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KNOWLEDGE…INNOVATION…ACTION

# Senate inquiry about food production in Australia

## Submission

Date: 04/07/2008

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From August 2001 to November 2007, Silvia was a Senior Researcher in the Packaging, Storage and Transport team at Food Science Australia (a joint venture of CSIRO and the Victorian Government) in Sydney.

Silvia is an Australian representative of the International Institute of Refrigeration (IIR). She is also a member of the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) and the Logistics Association of Australia (LAA).

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**Confidentiality status: PUBLIC DOCUMENT**

# Senate enquiry about food production in Australia

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This submission responds to the call for participation in the review of food production in Australia, in particular:

- How to make food affordable to consumers.
- How to make food production viable by farmers.
- How to make food production of sustainable impact on the environment.

I have submitted separate submissions to the following calls for submissions:

1) The Review Panel of the National Innovation System
2) The Garnaut Review Forum

I am attaching these submissions as background information and as supporting evidence of the arguments I make in this document. From these submissions, I wish to emphasise the following points:

**1.** A recent study (European Commission, 2007) compared the competitiveness of the European food industry with their counterparts in Canada, New Zealand, US Brazil and Australia. The Australian performance was found to be the weakest, using comparisons of real value added, export share growth and real labour productivity.

**2.** There is an institutional lack of belief in innovation as a tool for improving the performance of the agri-food sector. This is reflected in the gradual withdrawal of CSIRO from horticultural research and other food-related areas, the demise of the Food Innovation Grants and the shortage of government-led innovation initiatives to steer the industry towards a sustainable and profitable future.

**3.** The Australian agri-food sector is not likely to achieve its full potential until we invest in innovation. Innovation is the key factor that will enable Australia and the rest of the world to supply safe, wholesome and affordable food in an environmentally-challenged future.

4. There is a need for a concerted approach to innovation in the food industry, from agricultural production and rural based manufacturing through retail to consumer, thus adopting a value chain perspective. Such a concerted approach should recognise the highly dynamic nature of the food manufacturing industry, the benefits of market driven innovation and the usefulness of policy as an instrument to encourage innovation in the marketplace.
5. The current innovation system, which focuses on CRCs, RDCs, public R&D organisations and universities, has delivered a small number of innovations to the marketplace. NFIS had a strategic role in supporting business innovation, manufacturing, supply chain and value addition projects. Additionally, NFIS approached food innovation with a 'whole-of-the-chain' perspective. The termination of this initiative leaves a vacuum in R&D focused to food manufacturing and other areas of knowledge required to introduce food innovations in the marketplace (e.g. supply chain, consumer science and packaging).
6. From production through processing to retail, food supply chains have an often unmeasured impact on the environment. Policies and corporate efforts should focus on three main aspects:
    - Operational issues, which deal with supply chain processes and strategies from primary transformation of foods (e.g. harvest, slaughter, packing house operations) through manufacturing to retail. Aspects such as the effect of primary production on climate change, the impact of freight transport (Food Miles) and food and packaging waste at retail levels are all operational issues.
    - Consumer issues, which encompass consumer attitudes to environmental drivers and the impact of food consumption trends on greenhouse gas emissions.
    - Corporate issues, which include standards and regulations, financial risks, carbon trading and offsets.
7. For economies that largely depend in agricultural exports, such as Australia and New Zealand, it will become critical to demonstrate alignment with good environmental practices. To do so, investment in environmental innovation with a particular focus on food supply chains will be required.
8. Cooling, freezing, cold storage, refrigerated transport, commercial and domestic refrigeration are undoubtedly large contributors to carbon emissions in food-related industries. The estimated total energy spent in the Australian food industry to keep an unbroken cold chain from farm to consumer (Estrada-Flores S and Platt, 2007) is 19,292 GWh/year (or 18 megatonnes of CO2 –e). This is equivalent to 4.3 million cars circulating on the roads each year (or 30% of the total number of cars registered in Australia in 2006). This footprint does not take into account fugitive emissions, which can have an equally large contribution as those from indirect emissions through energy consumption[1]. Any plans to offset the carbon footprint of food chains will need to take into account the contribution of the refrigeration sector.

