

Information and Communications Technology and Australia's Regional Economic Competitiveness



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May 2015



Citation

Khorshed Alam (2015), *Information and Communications Technology and Australia's Regional Economic Competitiveness*, Report prepared for the Western Downs Regional Council. Australian Centre for Sustainable Business and Development, University of Southern Queensland, Toowoomba, Australia.

Acknowledgements

The author would like to thank Craig Tunley, Peter Greet and Alison Lister of the Western Downs Regional Council for being very helpful and supportive all the way through, Dr Michael Lane, Mohammad Salahuddin and Dr Md Shahiduzzaman at the University of Southern Queensland for their comments on an earlier version of the paper, Bernard O'Neil for proofreading the manuscript and Michael Erdiaw-Kwasie for his research assistance.

Contents

Executive summary	iv
1 Introduction	1
2 ICT: Creating innovation and productivity	4
3 ICT and competitiveness: Critical focus on regional perspective	9
4 Causal relationship: ICT as a driving factor for regional competitiveness, innovation and productivity	12
5 Conclusion	15
References	17

Executive summary

Considering the ultimate aim is for Australia to be a leading digital economy, information and communications technology (ICT) is now embedded in the very fabric of society – ranging from the basic way of life to the trajectory of economic development activities. A recent global policy discourse on national competitiveness has emphasised the significant roles regional towns and cities play in the growth and competitiveness of most economies. Put differently, regional competitiveness is a key engine of productivity and growth for many competitive nations. As ‘competitiveness’ emerges as the survival weapon for many developed economies in today’s global marketplace, countries like Australia are faced with greater challenges in their attempts to cope with and perform well in global competition. Recent trends in global competitiveness data show that Australia has risen two places in the ranking between the 2013 and 2014 periods. Nevertheless, the country is tagged with the status of being near the bottom of the top-ranked economies. Consequently, informed policy discussions have focused on promoting regional Australia as a local hub of competitiveness which significantly impacts on the national aggregate competitiveness.

Review findings in this paper illustrate that the positive correlation between ICT and economic growth are manifested through innovation, productivity and competitiveness. However, macro studies using national data have explored and tested these relationships using diverse methodologies, and the results appear to be positive and negative. It is worth noting that studies that investigate these underpinning factors of economic growth at the regional scale are limited, particularly in the Australian context. Thus, research into exploring ICT and economic growth indicators such as innovation, competitiveness and productivity from the regional perspective will help ensure consistent and accessible insights into the performance and development prospects of regional Australia.

From the regional policy perspective, this study ascertained that there is a need for more research at the regional level to assess critically how local economies are faring with national and global digital business environments. Policy efforts in this direction will unveil the potential that regional towns and cities have for inducing growth and change. As regional towns and cities contribute significantly to industrial activities whose output has a great impact on the national economy, future research exploring how ICT can impact on innovation

and productivity within local economies is needed urgently. Added to this, the roles that ICT are assigned in the knowledge economy at the national and regional levels have given rise to the need to assess critically the technological readiness of regions and how ICT can enhance their competitiveness in the national and international marketplaces. Such cutting-edge research can guide regional policy makers in developing policies and strategies that can help build local capacities towards the effective use of digital technologies – the next step towards regional competitiveness in the digital future.

Key Highlights

- Regional competitiveness remains a distant reality in Australia. Regional competitiveness suffers from internal and external threats such as regional inequality, digital technological divide, inadequate infrastructure, limited innovation opportunities and weaknesses in local institutions.
- Technological readiness promotes an ICT-led regional economy – one that positively influences innovation and productivity. ICT can positively transform a region's overall economic environment – an ideal pathway towards regional competitiveness and a digital future.
- Technological preparedness by regional towns and cities is critical in the digital economy, as failure to utilise digital technologies effectively will render regions uncompetitive in the digital future.
- As the resources sector in many regions is moving from the construction to production phase, it is appropriate to study the nature and determination of regional competitive advantages and how digital technologies can facilitate the regional economies shift from a minerals-led powerhouse to a smart competitor in the global market.



