Sustainable Built Environment National Research Centre

PROJECT 2.7

LEVERAGING R&D INVESTMENT FOR THE AUSTRALIAN BUILT ENVIRONMENT

A Vision of R&D Policy Directions

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March 2012

OUR VISION FOR THE FUTURE:

1. A national industry steering body which defines long-term strategic industry R&D priorities, and funds associated research in public organisations.

2. Government procurement shaped to support construction innovation and supply matching funds for strategic R&D.

3. Networked research institutes with world-leading interdisciplinary capabilities to provide expertise and skills relevant to the goals of the Australian construction industry.

This vision is underpinned by a culture of self-improvement, mutual recognition, respect and support across the innovation system.

1. RECOMMENDATIONS

Industry (includes government as a producer and asset manager)

It is in the best interest of the industries servicing the Australian built environment to engage with public research. This industry must lead and invest in its own research and innovation. However, traditional internal industry R&D is characterised by uncertainty, short-term focus and a reactive nature. The following actions could provide a link between industry and public-sector priorities to serve the long-term interests of the industry:

- Establish a national industry steering body to define long-term (5 - 15 year) R&D priorities for the construction industry, to be revised annually.
- Disseminate these priorities throughout industry, government and public-sector research organisations to help align research priorities and capacity building to achieve co-creation of knowledge with the long-term strategic interests of industry.
- Provide a new funding stream (derived in part from industry sources) to be distributed directly by the proposed industry steering body in order to provide incentives to public research organisations to grow capacity that is aligned with the long-term industry needs.

Government (as a client, regulator, and investor)

All governments must actively ensure that public infrastructure investment is effectively delivered:

- Public procurement should establish systematic and consistent standards that will drive innovation through investment in infrastructure. These activities should be paralleled with investment in relevant R&D capability. For example, if the Federal Government commits to allocate A$20 billion over four years through Infrastructure Australia (Minister for Infrastructure and Transport, 2008), leveraged by other local, state and territory funding, it ought to align its procurement mechanisms to build key industry capabilities and designate a defined percentage of the funding for R&D.
- State governments, through existing levy mechanisms funding trade training (industry training funds), should allocate a proportion of these funds towards long-term strategic R&D

determined by state chapters of the proposed national industry steering body. Research collaboration needs practical mechanisms for knowledge diffusion beyond the immediate research partners in order to change business practices.

- Federal funding for Centres of Excellence, CRCs, ARC Linkage funding, and CSIRO internal funding should: reflect the long-term strategic priorities identified by the proposed national industry steering body; and offer incentives for public research bodies to align their research capabilities with the needs of regional industry.

1.1. Public research organisations

Universities and government research agencies are highly reactive to external financial incentives. Public organisations can provide leadership through the following actions:

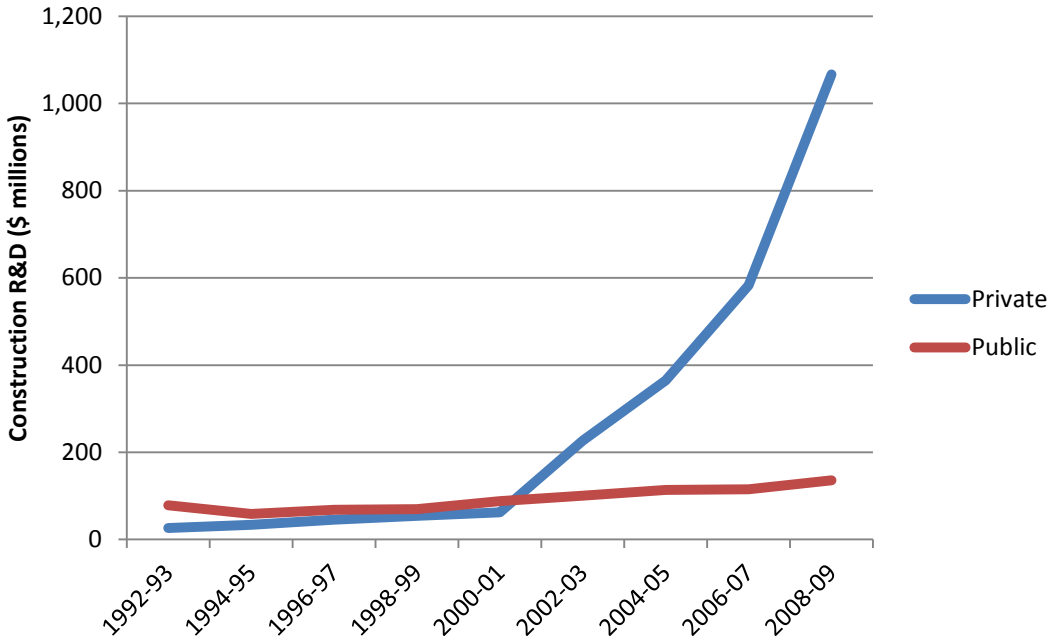
- Senior decision-makers in public research organisations must integrate industry priorities into internal investment allocation in order to ensure that their research capabilities match long-term industry needs; and
  Public research organisations building ongoing strategic partnerships with the construction industry while retaining a focus on leading-edge practice and transformational change.
- Build leading centres emphasising interdisciplinary models (social as well as technical), and ensuring initiatives are globally connected.

