Innovation, University Research and Information Infrastructure – making sound investments in information infrastructure

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ABSTRACT

Innovation determines the prosperity of nations. By equipping people with the skills to innovate, to embrace new and better ways of doing things, business and industry thrives, productivity increases and the nation benefits from a more prosperous and educated workforce. Collaborating and making connections are now integral to the innovation process, as information and ideas may come from anyone, anywhere, making innovation more pervasive, more open. Universities are key agents of a nation's innovation capability, as primary creators and disseminators of new knowledge, through research and teaching. They play a key role in the preservation and diffusion of knowledge through publishing, presentations, consultancies and the like. Increasingly nations seek to not only strengthen the key agencies of innovation, but also the links between them.

"Innovation is built on stocks of knowledge and capability, and the information flows of innovation capital around these." (Venturous Australia, 2008: p.18). If universities are the heart of the innovation system then information infrastructure is the lifeblood. It is through information infrastructure that knowledge is created, manipulated, interpreted, disseminated and preserved: through its libraries, information repositories, communication and collaboration tools, advanced computers, networks and its information specialists. This is recognized in many national and regional innovation strategies as agencies of government invest not only in their universities, but in a range of facilities.

But are we investing in the right ways in the right places if we wish to drive innovation through investment in information infrastructure? What is best done at a local university level? What is best done at a regional level? What is best done at a national level? What is best done through international collaboration? The global information landscape is rapidly evolving. Innovation, by definition, means change is a constant. Yet this does not absolve us, as university information professionals, from ensuring that our universities invest wisely in developing their information infrastructure, that they exploit regional, national and international opportunities in the most effective and efficient ways.

We must begin by understanding the vision and motivation of three of the key agents of innovation: the researcher, the university and the national government. When mapped against research information infrastructure services it is possible to determine a level of research information infrastructure service that any researcher should expect, that every university should deliver. These services are "pre-competitive" from a university perspective. They underpin the vision and motivations of the nation, the university and the researcher, driving competitive advantage for the nation as a whole, not privileging any university specifically. These are best delivered through national investment and national or international collaboration, in the most cost effective manner. There is a complex middle ground, where the inter-dependent motivations of the agents and the tensions between the short and long term make decision-making complex. Lastly there are services which provide distinct competitive advantage to a university. It is these that will yield the greatest investment benefit in the medium term. This paper seeks to assist universities to make informed investment decisions in their own information infrastructure and provide some observations on the ways in which universities may wish to shape regional or national information infrastructure policy.

1.   INTRODUCTION

This paper seeks to provide a framework to assist universities in making sound investments in research information infrastructure in an increasingly complex global knowledge economy. Whilst this paper is written from an Australian perspective, it is clear that in today's globalised world many of the drivers and challenges are common across the world's developed and developing nations – hence the strategies adopted by nations, and universities, are becoming increasingly similar. To develop a university investment framework it is necessary to understand the vision, motivations and strategies of the key agents who drive investment in research information infrastructure. For the purposes of this paper the key focus will be on the nation, the researcher and the university. This paper begins with a summary of the vision, motivation and strategies of these key agents. From this the implications for the development of research information infrastructure are teased out, providing the necessary foundation for the development of a university research information infrastructure investment framework.

1.1 A matter of definition

The term "research information infrastructure" within this paper is used in the broadest sense. Whilst much has been written about 'e-research' and 'cyberinfrastucture' the reality is that all research now requires the use of information and communication technologies- it is simply a matter of degree. "Research information infrastructure" within the paper refers to the information professionals, scholarly information, tools and technologies which underpin the research endeavor. Of existing definitions (of which there are many) it most closely resembles that of Borgman (2000 vi) - "encompassing the nation's networks, computers, software, information resources, developers, and producers".

