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LEVERAGING R&D INVESTMENT FOR THE AUSTRALIAN BUILT ENVIRONMENT

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This paper discusses a current research project building new understandings and knowledge relevant to R&D funding strategies in Australia. Building on a retrospective analysis of R&D trends and industry outcomes, an industry roadmap will be developed to inform R&D policies more attuned to future industry needs to improve research investment effectiveness. The project will also include analysis of research team formation and management (involving end users from public and private sectors together with research and knowledge institutions), and dissemination of outcomes and uptake in the Australian building and construction industry. The project will build on previous research extending open innovation system theory and network analysis and procurement, focused on R&D. Through the application of dynamic capabilities and strategic foresighting theory, an industry roadmap for future research investment will be developed, providing a stronger foundation for more targeted policy recommendations. This research will contribute to more effective construction processes in the future through more targeted research funding and more effective research partnerships between industry and researchers.

KEYWORDS: R&D policy; R&D diffusion; innovation systems; strategic foresighting; industry roadmapping

BACKGROUND

This paper describes research currently underway evaluating impacts, diffusion mechanisms and uptake of R&D in the Australian building and construction industry. Starting with a retrospective analysis of R&D trends and industry outcomes, a future-focussed industry roadmap will be developed to inform R&D policies more attuned to future industry needs, to improve research investment effectiveness. This collaborative project brings together academic (Australia and Finland); Australian government agencies at state and national levels; and private sector players to address this critical issue. The project aligns with the recently released Organisation for Economic Co-operation and Development *Innovation Strategy* (2010) which highlights the need for a whole-of-government approach to innovation policy, and 'stable platform(s) for coordinating actions, policies with a medium- and long-term perspective' (OECD 2010:23). This project uniquely addresses this focus in the context of the Australian building and construction industry.

To this end, this research will develop new theory for interactive innovation, built on open innovation, dynamic capabilities and absorptive capacity theories, in the context of strategic foresighting and industry roadmapping. This is based on the hypothesis that each of these theories can be brought together to address the specific characteristics and tensions which impact R&D in this industry. Conditions specific to this and like industries, requiring this

unique investigation include its disaggregated nature, intense competition and limited R&D investment.

The building and construction industry in Australia accounts for between 14%-20% of GDP (Furneaux et al. 2010). In 2008, the cumulative value of site-based residential, non-residential and engineering construction was A$160 billion (Newton et al. 2009). The industry employs around 950,000 people through 250,000 firms, the vast majority of which are small to medium-sized enterprises. The Australian Bureau of Statistics estimates that from an initial A$1 million of extra output in construction, A$2.9 million in additional output could be generated in the economy as a whole. This would create nine jobs in the construction industry and 37 jobs in the rest of the economy (ACIF 2002).

However, the productivity of this industry continues to lag behind that of the rest of the economy (Property Council of Australia 2009). To address this, the Australian Procurement and Construction Council (APCC) and the Australian Construction Industry Forum (ACIF) identified a set of national KPIs to track industry productivity performance. These indicators were further developed by the Australian Cooperative Research Centre for Construction Innovation (CRC CI) (Furneaux et al. 2010). These KPIs relate to safety; productivity and competitiveness; economic security; workplace capability; and environmental sustainability/eco-efficiency. Examples of poor performance in these areas which illustrate the extent of the problem include:

1) Deaths in construction increased from 3.14 deaths per 100,000 workers in 2004 to 4.27 in 2008 (CFMEU 2010). This compares to an overall fatality rate of 2.7 deaths per 100,000 workers across all industries.

2) ‘Productivity growth in the building and construction industry was less than the average for the market sector over the past five years. Were productivity growth to match that of the market sector, economic modelling shows that the accumulated gain in real gross domestic product between 2003 and 2010 would approximate $12 billion’ (Royal Commission 2002:3).

3) Kajewski et al. (2001) identify a key driver for ICT uptake as improved productivity, however the level of uptake remains less than optimal (Gallaher et al. 2004).