[1] Although some argue that fugitive emissions could have significant environmental impacts than indirect emissions. See:

**9.** Food transport occurs at every step of the supply chain, connecting production centres, warehouses, export destinations, retail outlets and consumers' homes. It is estimated that food transport in Australia accounted for 6.2 megatonnes of CO2-e in 2007, including the use of diesel for refrigerated transport purposes. This amount is equivalent to approximately 1.4 million cars circulating in Australian roads each year. New supply chain strategies and transportation methods could significantly cut these emissions and the transport costs.

**10.** Food waste in Australia is estimated to be 3.3 million tonnes annually, worth about AUD $5.3 billion[2].The reasons for food waste are numerous and encompass all food chain players, from producers to consumers. Changes in attitudes, practices and technology are required to decrease food waste.

**11.** Recently, the South Australia Premier Mike Rann announced a plan to measure and reduce the greenhouse emissions of the SA wine industry[3]. This is a positive step that brings awareness on the responsibility of the food industry in reducing environmental impacts. However, this is an isolated study. No national guidelines to assess carbon footprints in the food industry exist in Australia. I therefore see a need to create an organisation similar to The Carbon Trust in the UK, whereby this organisation provides:

a. Leadership and steering of the manufacturing sector towards a new economy based on reducing carbon emissions.
b. Specific methodologies and guidelines for carrying out carbon footprint analyses, taking into account the unique Australian economic and environmental conditions.
c. Training and education for Australian producers, processors and retailers.
d. Platforms for interaction between policy makers and supply chain players.
e. Intelligence and strategy on climate change and carbon emission issues.

Such an organisation can encompass all manufacturing areas, including food.

**SPECIFIC ACTIONS**

To me, the fundamental aspect raised by this enquiry is "How can the Australian agri-food sector can be more competitive?" The issues of affordability, productivity and sustainability are all angles of competitiveness. It is thus necessary to frame this problem in a whole-of-the-chain approach: we cannot resolve the issue of affordability if we simply focus our attention on growers and farmers. This issue is a consequence of the entire efficiency of the food supply chain, thereby involving growers, manufacturers, logistics providers, suppliers, wholesalers, convenience sector and retailers. Furthermore, competitiveness is also a reflection of the historic public and private

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http://www.accc.gov.au/content/trimFile.phtml?trimFileName=D08+7432.pdf&trimFileTitle=D08+7432.pdf&trimFileFromVersionId=827849

[2] Hamilton, C., Deniss,R. and Baker, D. Wasteful consumption in Australia.Discussion Paper Number 77. [Online] 2005. http://www.tai.org.au/documents/dp_fulltext/DP77.pdf. ISSN 1322-5421.

[3] http://www.greenhouse.sa.gov.au/PDFs/winesectoragreement.pdf

investment in building and developing the agri-food industry, thereby involving policy makers, research and education providers, entrepreneurs, and all the actors needed to innovate and educate new entrants in the sector.

Therefore, the following actions are oriented to tackle the competitiveness of the agri-food sector as a whole.

A. A new "sustainable co-innovation" model for the food industry is proposed in the attached innovation submission. The model requires a central strategic organisation, which would:
    - Provide a strategic framework for national food innovation, from a market-led, supply chain perspective.
    - Coordinate the activities required to introduce new technology in the marketplace
    - Coordinate government-led food innovation activities (e.g. grants and strategic directions for public R&D), from a supply and value chain perspective. This would avoid the lack of supply chain focus and would increase critical mass in the initiatives undertaken.
    - Enable the commercialisation stages in the innovation process, including assistance in seeking for venture / equity capital.
    - Provide timely competitive and technical intelligence to all stakeholders about the particular innovation areas targeted, bringing attention to current and emerging technologies and innovation trends in the targeted markets.
B. A review of the National Public Health Nutrition Strategy would be of benefit. Such a review should focus on:
    - increasing the levels of well being through healthy eating (portion control and balanced eating);
    - decreasing the environmental impact of our diets through the decrease of food waste and its packaging;
    - selecting foods that have a decreased carbon footprint or that offset their footprint through carbon offset schemes.