Introduction

The unprecedented rise in global competitiveness and need for innovation has made the future of many economies appear to be one of gloom and doom, thus making an ICT-led economy a prerequisite than an ‘opt-in’ or ‘opt-out’ choice (Colecchia and Schreyer, 2001; Green et al., 2012). For example, in Australia the mineral industry (encompassing exploration, extraction and processing) is a major contributor to the national economy: it accounts directly for up to 8% of gross domestic product (GDP; and significantly more when related activities are accounted for), more than 20% of business investment and approximately 50% of national exports (Makin, 2014; Minerals Council of Australia, 2014). It is fascinating to note that mineral commodities make up five of Australia’s top 10 export earners with total export earnings in 2012–13 estimated at \$144 billion (Minerals Council of Australia, 2014). Although the mineral industry still constitutes a backbone of the country’s economy (de Krester and Forrestal, 2012; Makin, 2014), recent high rises in international price volatility for primary commodities like minerals is chipping away at Australia’s competitiveness and resilience to the consequences of globalisation. Studies such as Regional Australian Institute (2014) have suggested regional areas are major victims of such global economic shocks, as they usually lack the appropriate technological impetus to sustain the local economy, boost innovation, enhance competitiveness and promote diversification.

Traditionally, mining and mineral extraction played a prominent part in the development of local communities or regions around the world. Typical examples include the city of Kalgoorlie in Australia, which contributes much to the economic and social development in the state of Western Australia and has become one of the largest Australian outback cities (Butler, 2010); Johannesburg in South Africa, which is now South Africa’s key industrial and financial centre, accounting for 16% of the country’s GDP and 20% of its exports; and the mineral discoveries in California and Nevada, which have helped realise the American dream in the West (Li et al., 2012). While the theoretical reasons to believe that resource booms can propel national economic growth are well established in the literature (Battellino, 2010; Connolly and Orsmond, 2011; Rayner and Bishop, 2013), resource-led development has not

lived up to its rhetorical promise at sub-national levels, particularly in regional towns and cities (Beer, 2012; Mudd, 2007; Stimson et al., 2011). A recent study by Plummer and Tonts (2013), for example, considered that Australia's recent resources boom has led to the persistence of spatial economic inequality as well as growing levels of uneven development among regional towns and cities. Similar studies affirm that, despite past research recommendations on the need for regional towns to capitalise on any location-specific competitive advantage, the ever-increasing levels of employment shortages, inadequate infrastructure, loss of affordable housing, social dysfunction and inequities in local mining communities continue to threaten drivers of regional competitiveness and economic development (Rolfe et al., 2007, 2011; Schandl and Darbas, 2008).

Complicating matters further is the huge dichotomy that exists between regional areas and metropolitan Australia in terms of ICT availability. Despite the claims in recent Australian studies on internet usage and the digital divide that ICT is available across metropolitan and regional areas, more recent data confirm that the rural and remote areas in Australia are disadvantaged in terms of access to ICT (Alam and Salahuddin, 2015; Alam and Imran, 2015; Australian Bureau of Statistics, 2013). Thus, the prevailing situations, such as a lack of infrastructure from which to build a technology-savvy knowledge-based economy, mean that Australian regions perform worse in terms of every indicator in the technological readiness index than metropolitan Australia.

Data from a recent study show that the small and medium firms' use of ICT is significantly and positively correlated with profitability and business performance in the Western Downs region in Queensland (Alam and Shahiduzzaman, 2015). However, smaller firms are found to be lagging in terms of innovation activities compared to larger ones. Regional Australia Institute (2014) further shows that the technological readiness of a region's workforce and economy is a critical and fundamental factor that affects its comparative advantage. Simply, regional Australia is more likely to compete better nationally, and possibly internationally, when there is reliable ICT infrastructure as well as corresponding investment capable of transforming technological readiness into economic growth. Consistent with recent observations of the potential impact of ICT on regional economic growth at the macro level, including improved competition, high productivity, innovation and economic diversification at the national scale (Colecchia and Schreyer, 2001; Green et al., 2012; Gretton et al., 2004), literature that explores such relationships at the micro level remains limited, notably any that focus on regional Australia (Plummer and Tonts, 2013). The existing literature on this

symbiotic relationship between ICT and regional development becomes scantier when researchers exclusively place ICT within the framework of regional competitiveness.