4) Engineers Australia (2005) report that poor documentation is ‘contributing an additional 10 to 15% or more to project costs in Australia’ (EA 2005:3) with ‘substandard project documentation’ equating to an estimated financial loss of $12 billion nationwide annually (EA 2005:4).

These examples highlight the need for those participating in the innovation agenda in this industry to establish a more focused industry R&D roadmap for addressing these complex challenges.

SIGNIFICANCE OF THIS RESEARCH

The Australian Department of Innovation, Industry, Science and Research (DIISR 2010) identifies an overall decline in spend on science and innovation as a percentage of GDP in Australia since 1993-94 of 22% (DIISR 2010:2). Australia’s spend on R&D as a percentage

of GDP is 2%, compared to that of Denmark, Germany and the United States of 2.5%; and Finland, Sweden and Japan of more than 3% (DIISR 2010:3). To address this, the Australian Government has identified a number of key initiatives including a target of a 25% for increased business engagement in innovation in the next 10 years; doubling the tax incentive for small-business (a critical component of the building and construction industry in Australia); supporting targeted responses to climate change; improving innovation skills and capabilities in the workplace; and maintaining a focus on business innovation through government sponsored industry innovation council's such as the Built Environment Industry Innovation Council (BEIIC) (DIISR 2010:6). Informing this project is the Australian Government commitment to an increased 'use of metrics, analysis and evaluation to inform policy development and decision-making (DIISR 2010:9).

More specifically, Hampson and Manley (2001) report on the relatively poor innovation record of the building and construction sector in Australia with an R&D expenditure of 1.4% compared to the share of site-based construction activity in total output of 6.5-7% of GDP. Recent findings by the Department of Innovation, Industry, Science and Research reveal that trend performance of this sector in terms of Gross Value Added outcomes (i.e. a measure of the value of goods and services produced in a sector) remains well below that of the manufacturing sector, despite a considerable drop in that sector's performance in the past three decades (DIISR 2009:24).

DIISR (2010) also highlights seven *National Innovation Priorities* being: (i) public research funding supports high-quality research that addresses national challenges and opens up new opportunities; (ii) Australia has a strong base of skilled researchers to support the national research effort in both the public and private sectors; (iii) the innovation system fosters industries of the future, securing value from the commercialisation of Australian research and development; (iv) more effective dissemination of new technologies, processes and ideas increases innovation across the economy, with a particular focus on small and medium-sized enterprises; (v) the innovation system encourages a culture of collaboration within the research sector and between researchers and industry; (vi) Australian researchers and businesses are involved in more international collaborations on research and development; and (vii) the public and community sectors work with others in the innovation system to improve policy development and service delivery (DIISR 2010:4). This current research addresses each of these priorities.

NEED FOR THIS RESEARCH

Current methods to understand and improve the process of R&D investment in the Australian building and construction industry are not currently well linked to important environmental, social and economic drivers such as technological and market developments. There is a lack of compelling case studies, and only limited innovation frameworks of relevance to this industry. As such there is an urgent need to study the dynamics, constraints and future vision for the industry using a structured methodology to gain this understanding. This is an essential precursor to new strategic policy responses that explicitly respond to the key emerging industry drivers and place the industry in the optimum position to leverage R&D to improve its performance.

Recent research has identified macro approaches to industry policy on the one hand, and detailed evaluation of product and process innovations on the other. Many researchers have

also stressed the importance of the role of key individuals. These approaches neglect the role of dynamic network interactions between multiple players and the temporary organisational structure in an industry where innovations at the individual project level determine the success or robustness of R&D uptake for the industry more broadly.

The need for this research is further reinforced by the strong recent focus on innovation beyond the now traditional realms of R&D and 'business innovation', to that of broader influences and factors associated with learning and interaction (Kraemer-Mbula and Wamae 2010 and OECD 2010).