2. A DYNAMIC AND INNOVATIVE SECTOR

A substantial increase in the Australian private investment in construction[1] R&D over the last two decades has led to a more innovative and dynamic construction sector. However, a mismatch exists between public and private investment (Barlow, 2012), with consequences for industry capabilities.

[1] As defined by the Australian Bureau of Statistics, the construction sector includes building construction, civil and housing, engineering construction and construction services.

Figure 1 – Private versus public R&D on 'construction' (Barlow, 2012)



Note: (i) Derived from ABS 8112 and Barlow 2011. (ii) Shows R&D expenditures by sector focused on the socio-economic objective 'construction'. (iii) 'Public R&D' counts R&D from the university sector and from state and federal government agencies.

In 2011 SBEnrc carried out three case studies to showcase differing processes in place to realise research support, project engagement and pathways to adoption, and impacts (SBEnrc, 2011):

- **Road construction safety** - R&D undertaken by the Queensland Department of Transport and Main Roads (QTMR) in developing a safer working environment for road construction workers. Initiatives examined included: the development and implementation of *Mechanical Traffic Aid;* the *Thermal Imaging Camera;* and *Trailer-based CCTV* (Kraatz, Hampson, & Campana, 2012).
- **Green buildings** – examined initiatives led by the Western Australia Government contributing to greening the stock of government buildings in that state and the leadership provided to the commercial development of other non-residential buildings (Hampson and Kraatz (2012), Kraatz, Hampson, and Campana (2012)).
- **Digital Modelling/Integrated project delivery** – explored the evolution over the last 20 years within the Project Services division of the Queensland Department of Housing and Public Works (QDHPW) which has led to the current implementation of advanced ICT through building information modelling (BIM) and integrated project delivery (IPD) (Kraatz, Hampson, & Campana, 2012).

Key findings from these three national case studies include (SBEnrc, 2012b) the important role of government in driving change, the pivotal importance of training and skill development underpinning innovation, the need for the right incentives to promote new behaviours, and the value of personal networks across the innovation system.

The Australian construction industry has grown in terms of gross value added (GVA) significantly faster than the Australian GDP in the last two decades (Barlow, 2012) and it is expected to continue

to have high activity and investment in the residential building and engineering construction sectors in Australia's capital cities (ACIF, 2012). Future uncertainty existing around: climate change policy, skills, economy, attitudes, policies/governance, energy and technology. Dramatic changes across a range of variables have the potential to change the nature of this industry (SBEnrc, 2012a).