Regional economic diversification has the ability to inform the creation of an enabling environment where the economies of towns and cities tend to be more resilient and flexible. Interestingly, a study by the Australian Bureau of Statistics (2013) found that the greatest economic threats – as identified in 39 regional towns – were the reliance on one or a few main industries and the need to diversify the region's economy. The study findings further show that a rigid regional economy has a higher probability of being more vulnerable to economic shocks such as falling resource prices and investment and employment insecurity. Following this reasoning, regional economic diversification can reduce regional unemployment and promote economic growth. Findings by Regional Australian Institute (2014) affirm that there is an appreciable level of diversity within the economies of regional Australian towns and cities but that traces of regionally diverse economies that lack the ability to propel development still exist. Many scholars have developed a range of models seeking to explain how economic characteristics such as industry sectors, employment, income, value of production and investment influence regional economic diversification and development (Maddison, 2001; Ville and Wicken, 2013). Despite these important works, the overall corpus of conceptual and empirical studies which focus on ICT-led economic diversification at the regional scale remains inadequate (Mardaneh, 2010; Stimson et al. 2006).

Following the gaps identified in the literature, which compound the complexities associated with the interrelated factors that drive regional competitiveness in Australia, it is appropriate to undertake a major assessment of how ICT propels regional competitiveness. This review aims to provide an understanding of ICT-led regional competitiveness in an Australian context. As this key aspect of regional economic studies has received little attention, the paper seeks answers to: (i) how ICT boosts innovation and propels productivity; (ii) how do competitiveness and economic growth relate in a regional context; and (iii) what is the causal relationship between ICT, regional competitiveness and economic growth.

After the introduction, the structure of the paper is as follows. Section two explores the link between ICT and innovation and productivity – two critical elements of economic growth. Section three further examines a bi-relational review on competitiveness and economic growth, focusing on the regional scale. Section four provides an assessment of the causal relationship between ICT, regional competitiveness and economic growth. The concluding section of the paper presents suggestions that have implications for future research.

Two

ICT: Creating innovation and productivity

Traditionally, production functions focus on labour, capital, materials and energy within an economy. However, contemporary exigencies due to the bifurcation of global competition, globalisation and the ICT revolution have necessitated the sharp emergence of knowledge as a production factor that involves skills, learning, organisation and innovation in many economies today (Seki, 2008; Powell and Snellman, 2004; Timmer et al., 2010; van Ark et al., 2008, 2012). Some evidence suggests that investment in knowledge can increase the capacity of the other factors of production and lead to new products and processes, and so knowledge is perceived as a key to long-term economic growth (Brinkley, 2006; Niebel, 2014). Not surprisingly, therefore, developed economies are becoming more knowledge-driven with an emphasis on generating, using and disseminating knowledge (Seki, 2008; Powell and Snellman, 2004). Arguably, ICT is the fastest way of disseminating knowledge and its vital role in rapidly emerging knowledge economies is well recognised. Findings from existing studies show that a significant reliance on intellectual capabilities rather than physical inputs or natural resources constitutes a key component of a knowledge economy – an economy where production and services are based on knowledge-intensive activities that ensure technical and scientific advancement (Dahlamn and Utz, 2005; Powell and Snellman, 2004; OECD 2000, 2012). According to Brinkley (2006), knowledge is an economic good which is a key in efforts towards value-adding and wealth creation. For instance, the estimated contribution of ICT investments to value-added growth in the business sector varies from 1% a year in Australia to 0.4% a year in Japan (Spiezia, 2012). In addition, a panel study of 20 Organisation for Economic Cooperation and Development (OECD) countries by Czernich et al. (2011) found that increasing broadband penetration raises GDP growth rates.

The total factor productivity (TFP) – the measure of an economy's long-term technological dynamism, taking into consideration the overall inputs – of many advanced economies has been associated with the production and/or use of ICT (Dabla-Norris, 2015; Oulton, 2001; Samimi and Arab, 2011). Microeconomic studies emphasise that the link between technology and productivity remains complex – given that the TFP growth in ICT-led sectors measures