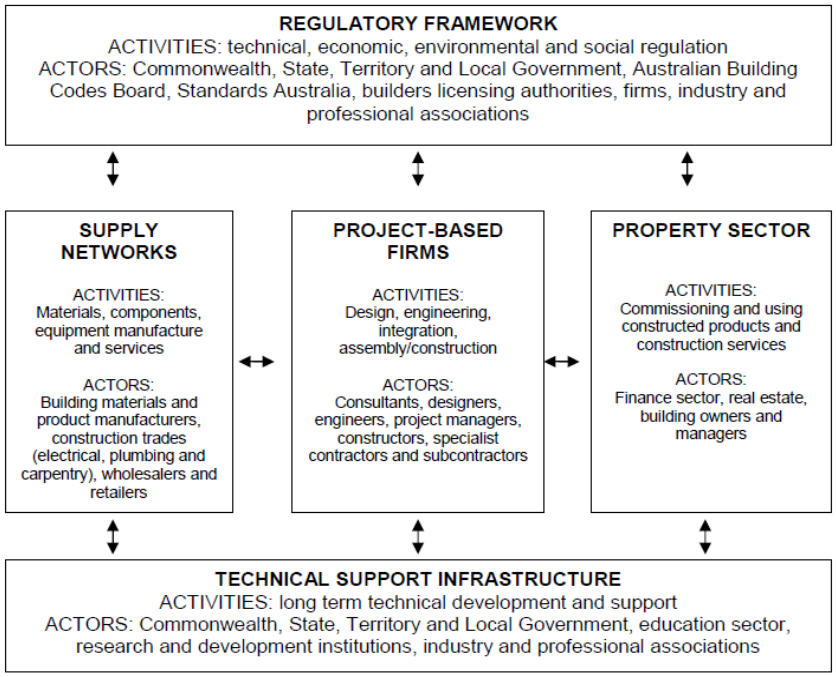
RESEARCH AIM AND INTENT

Aim of this research

The key aim of this project is to build new understanding and knowledge of R&D dissemination and uptake in the Australian building and construction industry, and thereby develop robust, sustainable pathways to increase the safety, productivity and competitiveness, economic security, workplace capability and environmental sustainability of the industry. The context for this aim is the national industry KPIs by the APCC and ACIF to track industry productivity performance (Furneaux et al. 2010). The development of strategies to maximise R&D's impact for improving industry performance becomes even more critical as the industry strives to respond to increasing public expectations in environmental protection and enhancement, increasing demand for packaged construction services and moves towards private-sector funding of public infrastructure.

Effectively leveraging R&D is a major challenge for the building and construction industry due to its disaggregated nature (Figure 1), intense competition and limited investment in R&D and new technologies including IT advancements.

Figure 1 - Building and construction industry cluster map (Department of Industry Science and Resources 1999:10)



Performance is further constrained by 'a focus on short-term business cycles and a project-to-project culture' (Newton et al. 2009). This project culture is also exacerbated by construction industry characteristics quite different to industrial manufacturing (Hampson 1993) such as location-dispersed sites, project cost, complexity, high risk of failure, limited repetitions in documentation and immobility of the final product, which make the construction industry unique (Nam 1990). Construction contracting in Australia is also regarded as a competitive and high-risk business (Uher 1994). This competitiveness is largely due to the fragmented nature of the sector with layers of often temporary contractor/sub-contractor relationships, with cost traditionally being the prime factor in the tender selection process (Hampson and Kwok 1997).