    This review would provide a driver for the food industry to measure their carbon emissions and provide such information through carbon labelling.
C. The use of distributed food production, which makes use of hydroponics to cultivate horticultural products in the roofs of large commercial buildings and centres, should also be considered. In Australia, the use of hydroponics in drought-affected areas should be considered. This system would allow decreasing the bulk of foods transported thus reducing costs and environmental impacts.
D. Productivity in the agri-food sector is largely dependent on the labour market. The well-known skill shortages are particularly felt in low-paid agricultural jobs. One way to tackle

this issue is to increase the level of mechanisation in the industry, through the implementation of mechanical harvesters, robotic carcass cutters, robotic picking and packing and so on. Other ways deal with schemes to attract temporary workers into Australia.

E. Perhaps Australia should go back to promote small scale production of foods. The Australian food industry evolved from fierce competition in the 1980's to relentless consolidation and the supremacy of retailers as a market power in present times. However, manufacturing technologies and knowledge have evolved radically since 1980. There is evidence on the economic advantages of micro-machine processing, flexible manufacturing and production de-scaling. All these aspects should be investigated for implementation in modern food supply chains.

F. The use of distributed food production, which makes use of hydroponics to cultivate horticultural products in the roofs of large commercial buildings and centres, should also be considered. This system would allow decreasing the bulk of foods transported thus reducing costs and environmental impacts. The use of hydroponics in drought-affected areas should also be considered.

G. Innovative supply chain strategies should also be considered. A recent example of environmental co-innovation is the Sustainable Distribution strategy, which involves thirty seven well-known food and consumer goods companies in the U.K. It is expected that this initiative will lead to savings of 23 million litres of diesel fuel per year, through sharing of vehicles and optimising the use of warehouses. Multimodal transport also needs to be assessed: the use of refrigerated rail services could decrease significantly the cost and environmental footprint of food transportation. Improving the rail infrastructure would be a necessary step to achieve reliable multimodal transport services.

   According to a recent report by Woolworth's, a significant trend in grocery retailing is the increase in the frequency of low value purchases by consumers (top up trend). This trend is likely to continue as food prices increase, thus leading to more transport costs (for the consumer), more traffic and less profitable operations for supermarkets. To counter this trend, supermarket logistics that may involve a float of refrigerated vans/trucks, which can be effectively converted in 'mini-supers', with a range of foods and other products may help. This service would effectively bring the supermarket to consumer, providing products that are often purchased frequently. This system would also tackle a social problem: online supermarket services are very convenient for computer-savvy individuals with an internet connection at home, but are less convenient for older generations with no home internet access.

H. Government-led initiatives and policies that encourage horizontal and vertical collaboration between food chain partners can go a long way in shifting the way of doing business in the food industry. Small and medium-sized enterprises gain particular benefits of collaborative

approaches, which can acquire skills and knowledge beyond their own capabilities. Advantages for manufacturers include a more systematic approach to new product development (NPD), an increased emphasis on market-oriented NPD and a stronger network for product market intelligence. Likewise, innovative retail-led processes such as efficient consumer response, collaborative planning, forecasting and replenishment and category management rely on the joint development of strategic category plans and the collaborative work of retailers and their suppliers.