2.   BACKGROUND

The act of research and innovation is a human activity, relying upon individual creativity and imagination, building upon existing knowledge. "Innovation is built on stocks of knowledge and capability, and the information flows of innovation capital around these." (Venturous Australia, 2008: p.18). If universities are the heart of the innovation system then information infrastructure is the lifeblood. We now live in a time where information and communication technologies have fundamentally re-shaped the ways in which knowledge is created, shared and preserved. Networks and associated technologies enable everyone to create, collaborate, access and share knowledge. The boundaries between nations, between organizations, between disciplines, between people have become permeable, increasing complexity whilst creating new opportunities and challenges. This world has been characterized as a global knowledge economy.

2.1 The innovation imperative

Innovation theory, and our understanding of the role that universities play in driving regional and national innovation, has evolved over the last twenty years. National prosperity in a knowledge economy rests upon the ability of a nation to apply existing knowledge and to innovate to build economic and social prosperity. By equipping people with the skills to innovate, to embrace new and better ways of doing things, business and industry thrives, productivity increases and the nation benefits from a more prosperous and educated workforce. Collaborating and making connections are now integral to the innovation process, as information and ideas may come from anyone, anywhere, making innovation more pervasive, more open. Many nations are responding to the innovation imperative through significant investment in universities, research and national information infrastructure. Australia has followed this trend, with the Federal Minister for Innovation, Industry, Science and Research commissioning the Cutler review in 2008 to examine the way in which Australia's national innovation system was positioned in a globally competitive Internet-enabled world (Cutler 2008). This led to the implementation of a Government innovation strategy, Powering Ideas, in 2009, a policy framework which seeks "to create a better Australia - a fairer, richer, healthier and greener Australia that can meet the challenges and grasp the opportunities of the twenty-first century….Our aim is to make innovation a way of life." (p.1).

2.2 The place of universities

"An internationally competitive economy begins with an internationally competitive innovation system – and that begins with internationally competitive universities." (Powering Ideas, 2009, p.32). Universities, as primary creators and disseminators of new knowledge, understandably feature heavily in the national innovation strategy. Within Australia most public research is done by universities. Universities play an important role as repositories of existing knowledge, together with a nation's research agencies, libraries and cultural institutions, and are hubs for the generation and exchange of new knowledge. Whilst networks are making more information accessible, facilitating collaboration, enabling anyone to contribute to knowledge creation, universities remain at the heart of a nation's innovation capability. Within the Cutler review there was recognition that innovation increasingly relies on distributed inter-organisational networks rather than innovation within an organisation. Universities form part of multi-faceted social or information channels or mechanisms through which information, knowledge and other resources are shared or co-produced- a much richer picture of university engagement than that of the traditional university concept of knowledge transfer (Perkmann, 2007). It is this richness that also creates complexity, creating new opportunities and new challenges for universities.

2.3 The place of information infrastructure

A nation's information infrastructure is central to its innovation system: from high speed networks, advanced computing and collaboration tools through to capturing research data for reuse, and making government data and national collections held by libraries, museums and other agencies more accessible. Not only do researchers and innovators require the tools to undertake their work, they require access to past knowledge upon which their creativity is founded. Australia creates 2% of the world's knowledge with 1.3% of the world's R&D expenditure (Cutler, 2008, p.20). Within this context national productivity growth will require the capability to adopt and adapt the 98 percent of new knowledge generated by the rest of the world. This highlights the need for a high level of interaction between knowledge providers and knowledge users. The role of the information professional will be critical to the broader innovation agenda. The importance of information infrastructure, in its broadest sense, had already been recognized through the National Collaborative Research Information Strategy which led to the release of a Strategic Roadmap for Australian Research Infrastructure, issued in August 2008. Powering Ideas served to reframe, reinvigorate and increase investment in national research information infrastructure policy and strategy.