To face the challenges ahead, a set of R&D priorities for the Australian industry have been articulated through the development of an industry roadmap. This was done in conjunction with key participants from nation-wide workshops held in 2011 (SBEnrc, 2012a). Five national core R&D priorities have been determined for the Australian property and construction industry:

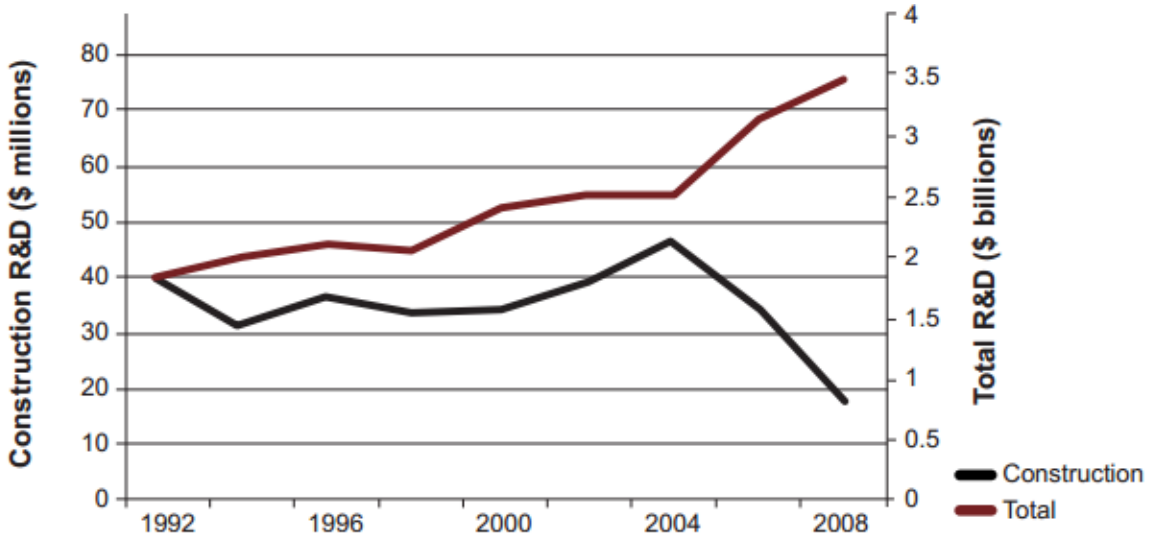
1. *Model-based facility lifecycle business models* – model-based information technologies for facility lifecycle management
2. *Intelligent infrastructure and buildings* – use of long-life sensors and information technology to improve facility durability and performance, and to reduce life-cycle costs
3. *Solutions for a more sustainable built environment* – adapt to changing market and regulatory environment and potential climate change
4. *Information and communications technology for radical redesign* – optimisation tools for integrating product and process design, for integrating single assets into local and regional networks, and for improving energy efficiency
5. *Biotechnology for tree-based materials* – develop materials, products and processes based on trees for structural and non-structural applications.

3. THE CHALLENGE

The Australian construction industry is an innovative and dynamic sector of the economy. However, SBEnrc has identified five key challenges that the industry still has to overcome that will require support from other sectors.

Nevertheless, all Australian governments have reduced their emphasis on construction R&D as a proportion of its total R&D spending. Between 1992 and 2008, government agency spending on construction R&D fell from 2.2% to 0.5% of total government sector R&D expenditure (Figure 2).

Figure 2 - Government agency R&D focused on 'construction' (SBEnrc, 2011)



Note: Derived from ABS 8109 and Barlow 2011. (ii) Compares government intramural R&D expenditures focused on the socio-economic objective 'construction' (left axis) with total government intramural R&D expenditures across all objectives (right axis) (iii) The right axis has been adjusted so that the growth-rates of both curves from 1992 are comparable.

The SBEnrc has identified the following key challenges and possible solutions:

1. *Timeframes* – A mismatch in the nature of research objectives between the public and private sectors is apparent. The private sector is typically driven by short-term, project-based objectives and workflow. Counter to this the public-sector's traditional focus has been on longer-term 'public benefit' objectives of strategic value to the community and the built environment. Research initiatives that engage both private industry and the public sector tend to maintain the short-term focus (based on research funding cycles) often with a more commercial rather than strategic focus. This can result in public organisations being reluctant to initiate joint activities, which in turn limits the development of synergies between both sectors. One consequence of this is a reduction in industry research capabilities which does not serve longer-term interests. **Implication: A mechanism to encourage/enable public and private organisations to build greater long-term strategic research capabilities is required.**