I. Establish a minimum quota of arable land that needs to remain dedicated for food production (as opposed to biodiesel production) and develop policies that will support and enforce these limits. This is an important measure, in view of the recent World Bank report[4], which shown that biofuels have forced world food prices up by 75 %.
J. Conduct an investigation on the level of food wastage in Australia, covering production, distribution, retail, convenience (e.g. restaurants, hotels, take-away businesses, hospitals, schools) and consumer. Evaluate the possibilities of reducing this waste through portion-control, consumer education and training for food handlers. Also, evaluate the potential for biofuel production from food waste.
K. Evaluate the use of policy and public procurement as a tool for improving the availability of foods (see attached document on innovation).
L. Consider lowering the barriers to food imports to tackle food affordability, thus allowing the imports of low cost food staples. To soften the effect of easing trade barriers for domestic producers, offer opportunities to add value to the products imported domestically, through improved packaging, storage, processing of imported raw materials, etc.
M. Differentiation through improved packaging, new product development and so on is essential to ensure that a downfall in food production can be tempered with increased value addition and product differentiation. This will make Australian products more marketable in discerning markets (e.g. Europe and USA).
N. Redouble efforts in research and commercialisation focused to develop the native food industry (e.g. bush tomato, desert limes and wattle seeds). This effort does not only pay in terms of product marketing and differentiation: it also makes use of desert land for food production.
O. Explore the benefits of using agricultural by-products to extract health-related substances (i.e. nutraceuticals) to value add further. A case study developed by CSIRO[5] shows the technical and financial aspects to be considered in this type of ventures.

[4] A. Chakrabortty Secret report: biofuel caused food crisis. Internal World Bank study delivers blow to plant energy drive. The Guardian: 4 July 2008. Accessed in 7 July at: http://www.guardian.co.uk/environment/2008/jul/03/biofuels.renewableenergy

[5] R. Seymour, S. Estrada-Flores, M. O'Grady, R. Garcia-Flores, D. Sier. 2007. Analysis of Value Chain Hurdles and entry restrictions in the meat industries for the production of chondroitin sulphate. Food Futures Flagship report. 105 pp.

P. Simplify/streamline the food regulatory system to support innovation and NPD, decreasing delays in the regulatory response to new product.
Q. Investigate the effect of changing supermarket practices on the entire supply chain, e.g. the introduction of retail-ready packaging and recyclable crates. Packaging costs greatly affect farmers. The introduction costs of new formats and new practices (e.g. packing of horticultural products in the field) are not necessarily shared amongst all the supply chain players. More studies on the value chain of perishable products and the distribution of costs and margins in Australian food chains are needed.
R. With decreased food security and increased food imports, an increase in food safety hazards can arise. Food safety in the Australian food supply chain should be highlighted as a potential issue of climate change and food shortages.

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*ESTRADA-FLORES S & PLATT, G. (2007) Electricity usage in the Australian cold chain. Food Australia, 59, 382-394.*

*EUROPEAN COMMISSION (2007) Competitiveness of the European Food Industry: An economic and legal assessment. . IN J.H.M. WIJNANDS, B.M.J. VAN DER MEULEN & POPPE, K. J. (Eds.).*

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# Sustainable co-innovation: the food supply chain as a case study

## Submission to the Review Panel of the National Innovation System

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# Sustainable co-innovation: the food supply chain as a case study

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## EXECUTIVE SUMMARY

This submission responds to the call for participation in the review of the National Innovation System on February 2008. My submission deals with the following aspects:

1) Innovation is a process that goes beyond theoretical conception, through technical invention to commercial exploitation. Therefore, R&D is an element of innovation.

2) One key distinction between R&D and innovation is that in the former, we don't necessarily know the outcomes. To create an innovation, the desired outcome must be known before tackling the problem with R&D.

3) All research has a purpose. However, a commercialising purpose is very different from a knowledge-seeking purpose. Funding mechanisms to deliver in both areas will have to follow very different rationale. My view is that grants investing in knowledge-seeking endeavours should be discussed separately from the discussion of a national innovation system.