the direct growth contribution of the use and production of ICT (Spiezia, 2012). Nevertheless, Spiezia (2012) suggests that in order to leverage ICT investment successfully, firms need significant complementary investments and innovation in areas such as business organisation, workplace practices, human capital and intangible capital. Interestingly, some recent studies (e.g., van Ark, 2014; Corrado and Jäger, 2014; Guerrieri et. al., 2005) have ascertained that the contribution of the TFP of the ICT sector to most economies, developing or advanced, has become more visible in recent decades (Table 1). For example, van Ark (2014) presents a case of Europe where it was observed that the investment effect from an ICT-using industry was high through capital deepening. This study found that, during 2011, the economy's digitalisation in Europe was reflected in rising labour productivity which helped make ICT capital remain strong, despite a constant decline in non-ICT investments. The studies of Oliner and Sichel (2002) and Jorgenson and Stiroh (2000) present an American case where a growth in the TFP of the economy was attributed to the significant and crucial impact of ICT. Colecchia and Schreyer (2002) applied Jorgenson's production possibility frontier approach to nine OECD countries up to the year 2000. Their findings showed that besides the United States benefiting from the effects of ICT capital investment on TFP growth, Australia, Finland and Canada experienced similar significant effects from ICT capital investments. Although advanced economies have been generally described as benefiting significantly from TFP growth in their ICT sector, it must be emphasised that the impact varies (Table 1). For example, Denmark, Italy and Sweden experienced almost 100% TFP growth from their ICT sector, while Austria and Ireland recorded comparatively low growth at 23% and 32%, respectively.

Table 1: Contribution of ICT-producing industries to TFP in selected countries.

Country	Productivity growth		% of TFP growth due to ICT
	Business sector	ICT industries	
Australia	0.02	0.01	40
Austria	0.58	0.13	23
Belgium	-0.37	0.15	100
Denmark	-0.39	0.15	100
Finland	1.44	0.50	35
France	0.43	0.21	49
Germany	0.41	0.29	69
Hungary	2.21	0.60	27
Ireland	0.78	0.25	32
Italy	-0.48	0.12	100
Japan	0.23	0.23	100
The Netherlands	0.40	0.19	48
Sweden	0.66	0.71	100
United Kingdom	0.28	0.19	67
United States	0.59	0.35	59

Source: Spiezia (2012)

Generally, the emergence and intense use of ICT have impacted enormously on the opportunities for firms and their efficiency in producing and providing goods and services. This relationship has been extensively studied for developed countries at the firm, industry and regional levels through a wide array of methodologies (Draca et al., 2007; Van Reenen et al., 2010; Cardona et al., 2013; Gordon, 2012). Interestingly, the evidence suggests that productivity growth not only depends on advances in technology, but also involves the efficiency with which labour and capital are combined to generate output (Balk, 2014; Dabla-Norris, 2015; Svyerson, 2011). For example, an Australian study shows that work routines, complementary investments in organisation and internal training, level of education and the use of ICT are important determinants of productivity growth (Productivity Commission, 2004). Adding to this, Hall et al. (2012) caution that ignoring these complementarities may lead to overestimating the effect of ICT on productivity. Using an aggregate production function approach, Shahiduzzaman and Alam (2014a) showed that investment in ICT had a significant impact on output, labour productivity and technical progress in the 1990s in Australia, although the contribution to output and labour productivity slowed down in the 2000s. Nevertheless, with ICT dominating social and business environments and, consequently, changing how businesses operate, the idea that ICT capital investments have productivity effects beyond just the addition of more capital equipment is widespread (Atkinson, 2007; Spiezia, 2012). Despite the optimistic views in many studies on the relationship between ICT investment and productivity effects, some sceptical views exist too. Gordon (2010), for example, questions the idea of ICT capital intensiveness proposed in some studies and argues that the sector is subject to increasing diminishing returns. Similarly, Carr (2003) cautions on the fragile nature of ICT-led investments, most especially as ICT becomes common in most developed countries.