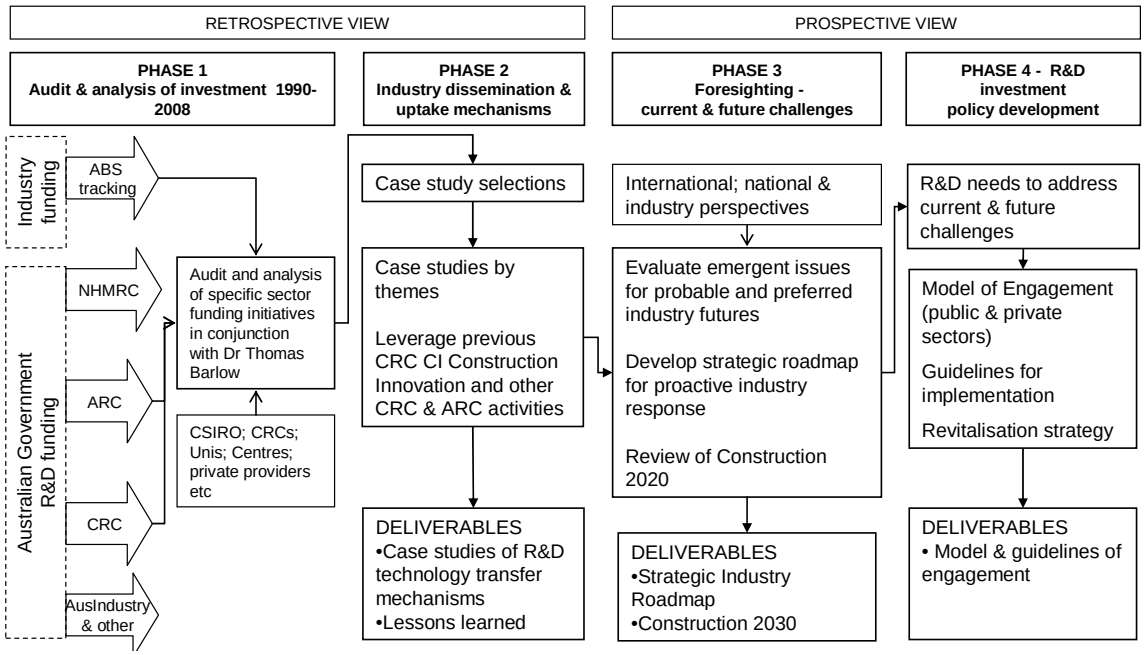
Research Intent

The intent is to develop new models of interaction and investment that maximise the value of R&D investment in this and like industries. These models will be based on improved understandings of the nature of future industry research needs, and lessons learned in diffusing research outcomes into public and private industry practice.

It will provide benefit to both public and private organisations in enhancing their uptake of R&D outcomes. This will be achieved through the active involvement of public sector infrastructure and building agencies, public sector social and economic infrastructure agencies along with industry leaders in innovation. The Chair of the Built Environment Industry Innovation Council (BEIIC) has stated that "this project will address many of our Council's documented concerns and I look forward to working with your team to assure the effective shaping of our industry inputs, and dissemination of project outcomes" (2010).

To achieve these aims and intent, four project phases have been designed (Figure 2).

Figure 2 - Project Overview



Research Method

This research provides a unique opportunity for a comprehensive study of R&D investment in the building and construction industry in Australia. Innovation and innovative behaviour are seen as key opportunities to raise industry performance and meet new challenges as the industry evolves. To achieve its stated aims, this research will develop a methodology to analyse and understand the multiple facets of the industry through the investigation of three research questions:

1) What are the success criteria and critical challenges which impact the industry's ability to maximise benefit from R&D investment?

2) What input into, and outcomes from, strategic foresighting and roadmapping are required in order to develop an effective R&D investment strategy?

3) What policy directions and initiatives are required to promote the pathways identified in the strategic roadmap?

The methodology underpinning this research brings together the combined strengths of the research team, and the practical working knowledge of industry collaborators. Researchers will integrate existing construction and management theory from a number of areas, specifically open innovation, dynamic capability and absorptive capacity theories in the context of a strategic foresighting and industry roadmapping process.

