

**Applying a sectoral system of innovation (SSI) framework to determining  
future capability requirements for research, development and extension**

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**Abstract**

A sectoral system of innovation (SSI) framework was used to enable industry leaders, public policy makers and researchers to determine future RD&E requirements in the Australian dairy industry. If triple helix interactions can be likened to the flow of 'blood' through the 'arteries' of an innovation system, the study reported in this paper has shown that applying a SSI framework to assess a system's current health and future fitness can identify specific options for improving the 'circulation' within the system.

**Keywords:** Systems of innovation, innovation policy, RD&E capability

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## 1. Introduction

A sectoral system of innovation (SSI) framework was applied to a study of future capability requirements for research, development and extension (RD&E) in the Australian dairy industry.

### 1.1 Systems of innovation

An accepted definition of innovation is 'the development of new products, services, processes and business models under conditions of risk and uncertainty'. Although enterprises make these decisions, they do not make them in isolation, but within persistent structures of business firms, economic institutions, science and technology infrastructures, policy frameworks and knowledge and resource bases and under varying degrees of risk (Smith & West 2007).

The results of innovation studies conducted primarily in Europe and the United States (Smith & West 2007), have concluded that:

- Innovation involves continuous interaction and feedback between perceptions of market opportunities, technological capabilities and learning processes within firms;
- R&D is generally not a *cause* of innovation, but an *effect* of innovation decisions made by firms;
- Innovation requires sustained investment under conditions of *risk and uncertainty*;
- Innovation capabilities are cumulative, building over time and dependent on sustained investment; and
- Innovation depends in large part on collaboration and interactive learning among the actors in the system.

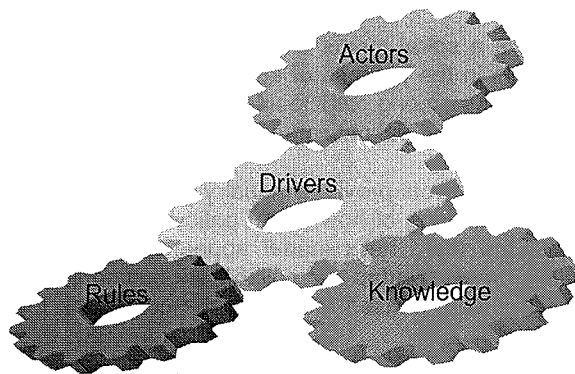
Over the past ten years, the focus of innovation studies has tended to shift from demonstrating the impact of innovation on growth and competitiveness, to analysing 'how' innovation occurs. There has been a convergence in the literature of innovation theory and systems theory giving rise to the concepts of national and regional systems of innovation based on geographic location, and sectoral systems of innovation (SSI) that are industry-based.

The sectoral system of innovation (SSI) framework developed by the authors provides a means for industry and public policy makers to assess the strengths and weaknesses of a current system supporting innovation in a particular industry sector. (Pitt and Nelle, 2008). The authors have applied the framework to address innovation capabilities within the red meat and dairy sectors in Australia.

Although traditionally classified as a low-to-medium technology sector because classifications are based on the rate of internal R&D expenditure, the agri-food industry has been highly dependent on science and technology advances. For the most part, these have been developed through sector-specific R&D programs that have created accessible distributed knowledge networks. In addition, the industry has a wide range of future innovation opportunities that include new science-based products and processes including adoption of new technologies developed in other sectors (eg ICT in supply chain management, 'smart materials' in packaging, biotechnology in product development, and robotics in food processing).

This study applied a SSI framework to develop and test analytical tools that can be used by industry, government and universities to assess current system capabilities and identify opportunities for strengthening the system. Figure 1 depicts the elements within an SSI structure.

Figure 1. SSI structure



The 'actors' in the system include: industry innovators, R&D providers, investors (private and public) and public policy makers. The 'rules' (also referred to as 'institutions') include the legal and regulatory environment as well as social and cultural norms. 'Knowledge' refers to both explicit and tacit knowledge bases. The SSI structure developed for this study also included an assessment of past and future 'drivers' of innovation looking at market pressures and opportunities as well as opportunities and pressures created by science and technology advances.