However, an emerging agreement is palpable among international economic agencies and in the ICT-led economic growth literature, where the majority of studies show the productivity effect of ICT as positive and significant, notably in advanced economies (Atkinson, 2007; Biagi, 2013; Cardona et al., 2013; Fernald, 2014; Jorgenson et al., 2008; Strauss and Samkharadze, 2011). Interestingly, trends in productivity patterns in advanced economies indicate that ICT capital has impacted more on productivity growth than non-ICT capital investments (Pilat and Devlin, 2004). According to Inklaar et al. (2006), ICT capital recorded 5–8 times higher returns on productivity than other kinds of capital in many industrialised countries in 2000. Consequently, this positive relationship between ICT capital and

productivity saw many advanced countries expand their ICT investment to benefit from growth opportunities. For example, Australia's rise in the ranking in ICT investment as a proportion of GDP from ninth in 1980 to third (to the United States and Japan) among OECD economies in 2010 is clear evidence (Australian Industry Group, 2013). Statistically, in a formal analysis of the productivity effects of ICT capital, Connolly and Fox (2004) observe a strong and statistically significant relationship between ICT capital investment and productivity growth in Australia's aggregate market sector, finance and insurance and agriculture. In another study, using Australian data from the mid-1960s to 2011, Shahiduzzaman and Alam (2014b) found cointegration between ICT capital and economic output and the positive role of ICT capital on economic growth in the long- and short-term. Similarly, Maliranta and Rouvinen (2003) show that ICT investment in Finland has had a higher productivity impact than non-ICT capital.

As business economy has become more dynamic, interest in innovation – its product, processes, market and organisation – has escalated (Aboal and Garda, 2012). The concept is broadly viewed as a productive process that depends significantly on human resources and an investment in capital assets aimed at improving the productivity and competitiveness of national and local economies (Aboal and Tacsir, 2015; Charlo, 2011; WEF, 2014). In establishing the relationship between ICT and innovation, many studies have ascertained that the production function at the microeconomic level involves a relationship between productive factors and output, and so ICT capital as a factor of production influences major components of the productive process significantly (Charlo, 2011; Hempell and Zwick, 2008). Thus, in some studies innovation and ICT use are considered complementary so that ICT capital deepening increases when firms combine ICT use with technological innovations (Brynjolfsson and Hitt, 2000; Hempell and Zwick, 2008; Koellinger, 2008). The rapid diffusion of ICT in industrialised economies saw the emergence of a variety of innovation potentials which impacted positively on sectors of the economy, including those outside ICT-producing industries (Aboal and Tacsir, 2015; Charlo, 2011; Hempell and Zwick, 2008). Hempell and Zwick (2008), for example, indicated that the application of ICT fosters innovation activities through firms developing more flexible company structures, improving business processes and introducing new products and services. According to them, ICT use promotes functional flexibility (the ability of workers to cooperate and take decentralized decisions) and numerical flexibility (the reduction of fixed costs, mainly due to outsourcing business processes) which have implications for innovation (Hempell and Zwick, 2008).

Koellinger (2008) applies a similar approach on a sample of European firms which reveals that e-business technologies are significant enabling factors of innovation by either improving processes or helping firms to develop new products or services.

Despite the potential positive effects of innovation on economic growth, a recent study by the Global Innovation Index (GII) (2014) indicate that innovations in many countries remain fragile and limit efforts to propel economic growth. For example, the GII study ranked Australia in the innovation leader's group with a rise from 23rd in 2012 to 19th and 17th in 2013 and 2014, respectively. However, national studies indicate that the economy is classified as having inefficient innovators – being at the bottom of the top. Following this innovation divide, the creation of innovation hubs through developing national plans to guide the knowledge economy as well as significant investment in technology transfer and diffusion of innovation should be a priority.

Three

ICT and competitiveness: Critical focus on regional perspective

As the new knowledge economy expands in the global market, increased competitiveness will be a prerequisite for most industrialised economies. The International Institute for Management Development considers that ‘Competitiveness of nations looks at how nations create and maintain an environment which sustains the competitiveness of its enterprises’ (Garelli, 2003, p. 701). According to the World Economic Forum and Global Competitiveness Report (WEF, 2014), ‘competitiveness’ refers to the ‘the set of institutions, policies, and factors that determine the level of productivity of a country’. The report clearly indicates that the concept of competitiveness involves both static and dynamic components, including investment in physical capital and infrastructure, education and training, technological progress, macroeconomic stability, good governance, firm sophistication and market efficiency, which are not mutually exclusive but together foster economic growth. Considering the economic connotation that the concept carries, many studies affirm that competitiveness has remained a major theme in the economic assessment of most advanced economies, including OECD countries, EU countries and those in the Western world (Borožan, 2008; Gardiner et al., 2004; WEF, 2014).