Open innovation system theory will be utilised to develop a deeper knowledge of R&D investment, diffusion and uptake. In this context R&D is treated as an open system in which innovative and 'valuable' ideas (contributing to organisational competitiveness) can be obtained from both within and outside traditional organisational boundaries (Chesbrough et al. 2006). Barlow (2006) discusses the approach as the 'increasing tendency of big companies to down-source radical innovation and creativity to small firms and the corresponding tendency of small firms to contract 'upwards' the development, scale-up, marketing and distribution of their radical new ideas' (2006:231). With the majority of organisations in the construction sector being small business (De Valence 2010:55), a key issue for this research is how open innovation systems can contribute to R&D diffusion and uptake.

Dynamic capability and absorptive capacity theories may provide additional insight into this approach. The former will be used to address the ability of organisations 'to shape, reshape, configure, and reconfigure enterprise assets so as to respond to changing technologies and markets' (Augier and Teece 2006:405). This ability enables organisations to identify and use those capabilities required to maintain advantage in a changing and competitive environment (Teece et al. 1997, Eisenhardt and Martin 2000, and Teece 2007). While absorptive capacity may be considered as one of these capabilities, explicitly considering this theoretical approach raises considerations of an organisation's 'ability to recognise the value of new, external information, assimilate it, and apply it to commercial ends' (Cohen and Levinthal (1990:128).

Further to this basis for investigation and analysis, strategic foresighting theory will be used to develop a unique, robust and valuable model of engagement for future industry R&D investment. In this context, foresighting is the intent-driven application of systematic and participatory future intelligence gathering and vision-building to inform decision-making and action-taking (Voros 2003, 2006 and 2009). Through this process, future state goals will be

defined with associated short, medium, and long-term strategies proposed for an industry R&D roadmap (Roos and Pike 2008).

Adopting this combination of theory will both facilitate and challenge current research thinking in this field. AEGIS (1999) and de Valence (2010) highlight the diverse and complex nature of the building and construction industry in Australia. This potentially requires different strategic approaches to R&D and its dissemination across this industry, whilst the competitive nature of the industry may also inhibit the sharing of 'valuable' ideas. Through bringing together these theories in this specific context, this research seeks to highlight and address the tensions which exist in both the theory and in industry in order to better foster the uptake of R&D outcomes in this industry.

The four project phases designed to build new knowledge, and develop an industry R&D roadmap and policies for dissemination are:

Phase 1 –Audit and Analysis of Investment - 1990-2008

This phase involves an audit and analysis of R&D investment in the Australian building and construction industry. This includes the identification of trends in this investment, (in universities and government agencies) and its distribution by funding source. Outcomes of this phase will include: (i) recommendations as to how R&D investment in this industry might be strengthened; and (ii) benchmarking between this and other comparable sectors. This will draw upon data gathered from the Australian Bureau of Statistics and the Australian Research Council, using information from public and private organisations.

Phase 2 – Industry Dissemination and Uptake Mechanisms

Phase 2 will provide a deeper insight into R&D dissemination and uptake through exemplar case studies. This will develop the existing knowledge base developed by researchers at the CRC for Construction Innovation and the Queensland University of Technology, relating to the impact, diffusion and uptake mechanisms of research and innovation in public and private built environment organisations. These case studies will be used to determine the critical characteristics of the processes of realising research support, direction-setting, project engagement, identifying and communicating research outcomes, and importantly, paths to adoption and impact.

Case study selection will take into account organisational engagement at various stages of the supply chain. In-depth understandings of the translation of R&D investment into tangible outcomes will be sought from these including: (i) explicit and implicit problems being addressed by the research; (ii) criteria for success and critical challenges; (iii) benefit/cost ratio and return on investment; and (iv) what would be the benefit if extended across whole industry?

These investigations will be based upon the successful *Building Research Innovation Technology and Environment* (BRITE) case studies previously undertaken through the CRC for Construction Innovation (Manley 2006), these studies will provide the hindsight to 'trace the interactions among … breakthroughs that led to present achievement' and to learn 'how basic research and synergies … took place and contributed to the system under study' (Gordon 2000:1). Through selecting and focussing on a discrete number of thematic case studies, researchers will undertake some initial 'backcasting' to examine decisions made up to 30 years ago in specific leading R&D programs (Courtney 2010). Case studies where the evolution from idea to policy to practice can be traced and analysed will be targeted. A

further key outcome of this phase is a valuable industry knowledge base that captures a snapshot of the industry R&D strategies and practices at the present time.

