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If living labs are the answer – what's the question? A review of the literature

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Abstract

The world's economy is becoming increasingly knowledge intensive. This will drive further technological, societal and organisational change. A knowledge intensive economy gives the producers of knowledge – universities – a potentially key role in shaping our future.

However, this paper shows that neither Australian industry, nor universities are good at collaborating for innovation. Change is needed but change is hard, resource intensive and never ending. This paper demonstrates why change is so difficult and suggests steps for success. It demonstrates why effective leadership is central to the change process and suggests further applied research to understand the practical obstacles that are preventing universities from developing partnerships for innovation.

It defines a principle for evidence-based innovation that is fit for the Anthropocene and proposes the sustainable development goals as a measure to understand the impact of university research in order to help move society in the direction society is seeking.

It also pries into the Pandora's box of the role of Universities in partnering for innovation in the Anthropocene and proposes further research on the role of 'leading by doing' on potential partnerships for innovation.

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Keywords: triple helix, living lab, collaboration, partnership, leadership

1. Introduction

The world's economy is continuing to transition from an age of the "white heat of technology" [1] to a knowledge intensive economy. The pace and rate of change is accelerating [2]. In a knowledge based economy knowledge of how to develop and use it is the key to success. The future should therefore be bright for universities (as knowledge creators and sharers) as well as businesses (knowledge users and sharers). It should be brighter still for those entrepreneurial universities and businesses that work together to combine their skills to innovate in a knowledge intensive economy [3].

However, Australian Universities do not compare well with their OECD counterparts in their ability to collaborate with industry for innovation [4] despite the fact that Australian research outputs are world class [5]. The potential of commercialisation of university knowledge is not being realised [6]

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and further it is unclear the level of uptake of research by university sector itself to aid commercialisation.

Australian industry too is generally weak at collaborating for innovation. It underperforms OECD competitors on collaboration with its customers, suppliers and universities both internationally and domestically [5] even though innovation was seen, by industry, to be the driver of business success. Industry is also poor at reaching out to other organisations to develop strategic advice relating to the future [7]. However, Australian industry does fund public research in universities at a level that is greater than the OECD average [5].

In addition to the changes that are happening as the knowledge based economy intensifies so too does humanity's impact on the natural environment. Society understands the scale of the impacts due to high quality research outputs from universities, industry and elsewhere. If there is to be a close relationship between business and publicly funded universities the innovation it produces needs to be based on evidence of its efficacy in the Anthropocene; if it is not it will be undermining the ability of society to deliver the sustainable development goals endorsed by the UN general assembly in 2015 [8].

1.1. Background

The world's economy is transitioning away from being industry based towards becoming a knowledge economy where knowledge is the predominant factor in driving economic growth. A knowledge economy is only truly possible in a networked world where knowledge can be shared with ease due to the network effect [9, 10].

1.2. Economic impacts

Developed economies are becoming increasingly knowledge intensive [11]. This is a process that has been recognised since the mid-20th century and possibly since the dawn of the Anthropocene in the 1750s [12]. The increasing reliance on, and importance of knowledge and information in product and service development has been widespread and accelerating with over 50% of GDP of major economies being knowledge-based [13]. This may be as high as 70% in some developed economies. However, the ability of economists to track the stocks and flow of knowledge through an economy is still developing [13].

The 'knowledge economy' is a widely used term to signify the intensification of knowledge use in the modern economy [13, 14, 15]). Using the term does not mean that previous economies (ie agricultural or industrial economy) were knowledge free – they were not. Those economies used the available knowledge effectively and were driven by technological innovation [12]. However, the key change was with the adoption of technology horizontally across the economy rather than vertically within trades. For example, the steam engine, and thereby access to power on demand, transformed many industries – from agriculture to textiles to public transport. It was this adoption of 'horizontal' technology (or general purpose technologies [16]) in the 1750s that started the transformation towards a knowledge-based economy; a trend Drucker noted in 1959 when he coined the phrase 'knowledge workers' [12].