2. *Fragmented nature of the industry* – Historically, there has not been coherent strategic planning within the industry due to fragmentation across all phases of the delivery supply chain and competing demands from sector participants (Newton, Hampson, & Drogemuller, 2009). This has led to difficulties achieving general agreement of research priorities. Additionally, the short-term, project-based nature of the industry impacts on organisation-based knowledge retention, eroding the capacity for experiential learning and long-term strategic thinking, with consequences for industry-wide learning or knowledge management. **Implication: Industry will only act strategically to define their common problems if they have a clear incentive to contribute and if there is a well-defined structure to define such research priorities.**

3. *Industry structure in the building sector* – The Small and Medium Enterprise (SME) focus of the industry restricts the capacity of most firms to: (i) invest directly in long-term R&D; or (ii) readily access innovations produced by others. Levies (currently underutilised) can have a significant impact on research outcomes through which organisations can improve training to SMEs. Research-

informed training is however still lacking. **Implication: There is a need to shift some of the levy funds to both R&D and training to achieve better industry outcomes.**

4. *Government risk aversion* – The public sector (local, state, and federal agencies) makes up Australia largest focussed client for construction projects. These government clients are often characterised as risk averse in terms of procurement, seeking the lowest conforming tender with the least possible cost. The public ownership of assets can also inhibit innovation in facility construction and maintenance where alignment between research and construction procurement is not well managed. **Implication: Governments need to: encourage innovation through the procurement process and introduce an R&D component to all major infrastructure and building programs.**

5. *Public sector expertise* – In most cases greater technical excellence exists today in industry than public sector, partially as a result of the disparity in R&D investment between the two sectors and a trend to outsourcing technical expertise. Furthermore, there is little incentive for leading researchers to engage in industry collaborations due to the greater prestige given by national competitive grant-funded research and lower perceived value of industry-relevant research. **Implication: An opportunity exists for practitioner/researcher exchange - to build a shared culture of innovation unhindered by traditional models. This would lead to: a rise in interdisciplinary approaches and potentially unorthodox solutions to industry challenges.**

4. MODELS OF INDUSTRY R&D ENGAGEMENT

4.1. Industry-sponsored research

Several examples exist globally of industry-based research funding bodies, typically initiated without government funding or leadership. However, research funding disbursed by these organisations across industry has often leveraged government funding such as ARC and CRC funding schemes. A key feature of this model is the focus of research on strategic, pre-competitive research with benefit to all consortium members, rather than individual firms. Members meet to: determine and prioritise objectives; assist in investment decision-making; and access to research outcomes.

Additionally, these consortia may also broker research partnerships between individual companies and public-sector based research providers to address a specific challenge faced by a particular company. This activity is enhanced by the existence of a broad capability and an established relationship built up through the sponsorship of previous strategic, pre-competitive research.

Three leading examples of industry-sponsored research councils are:

(i) AMIRA International (mainly based in Melbourne, Australia) – an independent association of minerals companies created to develop, broker and facilitate collaborative research projects.

(ii) Semiconductor Research Corporation (SRC, mainly based in North Carolina, USA) – a global industry/university consortium specialising in semiconductor research.

(iii) The Welding Institute (TWI, mainly based in Cambridge, The UK) – international consortium of researchers, scientists and engineers specialising in manufacturing, fabrication and management technologies.

4.2. Government-mediated industry R&D

Australia has a strong tradition of assisting industries with high SME involvement through funding for R&D. The common model is to levy industry activity and distribute these funds to priority areas identified by an industry board. The best known examples in Australia are the rural R&D corporations which have been acknowledged globally for their significant innovation in public research policy.

Internationally, the levy model has been employed to support R&D in construction: in New Zealand through the Building Research Association of New Zealand (BRANZ); and in Singapore through the Construction Industry Development Board (CIDB) for example. These entities have their funding directed towards industry priorities identified by an industry-led board, with input from government and researchers. Based on the levy model, building and construction industry training funds have been established for the building construction sector in Australia, to invest in trade skills development. This fund could theoretically be modified on a state-by-state basis through legislative amendments to also foster a viable and industry-responsive research fund.

Government can also play a role in encouraging industry players to associate and to develop a shared vision. One example of this is the Built Environment Industry Innovation Council (BEIIC), an industry body tasked with advising the Australian Government on innovation challenges. This Council has played an important role in bringing together many representatives from disparate organisations across the industry. A smaller and more focused group constructed along similar lines, and led by industry, could play a significant role in driving a future Australian public-private research agenda.