Given the significant roles that factors like the quality of an institutional environment, infrastructure, efficiency of the labour market, macroeconomic environment and technological readiness play in boosting the strength of most economies, developed countries continue to be highly ranked as ideal zones for capital investment due to the competitiveness of their economies (Table 2; Barro and Sala-i-Martin, 2003; De Soto, 2000; Feyrer, 2009; Fischer, 1993; WEF, 2014). However, some developed countries may belie this global assertion. For example, Australia has enjoyed a prolonged period of economic growth manifested by job creation, improved living standards and significant funding for social services, but it has begun to suffer a plunge as a result of rising global competition (McKinsey Global Institute, 2014; WEF, 2014). Trends from a global competitiveness country survey indicate that despite the strong financial development experienced in the

advanced economy of Australia, a drop in the overall competitiveness pillars index (such as macroeconomic situations, labour market efficiency and institutional environment) have led to its fall from 15th position in 2009 to 22nd in 2014 (Table 2; WEF, 2014).

Table 2: The global competitiveness index ranking for some selected countries.

Country/Economy	Overall Index Rank 2013/14 (out of 148)	Overall Index Rank 2014/15 (out of 144)
Switzerland	1	1
Singapore	2	2
United States	5	3
Finland	3	4
Germany	4	5
Japan	9	6
Hong Kong SAR	7	7
The Netherlands	8	8
United Kingdom	10	9
Sweden	6	10
Australia	21	22
South Africa	53	56
Nepal	117	102
Bangladesh	110	109
Guinea	147	144
Chad	148	143

Source: Adapted from the WEF (2014).

Increasingly, regional towns and cities are perceived as the lifeblood of a country's economy – they are largely regarded as a key source of wealth in most national economies. Competitiveness 'hinges on the productivity of the local regions' which implies that regional towns and cities are able to use available inputs efficiently to drive sustainable economic growth and prosperity (WEF, 2014, p. 5). As a result, more recently the concern of most advanced economies about competitiveness has quickly spread to regional, urban and local levels. Increasing interest in literature about regional competitiveness has developed new forms of regionally focused policy interventions to help improve the competitiveness of every region and city (Gardiner et al., 2004). A recent trend shows that the overall trajectory of global competitiveness on a national scale would seem to be a valid paradigm underpinning regional competitiveness in most economies (Regional Australia Institute, 2014). Following this fundamental connection, regional competitiveness can be defined as the set of factors (policies, institutions, strategies and processes) that determines sustainable productivity at the regional scale (WEF, 2014).

Regional competitiveness has been often considered as the aggregate of micro competitiveness or a derivative of national competitiveness (Borožan, 2008). Many studies share the view that regional competitiveness is an equivalent or proxy term for regional

productivity, given that regional competitiveness is strongly dependent on firms' performance (Porter, 2001). In other words, the productivity of a locality is determined by the productivity of the firms which operate within it. However, while firms ultimately want to achieve and steadily increase productivity and profitability, regional competitiveness can be realised if favourable macroeconomic and business-environment policies as well as strong digital infrastructures exist (WEF, 2014). Thus, success in creating such conditions which foster regional competitiveness enable the creation of value added and sustainable economic growth.

In Australia, for example, regional competitiveness faces diverse challenges ranging from macroeconomic situations to connectivity intensity, hence undermining the capabilities of regional areas to propel local economic growth (Baum et al., 1999; O'Connor et al., 2001; Stimson et al., 2001, 2003). A recent study focusing on the competitiveness of Australia's 560 Local Government Areas and 55 Regional Development Australia regions found that, amidst the growing local challenges, human capital, technological readiness and innovation emerged as central themes that can guide regions towards becoming strong, resilient and competitive (Regional Australia Institute, 2014). The findings clearly emphasised that regions can have sustainable economies if they look for sources of endogenous growth such as healthier and better educated local systems, quality broadband penetration and local business sophistication and innovation, to boost regional competitiveness.

Four

Causal relationship: ICT as a driving factor for regional competitiveness, innovation and productivity

Measuring the impact of ICT investment on economic growth has been examined thoroughly for certain industrialized countries (Qiang, 2009; Waverman et al., 2005). For example, Oliner and Sichel (2001, 2002) for America, Oulton (2001) for the United Kingdom, Gordon (2002) for Germany, and Parham et al. (2001) and Shahiduzzaman and Alam (2014a, 2014b) for Australia. These studies draw mixed conclusions on the causal relationship between ICT and economic growth. There is plenty of evidence that economic growth is manifested through competitiveness, innovation and the diversification of the economy.