The pace if the development has increased markedly in the late 20th and early 21st century with the widespread adoption of the internet [17] and the exponential growth in devices linked to the web (with Intel predicting 20billion devices connected by 2020 [18]). Some argue that proof of its development came with the rise, from the 1960s in the service economy where people with specific knowledge and skills did work for those who did not have it [19]. But the knowledge economy should not be merely defined by its initial association with the service economy. Rather it can be identified by its investments in research and development, education and training and new managerial work structures [13].

1.3. Societal impacts

And while our economy is transforming so to is our society and environment. The knowledge economy is leading to the development of two types of jobs: those jobs where people tell computers what to do and those jobs where computers tell people what to do [20]. The knowledge economy has been blamed for real wage stagnation in the low to middle income groups, stalling service sector productivity growth and increased inequality within society.

In order to maximise the benefits that the new knowledge and information will bring it is essential to adopt new work practices [21, 16]. Investments in technology enable complementary organisational investments which help to improve productivity [11] and these are often associated with workforce changes enabled by the adoption of the technology [22]. The flattening of hierarchies, development of team work where everyone has a voice, and the general empowerment of the workforce can only happen with easy access to knowledge and information are evidence of this new economic era, as well as a clear break with the past industrial based economy [23]. However, the gains from the adoption of new technology are not the same in each organisation – the limiting factor is the ability of the management to create a new environment that will maximise the benefit of the technology [24]. Similarly simply adopting a technological fix without associated process changes can have the opposite effect [16].

1.4. Environmental impacts

The world's environment is also being impacted which Hardin (1968) described as the "tragedy of the (un)managed commons" [25]. Today there are few if any unmanaged commons left and yet humanity's impact on our natural systems is significant and far reaching, even though positive for human well-being and economic growth [26]. The result is that the current geological epoch is referred to as the Anthropocene in view of the impact of humanity [27] – which are so significant as to be geological in scale.

1.5. Emergent 'mega' trends [43] and institutional responses

At the same time as these global changes to the economy, society and environment it is anticipated that economic activity will move from the north to the south and the west to the east [18]. This puts Australia – historically suffering from the "tyranny of distance" [28] – to being in the same time zone as a quarter of the world's universities. The middle class of this region is expected to expand by over a billion people by 2050 [18]. Politicians have argued that this means that the early 21 century is "the most exciting time to be Australian".

These are indeed exciting times and governments are taking steps to move in a more equitable and sustainable direction. In 2015 the world leaders unanimously agreed to 17 sustainable development goals (SDGs) which, unlike the Millennium Development Goals, all countries will pursue. These goals will guide the world's development over the next 15 years [8]. Further in Paris in 2015 world leaders committed climate action (goal 13) by taking steps to limiting global warming to 2 degrees centigrade (with a further commitment to plan to limit the increase of temperatures to 1.5c).

2. Research aims and methodology

This paper is part of a PhD looking at how universities and industry can better collaborate for low carbon innovation. This paper is designed to give a strategic theoretical backdrop against which further practical work can be tested. It is based upon a high level review of the literature searching under collaboration, living labs, sus labs, innovation, knowledge economy and triple helix through the Web of Science. Papers were read and categorised according to their relevance to both the development of collaborative structures for innovation as well as the delivery of 'future-proofed' innovation.

Within this paper the term 'university' is used to embrace academia in general with an emphasis on research for the public good. Similarly the terms 'business' and 'industry' are used interchangeably to reflect private sector economic activity. There is no significance with the use of the different terms – they are used to reflect the production of knowledge (for the public good) as well as private sector economic activity (largely for private benefit). Also research and innovation are used in this paper as part of a continuum where innovation is seen as taking research and commercialising it to produce a new product or service.