In addition, the Australian Government's planned *Industrial Transformation Research Program* is worthy of consideration. This program supports quality R&D partnerships that will help transform Australian industries. The Program is planned to: (i) focus on research areas that are vital for Australia's future economic prosperity, such as engineering, materials science and nanotechnology, communications, chemical engineering and biotechnology; (ii) support industrial PhD students and researchers to gain 'hands-on', practical skills and experience in these areas; and (iii) foster important partnerships between business and universities[2].

The China Architecture Design and Research Group (CAG) for example is probably the largest state-owned design enterprise in the world with over 1,000 senior designers and researchers, delivering a direct impact on construction projects such as the Beijing Railway Station and the National Stadium for the 2008 Olympic Games (Long, 2007). The link between national infrastructure priorities and industry research support is key in this example.

Infrastructure Australia[3] is a statutory body established in 2008 to advice government, investors and asset owners on issues relating to current and future infrastructure needs; financing mechanisms; and policy, pricing and regulatory issues. Its focus is on assisting governments to develop a strategic blueprint for future infrastructure investment. This agency distributes substantial government infrastructure funding and acknowledges a lack of R&D capacity linked to such investment (Infrastructure Australia, 2012).

[2] http://www.arc.gov.au/ncgp/itrp/itrp_default.htm
[3] http://www.infrastructureaustralia.gov.au/about/

Other strategic research partnerships may also be available. A number of the Construction 2030 priority areas have a natural affinity with existing Commonwealth-funded research programs or organisations. For example, the advanced IT focus may have synergies with research being commissioned by the National Information and Communication Technology Australia (NICTA): the nano-technology emphasis may be usefully linked to the Australian Nano Fabrication Facility (ANFF). Other government programs could potentially be identified that, while not specifically research focussed, potentially lend themselves to supporting industry research objectives. In particular, programs relating to advanced ICT, climate change, environmental efficiency and indigenous housing may be worth considering.

Further to all the above, the Australian Government could supply funds for strategic R&D from: (i) the construction industry levy; (ii) a fixed R&D provision associated with major infrastructure fund; and (iii) a mixture of traditional public funding schemes.

4.3. Government R&D tax programs

The Australian Government offers research and development (R&D) tax concessions and incentives to promote innovation.

The Research and Development Tax Concession was introduced in 1986 to encourage Australian industry to undertake such activities. It aimed to make eligible companies more internationally competitive by encouraging innovative products, processes and services and by promoting technological advancement and strategic R&D planning. It was intended to create an environment conducive to increased commercialisation by eligible companies. The concession was broad-based and market-driven (DIISRTE, 2011).

The R&D Tax Concession was replaced on 1 July 2011 by the Australian Government's A$1.8 billion R&D Tax Incentive (Australian Trade Commission , 2012) to provide tax offsets to encourage more companies to engage in R&D (ATO, 2012).

The program aims to help more businesses do R&D and innovate. It is a broad-based entitlement program, open to firms of all sizes in all sectors who are conducting eligible R&D (AusIndustry, 2012)

On the one hand, a 45% refundable tax offset, equivalent to a deduction of 150%, is available to eligible SMEs with an annual aggregate turnover of less than A$20 million (ATO, 2012).

On the other hand, a 40% non-refundable tax offset will be available to companies with an annual aggregate turnover of A$20 million or more - equivalent to a deduction of 133% and unused offset amounts may be able to be carried forward for use in future income years (ATO, 2012).

The Australian government has also announced that it will introduce quarterly credits for SMEs from 1 January 2014 (ATO, 2012).

These tax incentives have been widely used by industry and can be utilised for project-based as well as corporate R&D activity.