The inevitable structural transformation in most economies has rendered the role of technological change in the growth process more vital as they grow. Consequently, past economic growth models such as exogenous growth (e.g., the Harrod-Domar growth model and the Neoclassical model) and endogenous growth (e.g., externalities of investment, knowledge accumulation and human capital formation) have been revisited by many scholars, leading to the emergence of many contemporary ‘digital economic growth models’ which recognise the potential for new technology, including ICT, to contribute to economic growth (Aghion and Howitt, 1992, 2009; Kuppusamy et al., 2009). A typical example of such studies is the model of endogenous stochastic growth by Aghion and Howitt (1992), which expands the neo-Schumpeterian endogenous growth model. In this study, the proponents expand the initial argument of the traditional model and ascertain that technological progress creates losses and gains with the growth process being discontinuous. According to a review of the studies by Carlaw et al. (2005), the theoretical underpinnings of ICT and economic growth can be categorised into four broad groups: (i) exogenous growth models that follow Solow (1956) (Islam, 2003; van Ark 2002); (ii) endogenous growth models without explicit endogenous technological change (Barro, 1990; Lucas, 1988); (iii) endogenous technological change models (Carlaw and Lipsey, 2006; Helpman and Trajtenberg, 1998; Lipsey et al., 1998; 2005); and (iv) technology transfer models (Bernard and Jones, 1996; Dowrick and Rogers, 2001; Castellacci, 2001). The literature indicates that these conventional models do

not replace the past growth models but supplement them in terms of the conditions that drive economic growth – the basic priority of better living conditions for people (Kuppusamy et al., 2009).

Previous studies have identified that income level, cost of ICT, education, openness and institutional quality are the most important factors. Income level appears to be a major determinant of ICT diffusion. Pilat and Devlin (2004) point out that firms in countries with higher levels of income and productivity have greater incentive to invest in ICT. Furthermore, the costs of investment in, and use of, ICT are significant. Quibria and Tschang (2001) conclude that income level is a major determinant of ICT diffusion. Pohjola (2003) makes a similar conclusion: income is positively associated with computer hardware spending.

According to Biagi (2013), two key methodologies have been employed in the ICT-economic growth literature. First, growth accounting methodology which is based on neoclassical assumptions and can be applied to investigate the relationship between labour productivity growth and ICT capital. This approach is limited in scope in terms of measuring the indirect effects of ICT investment and it is generally applied only to sector/macro level datasets. Second, regression-based methodology which involves defining a set of conditions that allow the use of more flexible functional variables such as the relationship between labour productivity and its determinants. As this methodology is capable of measuring the direct and indirect effects of ICT investments, it is deemed to have a wider scope and hence can be applied to both macro and micro data (Biagi, 2013). Interestingly, other empirical literature show that a regression-based approach is more favourable since it can be used in cases where returns to scale are not constant as well as having the ability to consider the presence of externalities and spill-overs (Corrado et al., 2014; Meijers, 2007). Other methodologies applied in studying the ICT-economic growth nexus include the generalized method of moments, Cobb-Douglass production function, non-parametric techniques, multivariate regression, panel DOLS, firm-level production function and stochastic frontier (Salahuddin and Alam, 2015; Brynjolfsson and Hitt, 2000; Cardona et al., 2014; Niebel, 2014; Timmer et al., 2011; Van Reenen et al., 2010). For example, Cortés and Navarro (2011) employed a growth accounting approach for 27 European countries between 1980 and 2007: they observed that increased ICT capital investment and growth in human capital contributed substantially towards labour productivity growth in market services although countries differed significantly in terms of ICT efficiency. Following the same approach, Inklaar et al.