One of the purposes of applying the SSI framework is to understand how well the system currently functions and how adaptable it is to respond to future drivers of innovation. Pitt developed a system failure analytical framework in her work with the red meat industry in Australia (Pitt and Nelle, 2008). This study used a subset of those system indicators that related specifically to research, development and extension (RD&E) (Figure 2)

Figure 2. System health indicators

RD&E provider capabilities	<ul style="list-style-type: none"> <li>✓ Acknowledged international expertise &amp; alliances</li> <li>✓ Aligned with industry priorities</li> <li>✓ Range of public &amp; private 'knowledge brokers'</li> <li>✓ Provide access to multiple sources of learning</li> </ul>
Firm/industry capabilities	<ul style="list-style-type: none"> <li>✓ Excellent competitive intelligence</li> <li>✓ Innovation strategy - firm &amp; industry</li> <li>✓ High participation rates in R&amp;D projects</li> <li>✓ High adoption rates of new S&amp;T</li> <li>✓ Available, qualified staff</li> </ul>
Interaction	<ul style="list-style-type: none"> <li>✓ High levels of trust between firms and R&amp;D providers</li> <li>✓ High levels of collaboration in R&amp;D</li> <li>✓ Benefits of innovation shared along the value chain</li> </ul>

## 1.2 Relationship to the 'triple helix' model

Proponents of the triple helix model of university-industry-government relations (Etzkowitz, 2002) recognize that innovation is increasingly likely to come from lateral relationships across boundaries, rather than hierarchical structures within organisations.

According to Etzkowitz (2002), the 'triple helix' is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalisation with three dimensions of relationships: 1) lateral ties among participants within a helix, 2) the influence of one helix on another, and 3) creation of tri-lateral networks and organisations.

Like the triple helix model of innovation, the SSI framework provides industry, government and university policy makers with an increased understanding of how to set policy parameters to stimulate and support innovation. Whereas, the triple helix model appears to focus on identifying and facilitating how the 'institutional spheres overlap and collaborate and cooperate with each other' (Etzkowitz, 2002), the SSI framework is used to assess the conditions that stimulate or inhibit innovation within a specific sector.

A functional analysis can be designed to assess the current purpose, structure, delivery capabilities and adaptability of a SSI. (Figure 3)

Figure 3. SSI functional analysis

<b>Clear purpose</b>	<b>Coherent structure</b>
<ul style="list-style-type: none"><li>✓ Do stakeholders agree on current drivers of innovation?</li><li>✓ Do they perceive differences between past and future drivers?</li><li>✓ Is there a sector strategy for retaining international competitiveness?</li><li>✓ Are RD&amp;E objectives aligned with sector priorities?</li></ul>	<ul style="list-style-type: none"><li>✓ Are roles and relationships within the system clear and aligned?</li><li>✓ Are there differences among the actors on their knowledge creation and distribution roles?</li><li>✓ Are levels of duplication acceptable?</li><li>✓ Does the structure facilitate or hinder collaboration?</li></ul>
<b>Consistent delivery</b>	<b>Adaptability</b>
<ul style="list-style-type: none"><li>✓ Is there sufficient RD&amp;E capacity in the system?</li><li>✓ Is there evidence of effective collaboration in the system?</li><li>✓ How satisfied are innovators with RD&amp;E performance?</li><li>✓ Who are effectively taking the 'broker' roles?</li></ul>	<ul style="list-style-type: none"><li>✓ Is the system 'locked in' to dealing with past drivers?</li><li>✓ Is there evidence that innovators are addressing new challenges?</li><li>✓ Is there evidence that the RD&amp;E providers are adapting?</li><li>✓ Who will provide leadership for change?</li></ul>

These questions formed the starting point for the study of future RD&E capability requirements in the Australian dairy industry.