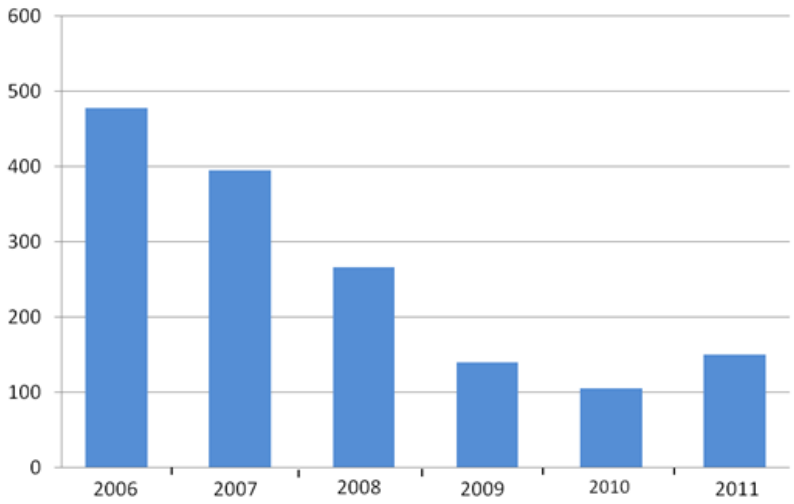
4.4. Government grants

Historically, Australian governments have sought to build partnerships between diverse industries and public sector researchers via long-standing public granting schemes. The *Australian Research Council (ARC) Linkage scheme* provides project-based funding to support collaborative research between universities and other members of the innovation system, including industry partners. The

Cooperative Research Centres (CRC) program fulfils a similar purpose at a larger scale and involving more partners, providing longer-term program-based funding.

Recently, these schemes have struggled to foster substantial public-private partnerships, despite the strong recorded growth in the private sector internal investment on R&D. For example, CRC funding capacity has been declining over the last decade leading to a total funding reduction (inflation adjusted) of 69% (Figure 3). Moreover, the CRCs that have been funded have tended to focus on very specific scientific themes. At present there is no CRC that serves the strategic supply chain issues of the construction industry.

Figure 3 - Total CRC funds granted between 2006 and 2011 (A$ millions adjusted for inflation to June 2012) (CRC 2011)



The ARC Linkage program has also experienced a steady decline in the funds granted (funds granted in 2012 were 25% lower than in 2006 in June 2012 dollars) (Figure 4) and success rates after the peer review process remain relatively low (average 43% success rate of applications lodged over the last seven years). Furthermore, although the overall allocation of funds as a percentage of the request has been increasing over the past 7 years, the same indicator has been significantly decreasing over the same period for those discipline categories under which built environment projects can be classified (Figure 5), falling by 14% between 2006 and 2012 (ARC, 2012). Additionally, traditionally there are two ARC Linkage rounds each year. The April 2012 round was cancelled and the funds reallocated to a proposed Industrial Transformation Research Program, but at September 2012, submissions have still to be called. These trends become a significant disincentive to industry participation if grant applications with willing industry partners are rejected or severely minimised, potentially reinforcing a culture of poor engagement.

Figure 4 - Total ARC Linkage funds granted between 2006 and 2012, adjusted for inflation (ARC 2012)