4) It is clear that some industries will benefit from a market push innovation model than from a technology push innovation model. The food supply chain is an example of an area that would benefit from a market push approach.

5) There is a need for a concerted approach to innovation in the food industry, from agricultural production and rural based manufacturing to retail, thus adopting a value chain perspective. Such a concerted approach should recognise the highly dynamic nature of the food manufacturing industry, the benefits of market driven innovation and the usefulness of policy as an instrument to encourage innovation in the marketplace.

6) The current innovation system, which focuses on CRCs, RDCs, public R&D organisations and universities, has delivered a small number of innovations to the marketplace.

7) NFIS had a strategic role in supporting business innovation, manufacturing, supply chain and value addition projects. Additionally, NFIS approached food innovation with a 'whole-of-the-chain' perspective. The termination of this initiative leaves a vacuum in R&D focused to food manufacturing and other areas of knowledge required to introduce food innovations in the marketplace (e.g. supply chain, consumer science and packaging).

8) A new "sustainable co-innovation" (SCOI) model is proposed for the food industry. The model is similar to the Forward Commitment Procurement model, but the concepts of co-innovation and innovation networks have been added.

9) The SCOI model requires a central overseeing organisation similar to NFIS. However, it is proposed that the organisation becomes a joint venture between private and public partners. This organisation would:

    a. Provide a strategic framework for national food innovation, from a market-led, supply chain perspective.
    b. Coordinate the activities required to introduce new technology in the marketplace
    c. Coordinate government-led food innovation activities (e.g. grants and strategic directions for public R&D), from a supply and value chain perspective. This would avoid the lack of supply chain focus and would increase critical mass in the initiatives undertaken.
    d. Enable the commercialisation stages in the innovation process, including assistance in seeking for venture / equity capital.
    e. Provide timely competitive and technical intelligence to all stakeholders about the particular innovation areas targeted, bringing attention to current and emerging technologies and innovation trends in the targeted markets.

10) The SCOI model also requires the following types of consortia:

    a. A buyer consortium, formed by two or more supply chain partners that establish an alliance to contract/purchase the new process/ product/ service developed by a supplier consortium.
    b. A supplier consortium, formed by two or more organisations that seek to deliver the innovation at the specifications (e.g. cost, time, performance) set by the legislative consortia.
    c. A legislative consortium, which aims to increase the receptiveness of the market to new technologies/processes/products by introducing standards, regulations and laws that increase performance targets in certain areas.

11) In the SCOI model, a buyer consortium (which may or may not include a public sector organisation) commits to purchase a pre-defined quantity of a product\ technology\service, currently under development but not yet available as a commercial offering. NFISC and the buyer consortium agree in the performance sought for the innovation. The supplier consortium is formed and solutions are sought, based on past innovations or completely new concepts. Meanwhile, the legislative consortium develops standards, regulations and certification processes that enable fair competition and enhance the chances of the uptake of new solutions at the agreed performance specification. When the innovation has been developed, meeting all performance criteria, the buyer consortium purchases the product at a specified volume and cost, at levels that encourage other supplier consortium to enter the market. The private sector would react by freeing investment to search for innovations that respond to those specifications.

12) In the context of SCOI, I do not necessarily advocate for the government to become the early market buyer that executes the forward commitment options. This may be effective in some areas, such as food safety (related to public good). However, the Government may not be the ideal buyer innovations that lead to new products, new markets or new processes.
13) Instead, I propose that food supply chain players form alliances that commit to buy the new product / service/technology when this is developed. The drivers for such commitment could be based in (a) superior value proposition (including financial, environmental and social performance); (b) new regulations encouraging the uptake of the innovation; and (c) a demonstrated increase of competitiveness in the marketplace if the innovation is adopted.

## CONTENTS



# 1 INTRODUCTION

During 2003/04, Australians spent more of their salaries in food and beverages than in any other household expenditure category, including housing. Although the manufacture of food, tobacco and beverages (FTB) contributes with almost 20% of the total value of manufacturing industries, the expenditure in research and development (R&D) of the FTB sector represents less than 8% of the total R&D investment in the manufacturing sector[1].