3.   MANAGING IN COMPLEXITY- THE MULTIPLICITY OF AGENTS AND PRIORITIES

"The networked information economy has not decreased the total capital intensity of information production, storage, processing, and communication, but it has decentralized its ownership." (Benkler, 2008, p.52). Knowledge can now be created, disseminated, shared and preserved (or lost) by everyone. Even if we confine ourselves to university research and its place in national innovation we have a myriad of agents: individual researchers; research centres or groups, which may span organizational or national boundaries; the university; the region; the state; the nation. Overlaying these are other informal or formal groups, such as discipline-based scholarly academies, which may be global in reach. Each of these agents brings their own priorities and motivations to the task of driving research and innovation. Yet to achieve success in a networked global knowledge economy each must work in concert, must avoid competitive behavior which works against achieving shared aspirations for an improved future. Achieving the national innovation agenda requires not just a strengthening of the parts, but a strengthening of the links between those parts (Powering Ideas, 2009, p.1).

This paper focuses on the researcher, the university and the national government (referred to as "the nation"). The following section outlines the vision, motivations and strategies of each of these agents, drawing out the implications from a research information infrastructure perspective.

3.1 The researcher

The noble vision of a researcher is to create new knowledge, but in order to keep doing so they must build their research profile to ensure tenure and promotion, and build their reputation to

attract research funding and research partners. From a researcher's perspective whilst their focus is clearly on the immediacy of their research they also have an interest in maximizing their research impact through publication and citation impact. As the research environment has become more complex, as the reliance on information and communication technologies has increased across all disciplines, and as a variety of scholarly publishing options have evolved each providing differing impact value, researchers are increasingly valuing the role that information professionals, with disciplinary knowledge, can play as part of their research team. Work undertaken by the author at the University of Melbourne (O'Brien 2008) confirmed this, as has a recent study by Intersect (2009) across four Australian universities which found that academics are seeking expertise in data management, data analysis and IT support.

Very few of the respondents to the Intersect study were aware of the national and state agencies which have been established to advance research information infrastructure, with only 3-4% indicating they used services provided by any of these bodies. The reality is that they care little about where, or how, the scholarly information, systems or infrastructure are delivered to support their research. Their primary motivation is that such services are responsive, easy to use and cheap, or "free", so that they might focus their resources (time and money) on their actual research.

In summary, it is proposed that researchers are motivated to:

- Increase their research impact
- Build their research profile
- Maximize the resources (time, effort, money) available for the actual research
- Minimize the resources (time, effort, money) they must devote to providing the research information infrastructure required to undertake the research.

3.2 The research university

The vision of a university is to create new knowledge, influenced by national imperatives to seek solutions to the economic, social and environmental challenges of the 21st C. To do so they must continue to attract good researchers, strong research partners and research funding. From a research university's perspective there is an incentive to maximize the value of the university's research outcomes for both the short and long term. Whilst a university's research strengths and priorities will determine where they invest in the immediate term, universities are long lived institutions - they seek to protect their right to research the most theoretical and intractable uncertainties of knowledge, not simply those that have immediate practical application or that might be set as national priorities (Boulton and Lucas 2008). Universities constantly balance the tension between delivering immediate value to their nation, as measured through research rankings or commercialization of research, with their vision of creating new knowledge for future generations unhindered by the immediate political imperative. Many will seek to foster research and innovation across all their disciplines, hence university information strategies and policies need to support the research base broadly, as well as the areas highlighted as current strategic priorities.

The university's commitment to the long term also impacts on how they consider the management and accessibility of scholarly outputs. The university will be motivated to maximize its overall research impact through publication, but this will, or should, be tempered by a desire to not only increase citation impact and journal ranking but to maximize true impact of research through open dissemination, maximizing access for all, and in protecting scholarly output for future generations of scholars.

From a research information infrastructure perspective the university will seek to maximize the value of its investments, targeting investment where it will add the most value in the short and long term. Universities now realize they must collaborate to compete. There is a strong incentive to lobby for government funding of research information infrastructure collectively, and to compete for government and other funding individually.