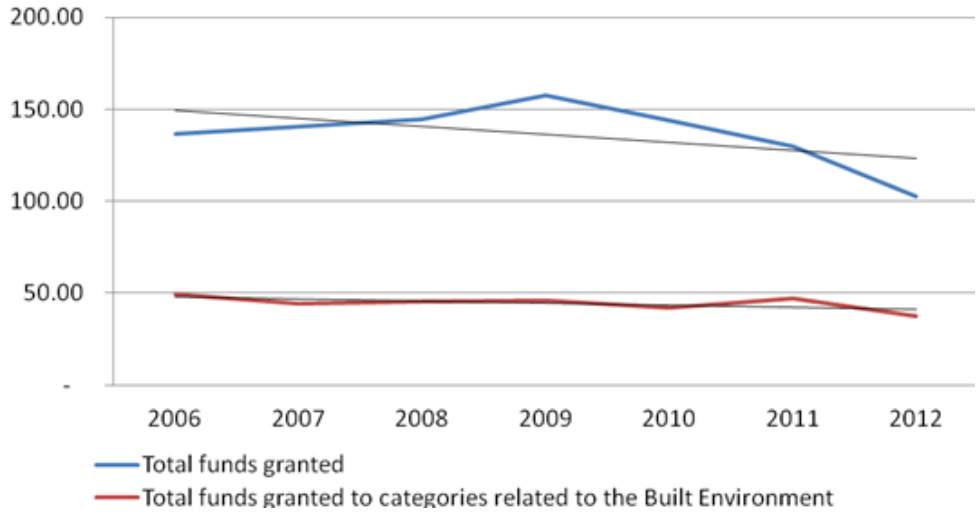
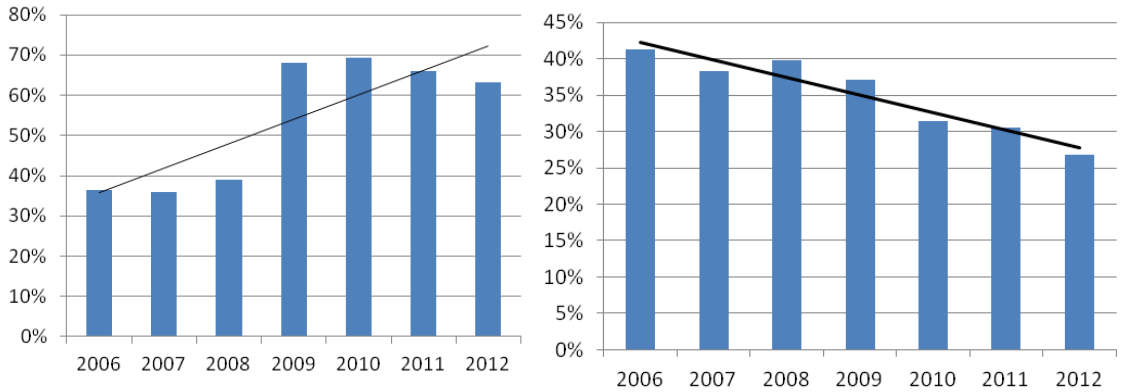


Figure 5 - ARC Linkage projects funds allocation as a percentage of request (2006 - 2012) for: (a) all successful applications (b) discipline panels under which Built Environment applications are classified (ARC, 2012).



Note: Derived from ARC (2012) *Linkage Projects Funding Outcomes. Discipline categories used for (b) containing built environment, architecture and civil engineering were:* PME = Physical, Mathematical and Information Sciences an Engineering, HCA = Humanities and Creative Arts, HSE = Humanities and Creative Arts, Social, Behavioural and Economic Sciences, EMI = Engineering, Mathematics and Informatics, EE = Engineering and Environmental Sciences.

Some foreign governments have taken steps towards proactively establishing construction industry development initiatives by providing funding independent of traditional academic peer review processes. To this end it is important to recognise: the value of the construction industry to the economy; the distinctive characteristics of construction R&D; and the need to build national capacity and productivity in this sector.

Tekes (Finnish Funding Agency for Technology and Innovation) for example, is the most important public funder of research, development and innovation in Finland. As an example of prioritisation, this organisation has identified an *intelligent built environment* as a focus and provides support for high quality research that generates significant commercial potential for business. It contributes to increasing research intensity, cooperation between companies, and knowledge and competence of

Finish infrastructure enterprises (Tekes, 2011). Industry-research collaborations involving multidisciplinary frameworks producing more applied and user friendly outputs are central to the Tekes research agenda.

4.5. Government agency research

Traditionally, governments maintained R&D capability in the built environment with responsibilities for allocating and carrying out construction-related investment. However, as governments have progressively reduced their internal design, construction and maintenance activities, they have also reduced the internal investment in construction R&D. Consequently, there has been a substantial decline in built environment R&D within government agencies at local, state and federal levels. Within the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia's largest public-funded industry oriented research organisation, the realignment of internal priorities has led to an additional steep reduction of such R&D.

In other countries (including Finland and the UK) government agencies have prioritised construction research as being integral to economic growth, and have used the strength of their national institutions to strengthen the capabilities of their local construction industry. In Finland this has occurred through the VTT Technical Research Centre of Finland and has led to the development of an internationally recognised expertise with commercial outcomes. In the UK, Constructing Excellence was established as an industry development agency to drive the change agenda in the construction sector (Constructing Excellence, 2012). Additionally, the UK Government has used its dominant position as major client to drive industry innovation and productivity by mandating the progressive use of BIM in the design, construction and asset management of government projects.

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