It is fair to say that R&D is not a synonym of innovation. Innovation is a process that goes beyond theoretical conception, through technical invention to commercial exploitation[2]. Therefore, R&D is an element of innovation. This view is supported by the recent report "Public support for science and innovation"[3], which defines innovation as:

> *"deliberative processes by firms, governments and others that add value to the economy or society by generating or recognising potentially beneficial knowledge and using such knowledge to improve products, services, processes or organisational forms. From the*

[1] Australian Bureau of Statistics, 2007

[2] Dept. of Agriculture, Fisheries and Forestry Australia. 2001. Recipes for success: case studies illustrating successful innovations by food businesses. Commonwealth of Australia. 51 pp

[3] Productivity Commission. 2006. Public Support for Science and Innovation, chapter 1: Introduction. Draft Research Report. Productivity Commission, Canberra. p. 7- Introduction.

> *perspective of this study, these improvements may be specific to the entity, to the industry, country or world, and could be incremental or novel."*[4]

Historically, public R&D organisations have been an integral part of the Australian innovation system. However, it has become clear that these organisations alone are not capable of providing the full spectrum of activities required to commercialise inventions. One key distinction between R&D and innovation is that in the former, we don't necessarily know the outcomes. Therefore R&D endeavours are always a success, as they always increase knowledge. However, new knowledge may not deliver commercial outcomes, at least in the short term. To create an innovation, the desired outcome must be known before tackling the problem with R&D. Furthermore, innovation is fallible. As stated by DTI and DEFRA, "innovation can always be accurately targeted to a commercial outcome but unlike research it can fail"[5].

## What motivates scientists?

R&D organisations contribute substantially to innovation, by:

a) Increasing the amount of useful knowledge.
b) Training skilled graduates.
c) Creating new scientific methodologies.
d) Creating knowledge networks nationally and internationally.
e) Increasing scientific and technological capacity.

And occasionally:

f) Creating new companies, often in collaboration with business-savvy partners

Given that most Government innovation initiatives in the past have placed significant demands on universities and R&D organisations to commercialise their scientific production, it is worth exploring the reasons why young scientists choose to work in publicly-funded research. Ultimately, people, and not policies or institutions, are the innovators.

Jindal-Snape and Snape[6] performed a study to understand the motivators in 18 scientists in a government research institute in the UK. The findings in this study were that curiosity, the need to do good science and the desire to make a difference, are the predominant motivators for scientists. None of these motivators related to financial issues (e.g. bringing external income) or management aspirations (e.g. becoming senior managers in the organization). Bigliardi *et al.* found that other motivators in engineering-oriented personnel include having the opportunities and facilities to have pleasant social interactions, such as interest-group meetings during breaks or off-duty hours[7]. The social dimension covers all contacts the employee has with other people, both inside the organization and in the environment of the organization - for example, customers, suppliers, colleagues and managers. Factors related to this dimension are communication, feedback, feelings of solidarity, acceptance, leisure time, status, leadership, power and the need to help others[8].

[4] DEST 2005c, p. 9

[5] DTI & DEFRA, 2006. Bridging the gap between environmental necessity and economic opportunity. 1st report of the Environmental Innovations Advisory Group.

[6] Jindal-Snape, D. and Snape, B.J. 2006. Motivation of scientists in a government research institute: Scientists' perceptions and the role of management. Management Decision. Vol. 44 No. 10, pp. 1325-1343.

[7] Bigliardi, B., Petroni, A. and Dormio, A.I. 2005. Organizational socialization, career aspirations and turnover intentions among design engineers. Leadership & Organizational Development Journal. v26 i5/6. 424-441

[8] Osteraker M., 1999, Measuring motivation in a learning organization, Journal of Workplace Learning, 11(2): 73-77.