In summary, it is proposed that universities, from a research perspective, are motivated to:

- Increase their overall research impact, using rewards and incentives to maximize research output and impact

- Boost their research ranking (prestige) to attract more research funding, good researchers and strong research partners
- Maximize the resources (time, effort, money) invested in driving competitive advantage
- Minimize the resources (time, effort, money) they must devote to providing "pre-competitive" infrastructure.

3.3 The Nation

At a national level the vision is to make the future better than the past, to make the nation more productive and more competitive, to address the economic, social and environmental challenges of the 21st C, to improve their nation's position on relevant international rakings such as those of the OECD. Governments, in their desire to build national competitiveness through research and innovation, seek to implement policies and strategies to maximize the value of their investment in university research to increase the economic and social prosperity of the nation. In a globally connected world nations must help their universities to be more competitive, and be more attractive collaboration partners. At a fundamental level they must ensure that appropriate national information infrastructure is in place, through a combination of government investment and stimulation of the private sector investment (see for example King and Kraemer, 1995; Andreotta, 1995).

Within Australia a Strategic Roadmap for Australian Research Infrastructure was issued in August 2008, at the same time that the Cutler Review was released. This Roadmap established a framework for investment in national research infrastructure, focusing on collaboration tools, a national approach to data services, high performance computing, high performance networks and access and authentication frameworks. It was the focus on a national innovation strategy that reinvigorated the national government's interest, resulting in significant further investment in research information infrastructure. More than A$3.1 billion has been allocated to the Australian national innovation agenda with more than a third of the funding targeted to build improved research information infrastructure. Strategies include more than a doubling of funding for the indirect costs of research flowing directly to universities over the next four years. This will provide Australian universities with the ability to increase their investment in research information infrastructure, should they choose to do so. An investment of A$1.1 billion has been made in the Super Science Initiative to "stimulate economic activity, supporting new jobs and building the platform for high-skill, high-wage careers in the future" (Australian Government, 2010), of which $900 million will be directed toward cutting edge research infrastructure. A further A$312 million targets e-research infrastructure:

- $97 million for data storage and collaboration tools through the Australian Research Collaboration Service (ARCS)
- A$48 million to establish a national research data commons through the Australian National Data Service (ANDS)
- A$130 million for national high performance computing initiatives and
- A$37 million for enhancement to the Australian research and education network.

It is also in the national interest to maximize the value of government investments in publicly funded research through policy, by requiring open access to the scholarly outputs from the research: both the published outcomes of the research and the data which underpins the research. Within Australia the major public research granting bodies now require adherence to the Australian Code for the Responsible Conduct of Research (2007) which requires proper management and retention of research materials and data for use by other researchers, subject to any ethical, privacy of confidentiality considerations.

In summary, it is proposed that the nation, from a research perspective, is motivated to:

- Maximize the impact of publicly funded research to make the nation more productive and competitive
- Boost the nation's ability to attract good researchers, and strong national and international research partners

- Build national competitive advantage through investment in appropriate research information infrastructure
- Drive effective use of public funds by research universities.

4.   BRINGING IT ALL TOGETHER

Creating a strong innovation system requires not just strong agents, but strong links between the agents. The actions of the agents are inter-dependant and, ideally, mutually reinforcing. Research information infrastructure plays a major role in both domains. Lynch (2008 p.78) posed the question "How does the campus cyberinfrastructure challenge differ from the national cyberinfrastructure challenge, recognizing that investments in these areas should be not just complementary but mutually reinforcing?" He highlights the need for local investment if a university is to be able to fully benefit from national investments. Borgman (2007, p.252) noted that "The situation calls for ways to balance the local needs of individual scholars, students, and teams with the global requirements of a distributed, multidisciplinary, multilingual, multipurpose e-Infrastructure." The complexity of the current environment should not be under-estimated. Universities have the potential to play a critical role in balancing these tensions, strengthening the links between the agents of innovation for mutual gain. The visions and motivations of the key agents have much in common, and it is these shared senses of purpose which will provide the best foundation for developing investment strategies that are acceptable, and valuable, to the multiple stakeholders. These aspirations must not be lost in the immediacy of daily demands – tactical behaviours must not be at the expense of the longer term strategic vision.