3. Universities and industry – partners in innovation?

Universities and industry have a complex relationship to each other in terms of how they engage with each other for research and collaboration. This is set out in Table 1. The relationship appears to be one of client/customer, or transactional rather than one of collaboration or partnership where each derives value, even if that value is different for each. For example, industry is seen to be weak at

collaborating with either other industry or universities. Universities however are good at collaborating with each other (for research) but poor at collaborating with industry for innovation. Universities and industry do work well together however undertaking research. It is not clear, from this literature review, the degree to which such research partnership produces research that derives public benefit or only research that derives private benefit. Industry funds universities to undertake research at a level that is greater than the OECD average. This stands in contrast to Australian Universities and industry being at the foot of the OECD league table for collaborating for innovation. In a knowledge economy collaboration will be the key to success as it is unlikely that any one organisation will hold all the knowledge and business skills to deliver innovative products and services in a networked economy.

Table 1: Australian Universities and business: customers or collaborators?

	Industry	Universities	Customers/students	Suppliers	Use foresight	Research user?
Industry	Collaboration between industry for innovation is weak and localized [29]	Industry fund universities to undertake research at level greater than the OECD and EU28 average. [30]	Industry is weak at collaborating for innovation with its customers [31]	Industry is weak at collaborating for innovation with its suppliers [31]	Industry weak at using strategic foresight [7]	User, and active funder of research
Universities	Collaboration for innovation is amongst the worst in the OECD [15]	Universities are good at collaborating with universities [32]	Investment by universities and students/alumni is the focus of increased attention [33]	Little evidence of universities collaborating with their suppliers for innovation	Unclear as to whether universities use foresight (although they do research scenarios)	Unclear if universities use the research they produce. Initial findings suggest they do not

One interesting absentee from the literature reviewed is the degree to which universities are willing to use their own resources (eg investment in campus development) to either imbed research outcomes or innovation in the p process. In such a case Universities collectively could use their buying power to partner with organisations who are interested in innovation or producing product ready for the Anthropocene. The fact that such a discussion is absent from the literature reviewed suggests this area could be fruitful for developing the next canvas upon which to draw university and industry collaborations.

3.1. Barriers facing collaborators

Universities and business need to become better at collaborating [34], yet resistance to change is deeply engrained within humans [35, 36], as well as the organisations we create [37, 38] and this is, in part, because of the evolutionary desire to not wasting resources by conserving energy.

This has influenced the way we think. Kahneman (2011) argues there are only two ways humans think: one is reactive unconscious thought and the other is contemplative and conscious thought [35]. Being able to react when you are being chased by a hungry tiger is very helpful for survival. However, it is not necessarily helpful when faced with a new situation. New situations possibly need new solutions, and new solutions can only be developed deliberately through conscious thought. Conscious thought takes time, and importantly (in evolutionary terms) energy. Evolution has developed the brain to limit this energy intensive response as much as possible. If new thought is needed the brain seeks to take the conscious thought and convert (through learning) into unconscious action.

The importance of this for organisations is that the same conditions apply. Businesses have processes to efficiently deal with the known situations they face. This is comparable to unconscious thought. If a new situation faces them they need to develop ways to deal with it and this is the equivalent of conscious thought. The new situation will be dealt with, and when it reoccurs it will also be dealt with on the basis of what the organisation did before. In the social sciences literature this is path dependence theory [39] where decisions made today are influenced by how successful decisions were made yesterday. This is also learning by doing [40].

Evidence from neuroscience supports this hypothesis with the discipline of neuroplasticity demonstrating how particularly damaged brains can relearn activities and then, in order to save energy, turn them into reactive thought [41]. The difference that neuroplasticity brings to this stream of research is that it suggests that path dependence theory must, and always will, be a self-fulfilling prophesy as neither humans nor organisations have the necessary resources of energy (or finance) to consciously respond to each situation they face as if it were new. They need an armoury of (unconscious) responses in order to use their energy (or financial resources) efficiently and this limits their ability to respond to new opportunities effectively. Businesses ability to respond is strictly limited by two finite resources: leadership and financial.