## 2. Study objectives and methodology

The study was part of a series of studies commissioned by the 'Dairy Moving Forward – Dairy Industry Steering Committee' (comprised of key industry and government stakeholders) to strengthen the Australian dairy industry. The aim of the Dairy Moving Forward Committee was to develop an action plan for future RD&E capability requirements to ensure that RD&E in the dairy industry continued to deliver productivity, sustainability and business system improvements to the industry over the next 10-20 years.

The Steering Committee believed that the future capability of the RD&E system would be dependent on having people with the right expertise working within organisations that stimulated sustained collaboration with other researchers and end-users to deliver innovative solutions to future dairy industry challenges and opportunities.

They understood that sustained collaboration is not an end in itself, but rather the means to effectively mobilise scarce resources to address increasingly complex problems. Sustained collaboration requires participating partners to be clear about the values and objectives they share, as well as the specific benefits to be realised from the collaboration.

To address these issues, a sectoral system of innovation (SSI) framework encompassing industry users and investors, public policy makers and investors, and RD&E providers was applied to analyse the current dairy industry RD&E system and identify future requirements.

The key elements of the adapted framework included:

- Drivers & insight – how insight into future drivers of innovation shaped RD&E capability requirements;
- Strategy & investment – how the strategic framework shaped collective decision making and investment;
- Sourcing and commissioning RD&E services – how sourcing criteria shaped RD&E provider responses and contributed to effective and efficient capability development; and
- Delivering RD&E services – how services were developed, delivered and distributed.

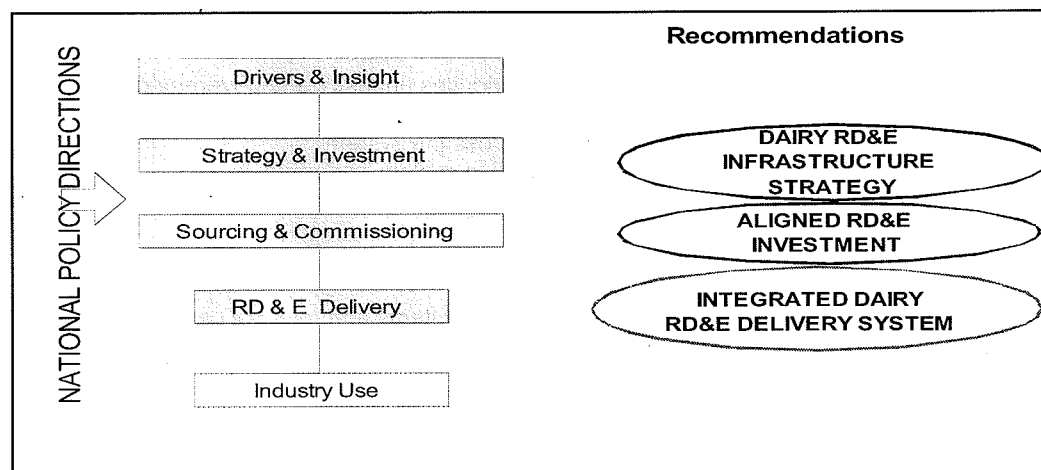
The study was conducted in two parts: 1) an analysis of the current strengths and weaknesses of the pre-farm gate dairy innovation system based on 60 interviews with progressive farmers and manufacturers, RD&E investors (both government and industry) and RD&E providers, and 2) an assessment of the future capability of the system to deliver innovative solutions to projected industry challenges and opportunities.

### 3. Study conclusions and recommendations

This paper contains only the conclusions related to strengthening the way the dairy innovation system functioned. The recommendations focused on assisting the investors (both industry and commonwealth and state governments) to create a more integrated and responsive dairy RD&E system.

The study concluded that the stakeholders in the dairy industry generally agreed on the major drivers that would influence the future RD&E strategy, and that those drivers would require increased capability within the system to deliver innovative solutions to the industry. Given the assumption that future RD&E investment would remain at relatively the same levels as current expenditures, the capacity to invest in new or enhanced RD&E capabilities would have to come from increasing the efficiency and effectiveness of the current system. Figure 4 depicts the recommendations made to strengthen the RD&E system.