5.   TOWARDS A UNIVERSITY INVESTMENT STRATEGY

Within Australian universities, with more than a doubling of funding for the indirect costs of research flowing directly to universities over the next four years, it is timely to ask if we are investing in the right ways in the right places to drive research and innovation through investment in information infrastructure. As university information professionals we have an obligation to ensure that our universities invest wisely. We have an obligation to our researchers to ensure they are provided with the best possible research information infrastructure services. We have an obligation to contribute to, and exploit, regional, national and international opportunities in the most effective and efficient ways. Universities have a privileged position, with a unique opportunity to strengthen the national innovation system not only through their own actions, but through forging and strengthening the links between key agents within the innovation system.

By mapping the vision and motivation of three of the key agents of innovation: the researcher, the university and the national government, against the range of research information infrastructure services, a university investment framework can be formed.

5.1 Pre-competitive research information infrastructure

There is a level of research information infrastructure service that any researcher should expect, that every university should deliver. It is these services that I would describe as "pre-competitive" from a university perspective. They underpin the vision and motivations of the nation, the university and the researcher, potentially driving competitive advantage for the nation as a whole. These are the services which are best delivered through national investment, or national or international collaboration, in the most cost effective manner.

Questions to be asked are:

1. Does this service advance the vision and motivations of the university and the nation?
2. Does this service provide my institution with a greater competitive advantage if advanced at a national level rather than individually?

If the answer to these questions is 'yes' then influencing government policy and investment strategy, or seeking out collaborating partners, should be the preferred strategy. Examples of this would include high capacity information networks, national identity and access systems and data storage. National competitive advantage is derived from such networks, but from a university's perspective, unless this is an area of research for the particular university, their networks must simply keep pace.

Large investments in expensive "landmark" research infrastructure, such as a synchrotron or peak computing facilities would also meet these criteria. Even as increased performance and lower costs make it possible to derive more compute capability at a local level, whether within a university or a research group, with the growth of cloud-based services and increasing interest in driving green IT solutions it is becoming more difficult to justify the benefit of local investment in advanced research information infrastructure.

National identity and access systems are necessary pre-competitive infrastructure, enabling the nation's researchers to become part of the global research community. Universities must invest adequately to participate in such initiatives and encourage national collaboration and investment.

Data storage infrastructure, providing that appropriate security and access measures can be met, provides no competitive advantage to a university. This may be an obvious candidate for national investment, as is occurring within Australia, though it may increasingly make sense to source this internationally through the Internet cloud.

5.2 The complex middle ground

Some components of research information infrastructure services blend pre-competitive and competitive advantage in a complex fashion. This is where the tension of long term vision competes with immediate competitive advantage for attention. Where Marginson (2010) urges that we "recognize, understand and factor into our organizational systems the post-capitalist production of knowledge goods, which is the primary zone where we make our future."

Questions to be asked are:

1. Does this service advance the vision and motivations of the researcher, the university and the nation?

2. Does this service provide my institution with a greater competitive advantage if advanced at a national level?

3. Does this service provide my institution with a greater competitive advantage if advanced at an institutional level?

4. Does this service provide our individual researchers with greater competitive advantage?

If the answer to these questions is 'yes' then a more complex investment response is required.