Although all organisations are capable of learning, those that do not have established process, or those where processes can be quickly established to match the issue they are confronting, are the most likely to respond the quickest. In innovation – particularly in a situation of disruptive innovation (ie the scenario being faced is entirely new) age is important. Typically young, or small organisations, being the most adept at adopting the change quickly [38] as from their perspective it is not really change in as much as everything is new to them. Importantly, in a disruptive environment first-mover advantage is the key to success [38]. And the knowledge economy is based on disruption – disruption to organisations, society and to technology.

The importance of this insight is that change is and always will be difficult and resisted for evolutionary reasons. However, to make is less entrenched there are key steps organisations and people can take to maximise the chance of successful implementation of change. It is less difficult to deliver when all stakeholders understand what motivates each other and there is a clear understanding of the motivation behind each proposal and what the action is seeking to achieve [21, 42, 43]. Hakkarainen, and Hyysalo (2013) argue for the need to “learn how to interact before interacting for innovation” [67]. Living labs provide the opportunity to address such organisational and cultural barriers as long as there is strong governance model between the partners [44].

In transitioning to a deeper knowledge-based economy will impact technology, society and organisational structures responding effectively to the changes will be key.

4. What is the role for universities in the knowledge economy?

The knowledge economy brings with it technological, organisational and societal innovations and change [45]. In a society dominated by the exploitation of knowledge the role of entrepreneurial universities can be significant at it gives universities the opportunity to partner with business to deliver benefits to society, business and universities. There are many models for such partnership, and the need for such partnerships have been identified for some time [14].

4.1. Living labs

> “The OECD science system is facilitating the challenge of reconciling its traditional functions of producing new knowledge through basic research and educating new generations of scientists and engineers with its newer role of collaborating with industry in the transfer of knowledge and technology” [13]

Within Europe the response has been the creation of Living Labs to tackle Europe’s declining economic competitiveness and societal challenges [46]. The proposal was developed and agreed under the Finnish Presidency in 2006. Living Labs were developed in response to a shift in the strategic discourse between government and business/universities. In Europe this discourse has been about driving innovation and thence economic development by more effective leverage of public investment in research [14]. This has been productive with significantly higher levels of engagement between business and academia than in Australia [5].

4.2. Evolution of living labs

A Living Lab is a real-life place for user co-creation of innovations in knowledge, products, services and infrastructures. [40] where user is used in general terms and may refer to those living in the lab, if there are any, but equally well to stakeholders from business, society and academia.

There are 170 active living labs in 20 of the 27 EU countries. Most are focused on delivering traditional economic returns (such as jobs, new products and services, regional economic

development). But there are sub sets, the so-called Sus Labs [40] and Urban Living Labs [47], Smart Cities [48] that seek to deliver benefits for traditional economic partners, as well as the public good or meeting societal needs [49, 50]. Even though it has been argued that the sustainable development community and living lab communities are "hardly intertwined" [51], increasingly living labs have been seen as an approach to deliver innovation based on societal and end user needs by producing knowledge, goods, services and infrastructure that is fit for the Anthropocene.

Stahlbrost (2012) proposes five key principles, which should permeate all living lab operations: value, sustainability, influence, realism and openness [52]. In the living lab literature there is a discourse about the need to reduce the environmental impact of economic activity in order to deliver value for all stakeholders, with a cleaner environment – rightly - being seen as benefit to society (for example 47, 52, 53]. There is clearly much in this argument. However, this misses the potential power of a living lab to showcase for society, government and business how innovation can be undertaken to meet evidence-based societal and end user needs though partnership between knowledge creators and knowledge users.

The key difference being reducing environmental impact of a product or service does not necessarily equate with meeting science based needs. The clear case in point is the scientific agreement behind the need to reduce carbon emissions. The research community is clear about what society needs to do to prevent anthropogenic climate change exceeding 2 degrees centigrade [54]. A key partner in the living lab community is the research community and the research community should respond to and implement its own research and deliver innovation and mitigation at the same time. It is also for this reason that leadership is so important.

Therefore, in table 2 Stahlbrost's (2012) 5 key principles have been reframed to be explicit about the imperative of delivering the evidence based needs of society as well as helping to deliver progress towards the remaining sustainable development goals.