Figure 4. Analytical framework and recommendations



*Recommendation 1 – That the dairy industry prepare a whole-of-industry RD&E Strategy.*

A more detailed RD&E Strategy was needed to form the basis for major investors to agree on relative priorities for RD&E outcomes that in turn would shape funding allocations across a balanced portfolio of infrastructure and project investments.

A periodic update of the RD&E strategy would be required to test and refine assumptions about future innovation drivers and technology trends, identify changes in relative priorities and assess the extent to which the RD&E system had delivered innovative solutions. The study recommended that the update process engage a broad range of potential investors in dairy RD&E capability including dairy manufacturers, federal and state governments, and other industry sectors with shared interests where joint investment could be considered.

*Recommendation 2 – That significant dairy industry and government investors commit to pool investment funds for priority dairy RD&E projects and infrastructure capability.*

Sourcing and commissioning RD&E services is the system function that enables investors to directly influence how RD&E capability is developed and managed by providers to deliver priority industry outcomes. The study concluded that the dairy RD&E investment process should be managed at a national industry level to align investment commitments with future capability requirements, and that significant investors should commit to a pooled investment fund that would align their strategic investment in priority RD&E projects and underpinning capabilities.

Alignment of significant investors behind the strategic RD&E priorities would send a clear and powerful signal to RD&E providers about the outcomes needed by the industry, and the industry's expectations that RD&E providers would collaborate wherever possible to deliver those outcomes as efficiently as possible.

*Recommendation 3 – That RD&E investors influence the development of a nationally integrated delivery system.*

The study recommended two options for the development of an integrated delivery system across Australia: 1) create 'specialisation clusters'<sup>i</sup> to accelerate delivery of priority R&D outcomes and 2) develop a 'national innovation network'<sup>ii</sup> to effectively link researchers with innovative farmer groups and public and private RD&E service providers.

Recognising that an active network would require the capability to create and maintain effective linkages, the study recommended that the national innovation network include 'hub services' that would provide two critical functions within the network: a 'broker' to create productive research partnerships and a 'wholesaler' to translate research results into applied learning materials and tools.

The study concluded that the recommended system improvements would benefit all major stakeholders:

*Investors*

- Would align RD&E investment with strategic priorities (industry and government)
- Would provide flexible structures for co-investment
- Would increase incentives for collaboration across the system
- Would provide consistent standards for reviewing system performance.

*Innovative dairy farmers*

- Would encourage responsive, solution-driven RD&E providers
- Would provide access to national R&D services
- Would provide customisation for diverse farming systems and regional conditions.

*R&D service providers*

- Would provide clear signals on industry priorities
- Would provide sustained investment to build capabilities
- Would reduce barriers to collaboration
- Would integrate private service providers into the system.

#### 4. Implications for the triple helix model

The study illustrates that the triple helix model and the SSI framework have much in common. Both are concerned with understanding how knowledge capitalisation and innovation can be stimulated and enhanced. Both recognize the value of collaborative interactions among actors in the system.

If, as Dzisah and Etzkowitz (2009) propose, triple helix interactions can be likened to the flow of 'blood' through the 'arteries' of the system, the study reported in this paper has shown that applying a SSI framework to assess a system's current health and future fitness can identify specific options for improving the 'circulation' within the system.

The authors acknowledge that the SSI framework discussed in this paper is still at an early stage of development with significant opportunities for further research and application. They continue to be engaged in studies that adapt and extend the framework and its impact on innovation policy and programmes.

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<sup>i</sup> The term 'specialisation cluster' was used rather than 'centre of excellence' that carries the connotation related to strategic research in a single physical location.

<sup>ii</sup> The term 'national innovation network' (rather than extension) was used to emphasise the fact that the objectives are to increase innovation in dairy businesses, to include the role of progressive dairy farmers and to acknowledge the increasing importance of private service providers.