Included within this domain are the scholarly publications, research data and associated tools, created by our researchers. Access to the world's scholarly information, which provides the foundation for the development of new knowledge, is arguably pre-competitive. Everyone benefits. Collaboration and investment at a national (or even international level, such as SCOAP3) ensures the best outcome for a university and the nation. Houghton and Sheehan (2006) analysed the literature and quantified the potentially measurable impacts of enhanced access to research findings, for researchers, government and the wider community. These benefits included more timely access to both accelerate collaborative research, adoption and commercialization; a greater opportunity to inform professional practice; the potential to create more informed citizens and consumers with implications for better use of health care, social benefits and education, and potentially improved productivity. Their modeling showed significant economic benefit from open access to publicly funded research, with, for example, an estimated 5% increase in access and efficiency in Germany worth USD 3 billion. Yet peer-reviewed prestige publication is still the route to academic success, and improved university and national research rankings. Publishing in the "right way", which may exclude opportunities for open access publishing, can significantly increase research impact as measured through citation and journal ranking, increasing a university's competitive advantage.

Scholarly output now includes not only the published works but the research data, tools and techniques associated with the research. An unknown amount of this research data will have value for the future as an important part of scholarly output. Whilst researchers are motivated to have ready access to the data, tools and techniques they have previously used for their own benefit, there are strong disincentives for researchers to engage with long-term data management, including concerns of loss of competitive advantage. Universities serve to benefit in a range of ways (see the following section). Again there will be an inevitable tension between maximizing institutional value whilst contributing to the global store of knowledge. This is an area where the researcher, the

university and the nation all have the potential to gain competitive advantage if a more coordinated approach is taken, but where the best investment model is still unclear.

Government policy and investment in services which encourage open access to the outcomes of publicly funded research make good sense. But the researcher and the university are also motivated to increase their research impact and prestige. Whether to influence and support government policy, whether to invest locally, becomes a matter of balancing tactical short term advantage for the university with longer term strategic advantage for both the university and the nation. Within Australia policy has been established to encourage open access to scholarly outputs. The government has provided policy incentives and investment to establish university-based digital repositories. Currently significant investment is being made in the development of a national research data fabric and the tools and data storage infrastructure to support this. This is an area of evolving policy, an area that will provide great opportunities, and many challenges, requiring all the agents to work in concert to achieve the best shared outcomes.

Ensuring senior university executive awareness of, and engagement in, national (and international) research information infrastructure opportunities will be critical if the most effective investment decisions are to be taken in the complex middle ground.

5.3 Driving a university's competitive advantage

As the services move closer to the actual researcher more competitive advantage can be derived from targeted investment. Where the answer to the following questions is 'yes' there is a distinct competitive advantage to be gained for the university.

1. Does this service advance the vision and motivations of the researcher, the university?
2. Does this service provide my institution with a greater competitive advantage if advanced at an institutional level?
3. Does this service provide our individual researchers with greater competitive advantage?

Where the bulk of research income comes through competitive grant funding for specific projects, and where government funding of the indirect costs of research is allocated out to researchers and research groups on an 'as earned' basis (as in many Australian universities), there is limited incentive for researchers to minimize duplication of services and infrastructure, particularly if they feel they must relinquish control. The researchers putting forward a research proposal may not know what infrastructure service options exist, nor how best to maximize the impact of their research (see for example the earlier studies mentioned). It is unlikely that they will understand how best to manage their research data if it is to provide long term value to the scholars of the future. It is pointless to assume that this will be resolved through researcher training. Researchers are not motivated to understand the evolving national research information infrastructure framework, nor to become experts in information/IT, nor is it a good use of their time and expertise. They may, across some disciplines, have an understanding of the landmark facilities available to them, though this should not be assumed. A university has the potential to derive competitive advantage by including information professionals at the inception stage of the research proposal, and as required throughout the research itself (though this latter work may be best covered by the research grant funding). This will ensure that the research maximizes use of existing university, state or national services and infrastructure (a university motivator) whilst minimizing the resources the researcher must put into providing research infrastructure (a researcher motivator) and driving more effective use of public funds (a national motivator). For the university it provides a distinct competitive advantage in many ways: producing more effective research, making the outputs of its research available for current and future scholars, attracting research partners and scholars and ultimately enhancing the university's research profile.

