3.0	6.1	L	L	L	L	H	L	
Electricity, Gas, Water and Waste Services	Metro-Core	1.7	1.1	0.6	0.8	0.4	1.0	L	L	L	L	L	L	
	Metro-periphery	1.8	1.2	0.8	0.9	0.4	1.2	*H*	*L*	*L*	*L*	*H*	*L*	
	Regional	2.4	1.7	1.1	1.4	0.6	1.5	H	H	H	H	H	L	
	Rural	1.5	1.3	0.9	1.0	0.4	1.1	L	L	L	H	H	H	IR
Construction	Metro-Core	5.7	5.1	5.3	5.1	2.8	6.4	L	L	L	L	L	L	
	Metro-periphery	7.6	7.1	7.4	7.4	4.1	9.6	H	H	H	H	H	H	
	Regional	7.3	6.8	7.1	7.0	3.6	8.5	L	H	H	H	H	H	
	Rural	5.4	4.9	5.3	5.7	2.7	7.1	L	H	H	H	H	H	
Wholesale Trade	Metro-Core	6.5	6.5	5.5	4.6	2.1	4.0	H	L	L	L	H	H	IR
	Metro-periphery	6.7	7.4	6.8	5.9	2.4	4.7	H	H	H	H	H	L	
	Regional	4.8	5.4	5.0	4.5	1.45	2.9	*H*	*L*	*L*	*L*	*H*	*L*	
	Rural	3.4	3.8	3.7	3.6	1.2	2.4	*L*	*L*	*L*	*L*	*H*	*H*	
Retail Trade	Metro-Core	13.1	12.9	9.7	9.7	4.7	9.0	L	L	L	L	L	L	
	Metro-periphery	15.1	15.2	11.0	11.5	5.5	10.8	L	L	L	L	H	L	
	Regional	16.5	16.4	12.4	12.7	5.6	11.8	L	L	L	L	L	L	
	Rural	10.6	10.5	7.8	7.8	3.7	8.0	L	L	L	L	H	L	
Accommodation and Food Services	Metro-Core	3.8	4.7	6.7	7.0	3.2	6.9	*H*	*H*	*H*	*L*	*H*	*L*	
	Metro-periphery	2.3	3.0	5.2	5.4	2.5	5.4	H	H	L	L	H	L	IR
	Regional	3.8	4.8	7.2	7.2	2.9	7.0	L	H	L	L	L	L	
	Rural	3.8	4.5	5.9	5.8	2.6	6.1	H	L	H	H	H	H	

Transport, Postal and Warehousing	Metro-Core	5.0	4.5	4.1	4.0	1.8	3.7	L	L	L	L	L	L	
	Metro-periphery	6.0	5.3	5.3	5.3	2.6	5.5	L	L	L	L	L	L	
	Regional	5.4	4.5	4.4	4.3	1.9	4.4	H	H	H	H	H	H	
	Rural	4.3	3.7	3.9	4.0	1.8	4.3	L	L	H	L	H	H	IR
Information Media and Telecommunications	Metro-Core	2.1	1.7	3.3	3.4	1.4	2.7	**L**	**L**	**H**	**H**	**H**	**H**	
	Metro-periphery	2.2	0.8	2.3	2.3	0.4	1.6	L	L	H	H	H	L	IR
	Regional	1.8	1.3	2.0	1.6	0.6	1.1	H	L	L	H	H	H	
	Rural	1.6	1.1	1.0	0.9	0.3	0.5	L	L	L	H	H	H	IR
Financial and Insurance Services	Metro-Core	5.7	6.0	5.1	5.0	2.7	5.5	H	H	H	H	H	H	
	Metro-periphery	4.9	5.0	4.0	3.7	1.8	3.5	H	H	H	H	H	L	
	Regional	3.2	3.1	2.5	2.3	1.0	2.1	H	L	L	H	H	H	
	Rural	1.9	2.0	1.5	1.2	0.5	1.1	*L*	*L*	*L*	*L*	*H*	*H*	