-able 2. Five key principles underpinning living labs (based on Stahlbrost, 2012).

Principle	Definition
Value	Delivering value for all partners (throughout the value chain)
Sustainability	To follow scientific advice to help maintain a healthy environment as well as to help make progress towards delivery of all of the sustainable development goals
Influence	Acknowledging that all partners have influence in the product innovation process
Realism	Innovation should be conducted in as close to real life environment as possible
Openness	To have an open process to benefit from multiple perspectives

Living Labs offer the potential for universities, academia and society to co-create new knowledge and services together by bringing together various expertise to validate new products and services in a real-life environment [55]. The potential benefits are set out in table 3 below.

Table 3. Partner needs and potential partner benefits

	Need	Benefit
Academia	• Partnering with business for innovation • Higher impact research • Collaboration • Research income	• Enhanced role in a knowledge economy Increase research and teaching output • Higher impact research • Evidence based research • Combined research tracks
Industry	• Lack of capability in collaboration	• Developing competitive edge to build on time, to budget and consistent with SDGs
Government society	• Not meeting evidence based carbon reductions	• Make progress towards delivery of SDGs • Efficient use of investment in research

Dell'Era and Landoni (2014) have categorised 4 underpinning models of living labs in order to help with understanding the array of different business models [56]. Whilst helpful it is the grey areas between the models that will also reveal insights and develop new models [57] . The basic models are:

- Value capturing (using an existing technology in a new way (cf steam engines discussed above));
- Value creating (exploring new technologies);

- Based on open innovation; and
- Based on closed innovation.

Such categorization is useful since living labs cover a wide array of disciplines, products and services: from health, dementia [58], regional small and medium sized enterprises [59], energy and environmental decisions at a community level [60], people with disabilities [61], sustainable domestic technologies [50], eco-cities [62], smart cities [48], business models for successful innovation [63]; architectural [54] and enabling community innovation [64].

Living labs are not a universal panacea for linking business, universities and society and will not be appropriate for all circumstances. For example, highly innovative university spin-offs may not benefit due to the more homogenous nature of their social networks since real value is derived from a diverse social network [65]. But they are a highly flexible, simple and adaptable model for knowledge based innovation.

And more recently living labs have been created to develop professional competencies – this extending the product or service focus to an individual's development [66] . This latter methodology could offer insights to address the need for system changes to complement technology changes [20, 67].

4.3. Business models for innovation

Whilst leadership is critical for a successful living laboratory there is no single model of effective leadership – with different styles benefiting different geographic areas [68] and structure [40]. However, the business model does need to reflect the operationalisation of the living lab (ie open or closed, exploitative or explorative [57])). The question of different business models for different geographic regions does raise issues for the transferability of methodology [69] (rather than the living lab concept), and as such will result in some mix of learning by doing and learning from experiences of others [40]. However, the problems with transferring methodology between regions (and firms) can be reduced by close attention to understanding how each method works [42].

5. Conclusions and further research

In a knowledge-based economy the issue of developing living labs for innovation is a good one, which has been successful elsewhere. It offers a route to effectively commercialise new products and services in partnership with business. It is a model that can benefit all three actors at the same time (see table 2). Ultimately it can offer universities a more central role in society as their impact would be more widespread and visible. However Australian business and universities are poor collaborators. Change is demonstrably difficult to deliver effectively and continuously. It requires good leadership to create the environment that is accepting of change.

The exciting challenge for universities and business is how to collaborate for innovation whilst addressing the economic, social and environmental issues associated with the transition to a knowledge economy in a way that moves society out of the Anthropocene and towards the evidence based future that society has agreed.

Further research is needed in two areas to understand how to improve collaboration with industry. One area is around campus redevelopment. In such a scenario universities are contracting industry to refresh their campuses. As such universities have the opportunity to integrate research and teaching outcomes into the process. To date there is little evidence that this is being done.

The other is around leadership and whether universities adopting research outputs before asking others to adopt them would impact favourably the potential for business to partner with universities. The theory suggests it would.

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