Whilst research data management forms part of the complex middle ground, there is real competitive advantage for a university through investment in this area. Existing research data can be re-mined and re-used, research algorithms, tools and techniques can be easily shared, large data sets can be visualised to render complex findings in useable ways. With appropriate stewardship research data has the potential to significantly increase research impact, provide competitive advantage to the university and the researcher by increasing their profiles, and attracting research partners and new researchers. Universities are one of the enduring features of the research

landscape and hence arguably a logical home for long term commitment to data stewardship. One of the policy problems with data curation and preservation is that the costs persist long after the project ends. Yet universities have invested significant sums of money (through government funding) in building and sustaining library collections for future generations of scholars. They have done so based on a belief that the library plays a key role in supporting their research and learning through preserving and making accessible scholarly output. Borgman (2008) suggests that research data may become the new 'special collections' for libraries.

Lynch (2008) sees the biggest challenge for universities as the design and staffing of organizations that will work with academics to access local, national and global cyberinfrastructure services, assisting faculty to manage their data, prepare for handoff for curation and aiding them in data reuse, mining, computation. By providing such services the university has the opportunity to gain real competitive advantage in both the short and long term.

Whilst open access publishing forms part of the complex middle ground, universities can gain real competitive advantage by making targeted investment in this area. In a complex evolving scholarly information environment it is neither reasonable, nor sensible, to expect researchers to necessarily know how best to maximize their research impact through publishing, nor to understand how best to balance the benefits of open access publishing with decisions about increasing impact though publishing in highly ranked journals. Real competitive advantage can be gained by a university establishing a publishing advisory service to assist researchers to maximize their research impact (O'Brien, 2010).

The new environment rewards researchers who profile themselves and their work most effectively. Researchers seek to build their research impact and profile, universities seek to build their research impact and ranking, and nations seek to maximize their research investment and build national competitiveness. They all stand to benefit from sophisticated systems to link information about university research strengths, researchers, their grants, their publications. There is merit in national policy and investment in this area, but universities and individual researchers, who hold most of the data, will be motivated to promote themselves and their work. Whilst this may be a candidate for the middle ground, in the short term it is likely that the greatest competitive advantage will flow to those universities who promote their research and researchers. Ideally this should occur within a framework that works for the nation and also for the individual researcher.

6.   CONCLUSION

Innovation, by definition, means change is a constant. Universities have a privileged position within a nation's innovation system, with a unique opportunity to strengthen the nation, not only through their own actions, but through forging and strengthening the links between key agents within the innovation system - building the bridge between researchers, university and national priorities. To achieve success in a networked global knowledge economy each of these agents must work in concert, ideally avoiding competitive behavior which works against achieving shared aspirations for an improved future. These issues are self evident when we consider the research information infrastructure required to drive competitive advantage. By better understanding the vision and motivation of three key agents of innovation it is possible to work toward an appropriate university investment strategy. There is a level of research information infrastructure service that any researcher should expect, that every university should deliver. These services are "pre-competitive" from a university perspective. They underpin the vision and motivations of nation, the university and the researcher, driving competitive advantage for the nation as a whole, not privileging any university specifically. These are best delivered through national investment and national or international collaboration, in the most cost effective manner. There is a complex middle ground, where collaboration and negotiation, coupled with investment at all levels, will provide the ultimate solution. Yet there are some services which provide distinct competitive advantage to a university. It is these that will yield the greatest investment benefit in the medium term.

This paper reflects the context from a time-bounded Australian perspective, a time when policy and technology are rapidly evolving. It is clear that many nations are following broadly similar strategies as we each grapple with increasingly shared challenges and opportunities. As university information professionals it will be our role to assist our universities, and our nations, to make informed

investment decisions. This paper has sought to provide some insight into the complexities, challenges and opportunities of the global knowledge economy of which we all play a part.

Innovation, University Research and Information Infrastructure

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Innovation, University Research and Information Infrastructure

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