Phase 3 – Foresighting – Current and Future Challenges

This phase will extend a solid base of technology and industry foresighting carried out by VTT Technology Foresight and Technology Assessment research unit (Finland) and Swinburne University of Technology (Australia). Foresighting in this context is the intent-driven application of systematic, participatory, future intelligence gathering and vision-building processes to inform present-day decisions and mobilise joint actions. To achieve this, foresighting and content experts are brought together to develop strategic visions and anticipatory intelligence. From these goal states, short, medium, and long-term strategies are defined in the context of a *roadmap* (with supporting strategic implementation actions). This is targeted towards different aspects of a business, with technology and R&D investment and activities being the focus of this project. Key assumptions in this process include: (i) visions serve as the basis for continuous evolution and innovation; (ii) clear roadmaps define the path from today (as-is) to the desired vision (to-be); and (iii) strategic implementation actions provide the means to follow the roadmaps to achieve the vision (Kynkäänniemi 2007 and Kazi et al. 2007).

The application of technology roadmapping to underpin industry policy formulation has long traditions in Europe (e.g. Finland), but has had limited use in Australia especially in the building and construction industry. No research relating to the application of technology roadmapping to inform decisions on business model choice has (to our knowledge) been undertaken. This research will thus provide a substantial contribution to cumulative knowledge in the field.

This work will better inform public policy development and shape public and private organisations' technology strategy. Along with the R&D roadmap, a key outcome of this phase will be the review and revitalisation of Construction 2020 (Hampson and Brandon 2004), to provide a focus for R&D investment in Australia through to 2030.

Phase 4 – R&D Investment Policy Development

The intent of this phase is to maximise the value of R&D investments to public and private organisations. The first step will be to identify: (i) priority opportunity areas and applications for R&D investment; and (ii) actions for implementation. The key tangible outcome of this will be a *Model for Engagement and Guidelines.* These will provide a clear set of strategies to allow public and private organisations to more profitably engage with research institutions to secure valuable short, medium and long term benefits. Through involving key players in the development of this output (i.e. the Built Environment Industry Innovation Council, relevant State Government Departments and key industry and research players) the developed policy outcomes will become central to R&D investment in Australia in the following decade. This final phase will be informed by dynamic capability and open innovation theory to facilitate uptake.

DISCUSSION

There are several anticipated outcomes of this research.

Firstly, this project will advance the knowledge base within innovation, construction and management research, as well as foresighting and roadmapping disciplinary knowledge. Specific theories, methodologies and tools in each of these disciplines will be extended and adapted to better address the specifics of the Australian building and construction industry.

Secondly, a new integrated innovation methodology has the potential to lead to better understanding and dissemination of R&D outcomes in the disaggregated, highly competitive, project-driven building and construction industry. Through a comprehensive exploration and integration of these relevant theories, contextualised through historical data and case study analysis, this study can make a leading edge contribution to the international knowledge base.

Thirdly, this research will build an extensive knowledge base of underlying drivers and key success factors for innovation in the Australian building and construction industry. This knowledge base will derive from the Phase 1 audit and analysis, Phase 2 case studies; and the extensive workshops proposed for Phase 3. Through data and knowledge from each phase informing the next, the process of refinement will result in targeted and relevant outcomes.

And finally, research outcomes will contribute to policy development for this industry, in Australia, for the coming decade. Through bringing together key industry players to develop an industry R&D roadmap, and pursuant policy guidelines, this research will provide a valuable resource for national and state public agencies, and private organisations to better capture the benefits of using R&D as a driver for competitive advantage.

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