Rental, Hiring and Real Estate Services	Metro-Core	9.3	11.1	1.8	2.1	1.0	1.9	H	H	H	H	H	H	
	Metro-periphery	6.4	7.5	1.5	1.7	0.8	1.6	H	H	H	H	H	H	
	Regional	4.4	5.5	1.5	1.5	0.7	1.4	H	H	H	H	H	H	
	Rural	2.4	3.0	0.7	0.9	0.4	0.8	**L**	**L**	**H**	**H**	**H**	**H**	
Professional, Scientific and Technical Services	Metro-Core	NA	NA	9.3	10.0	5.0	11.4	NA	NA	H	H	H	H	
	Metro-periphery	NA	NA	5.7	5.9	2.9	6.6	NA	NA	H	H	H	H	
	Regional	NA	NA	3.8	4.0	1.7	4.2	NA	NA	H	H	H	H	
	Rural	NA	NA	2.3	2.5	1.0	2.5	NA	NA	H	H	H	H	
Administrative and Support Services	Metro-Core	NA	NA	3.3	3.7	1.6	3.4	NA	NA	H	H	H	H	
	Metro-periphery	NA	NA	2.9	3.4	1.6	3.2	NA	NA	L	L	L	L	
	Regional	NA	NA	2.4	3.2	1.2	3.1	NA	NA	H	H	H	H	
	Rural	NA	NA	1.5	2.1	0.9	2.2	NA	NA	H	H	H	L	
Public Administration and Safety	Metro-Core	5.5	5.6	6.3	5.8	1.7	6.9	H	L	L	L	L	L	
	Metro-periphery	5.7	5.6	5.8	5.3	3.0	6.4	*L*	*L*	*L*	*L*	*H*	*H*	
	Regional	4.8	4.7	5.0	6.0	3.0	7.2	L	H	L	H	H	H	IR
	Rural	4.9	5.2	6.1	9.3	5.1	8.6	H	H	H	L	L	L	IR
Education and Training	Metro-Core	7.5	7.9	8.6	8.3	4.0	8.7	H	H	H	H	H	H	
	Metro-periphery	6.4	6.7	6.9	7.2	3.6	7.9	H	H	H	H	H	H	
	Regional	7.1	7.3	7.9	7.8	3.4	8.1	*H*	*L*	*L*	*L*	*H*	*L*	
	Rural	6.0	6.8	7.1	6.9	3.3	8.1	L	L	L	L	H	L	
Health Care and Social Assistance	Metro-Core	11.0	11.6	11.5	10.5	5.3	11.7	H	H	H	H	H	L	
	Metro-periphery	8.0	8.6	9.1	9.2	4.9	11.1	H	H	H	H	H	H	
	Regional	9.2	9.9	10.7	10.6	5.0	12.9	L	L	L	L	L	L	
	Rural	6.0	6.9	7.6	7.4	3.8	9.2	L	L	L	L	L	L	
Arts and Recreation Services	Metro-Core	2.5	2.6	1.9	1.8	0.8	2.0	H	H	H	H	H	H	
	Metro-periphery	1.6	4.6	1.3	1.3	0.6	1.4	H	H	H	H	H	H	
	Regional	1.3	1.5	1.0	1.1	0.4	1.1	H	L	L	H	H	L	
	Rural	0.7	0.8	0.6	0.8	0.3	0.9	L	L	L	H	H	L	IR
Other Services	Metro-Core	3.5	3.6	4.3	3.4	1.6	3.2	L	L	L	L	L	L	
	Metro-periphery	3.4	3.7	5.0	4.3	1.9	4.0	H	L	L	L	H	H	IR
	Regional	2.8	3.5	4.7	4.2	1.7	4.0	L	H	L	L	H	H	IR
	Rural	1.9	3.2	3.0	3.0	1.3	3.8	L	L	L	H	H	L	IR