(2005) compare the ICT contribution to the economies of the United States and four European Union countries (France, Germany, The Netherlands and the United Kingdom). The findings revealed that the United States had higher ICT contributions than the other four countries during the period 1979 to 2000. Regression-based approaches have been employed in many country-specific studies to explore the causality between ICT and economic growth (Antonopoulos and Sakellari, 2009; Arvanitis & Loukis, 2009; Dholakia and Harlam, 1994; Mbarika et al., 2003). For instance, Dholakia and Harlam (1994) adopt a multiple regression model and ascertained that ICT is the most significant predictor of economic growth among other determinants. Mbarika et al. (2003) utilize a linear regression model to examine the relationship between ICT investment and per capita GDP. Also, using a multivariate regression, a positive and significant causal association was found between the regional level of income and ICT infrastructure in Poland, with causality running from the former to the latter (Cieřlik & Kaniewska, 2004).

Generally, just as some regression studies unveil a bidirectional association between ICT developments and economic growth (Kretschmer, 2012; Lam and Shiu, 2010; Karner and Onyeji, 2007; Wolde, 2007), a unidirectional association was also observed in other studies (Shiu and Lam, 2008). Regression models have gained significant popularity in industry level studies, which are considered to be more conclusive than the aggregate level studies (Dedrick et al., 2003; Kretschmer, 2012). For example, despite the positive outcome for ICT and economic growth at the country level in the Asia-Pacific region (Dedrick et al., 2003), there was a lack of conclusive evidence regarding the causal relationship due to the comprehensive range of factors that affect economic growth. At the firm level, econometric analyses have shown that firm performance could be impacted positively through the use of ICT (Gretton et al., 2002; Arvanitis and Loukis, 2009; Badescua and Garcés-Ayerbe, 2009). However, to a certain extent, the results vary within territorial (national, regional and metropolitan) scope, between ICT-producing and non-producing firms and between ICT-using firms and non-users (Pilat, 2004). Interestingly, plenty of notable studies that employed an extensive variety of methods and data show that both productivity performance and labour productivity of firms using one or more types of ICT tend to be much better than non-users (Jovanovic and Rousseau, 2005; Pilat, 2004; Vu, 2011). Regrettably, studies that replicate research at the regional scale focusing on ICT-led local competitiveness remain scarce, especially in Australia (Plummer et al., 2014). More research needs to be undertaken in the Australian context, particularly as the aim is to be a leading digital economy.

Five

Conclusion

The main purpose of this paper was to explore the relationship between ICT and indicators of economic growth from the regional economic perspective. Answers were sought to the following questions: (i) how ICT boosts innovation and propels productivity, (ii) how ICT capital promote competitiveness – a critical focus on regional context and, finally, (iii) what is the causal relationship between ICT and economic growth indicators (innovation, competitiveness and productivity). In addressing these research questions, the paper was categorised into three broad thematic areas. First, the paper presented an overview of ICT within the frameworks of innovation and productivity. The review findings show that the digital economy has led to ‘knowledge’ being viewed as a critical factor of production, hence impacting on the production process. Then the paper discussed some empirical studies which depict how the use of ICT capital has influenced innovation and productivity in most developed economies. Second, the paper explored how ICT capital propels territorial competitiveness at the national, metropolitan and regional levels. The consequences of the emerging knowledge economy have rendered ‘competitiveness’ a critical condition that determines the survival of economies in the globalised business environment. The paper presented several factors which determine the success of national competitiveness on the global scale and recapped a regional sketch from an economic development perspective. Third, the analytical review found that economic growth models have been revisited by scholars following the emergence of the knowledge economy, thus leading to the development of digital economic growth models. Diverse methodological approaches have been adopted in establishing the link that ICT has with economic growth indicators, but growth accounting and regression-based methodologies are dominant. Some empirical studies where each of the methodology has been applied were presented.

From the regional policy perspective, the findings of the study indicate that there is a need for more research at the regional level to assess how local economies are faring in the national and global digital business environments. Such policy efforts will help develop the potential that regional towns and cities have for economic growth and change. As regional towns and

cities contribute significantly to industrial activities whose output has a great impact on the national economy, future research exploring how ICT can impact on innovation and productivity within local economies is needed urgently. Added to this, the roles that ICT are assigned in the knowledge economy at the national and regional levels have given rise to the need to assess critically the technological readiness of regions and how ICT can enhance their competitiveness in the national and global marketplaces. Such cutting-edge research can guide regional policy makers in developing policies and strategies that can help build local capacities towards the effective use of digital technologies – the next step towards regional competitiveness in the digital future.

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