These observations do not aim to stereotype researchers as persons with no commercial drive and always resistant to commercialise the results of R&D. Indeed, a US study[9] found that academic researchers who have research grants and contracts work more extensively with industry than those without grants or contracts. Furthermore, the scientists who have industry contracts interact with industry to a greater degree than those who are exclusively funded by governments.

However, traditional academics and scientists do have concerns on the growing pressure on public R&D institutions and universities to produce immediate useful knowledge with close-to-market commercial benefits. This is often at the expense of longer term programs and the development of basic scientific research, which are key ingredients for groundbreaking science. Recent studies show that researchers that maintain a funding relationship with a private sponsor (or a Government grant that is set to respond to specific demands of the private sector) experience a decrease in their academic publications by 25%. Furthermore, academic talent is not necessarily a funding criterion for sponsors[10]. Therefore, concerns over a decrease in traditional scholarly activities as Government funding focuses on reaching commercial goals are funded.

This author knows of more than one public R&D researcher that has either left the organisation to join a university to continue their scientific endeavours "with more freedom", or that has abandoned research to pursue a business career. Both types of researchers often leave in frustration, due to the complexities of following the double mandate of public R&D institutions: the public benefit driver *vs* the commercial driver.

From the previous discussion, we conclude that a nation that excels at innovating does not necessarily excel at creating new knowledge and groundbreaking science. The opposite statement is also true: a nation that excels at developing new scientific frontiers does not necessarily excel at innovating.

Do we want to see Australia as a nation of innovators or as a nation of Nobel laureates in the coming decades? Or do we want both? What is the *purpose* of the Australian Government?

## Science in the innovation continuum

All research has a purpose. However, a commercialising purpose is very different from a knowledge-seeking purpose. If the new Government is seeking a balance between these, it should be aware that funding mechanisms to deliver in both areas will have to follow very different rationale. My view is that grants investing in knowledge-seeking endeavours should be discussed separately from the discussion of a national innovation system.

Past Government systems seemed to focus on the transformation of public R&D organisations into innovation "factories". This may well be what it is required, but the roots of public R&D organisations are closer to knowledge-seeking endeavours than to innovation. Public R&D organisations and universities will require a clear mandate on the balance between funding for curiosity driven science and science targeted to bring commercial outcomes. A possibly more important issue is that the Government investigates what is the right funding split between the two.

Figure 1 shows a conceptualization of (a) what the innovation continuum encompasses; (b) how science can feed into innovation; (c) how the market can influence science; and (c) how scientific endeavours are successful even if they don't produce an immediate innovation. In the proposed concept, we assume that all ideas that progress into an innovation continuum, either supported by

[9] Bozeman, B. And Gaughan, M.2007. Impacts of grants and contracts on academic researchers' interactions with industry. Researc1h Policy 36:694-707.

[10] Goldfarb, B. 2008. The effect of government contracting on academic research: Does the source of funding affect scientific output? Reserach Policy. 37: 41-58.

private of public funding, are worth exploring[11]. New theories or knowledge (either born out of curiosity/creativity or market driven needs) lead to basic research, which in turn could lead to developing a close-to-market application, or not. A reason for the latter may be that present technology limits commercial application (e.g. Einstein's theory of relativity was developed in 1905, but its application for the development of global positioning systems occurred 68 years later). Or perhaps the phase of applied research shows that the new product/service/technology will not be able to compete in price with current substitutes. Or perhaps the innovation infringes other's patents. There are several reasons why innovations fail. But in this context, it is the implementation, rather than the new idea, what fails.

The model presented implies that, for every research that fails to deliver an innovation in a particular application field (e.g. electronics), there may be *n* different fields that may benefit from the same research (e.g. instrumentation). This multiplicative effect is further illustrated in Figure 1a. This effect explains why one of the ways to assess the impact of patented inventions is to quantify the citations of the original patent, either in the same area of application or in different areas.

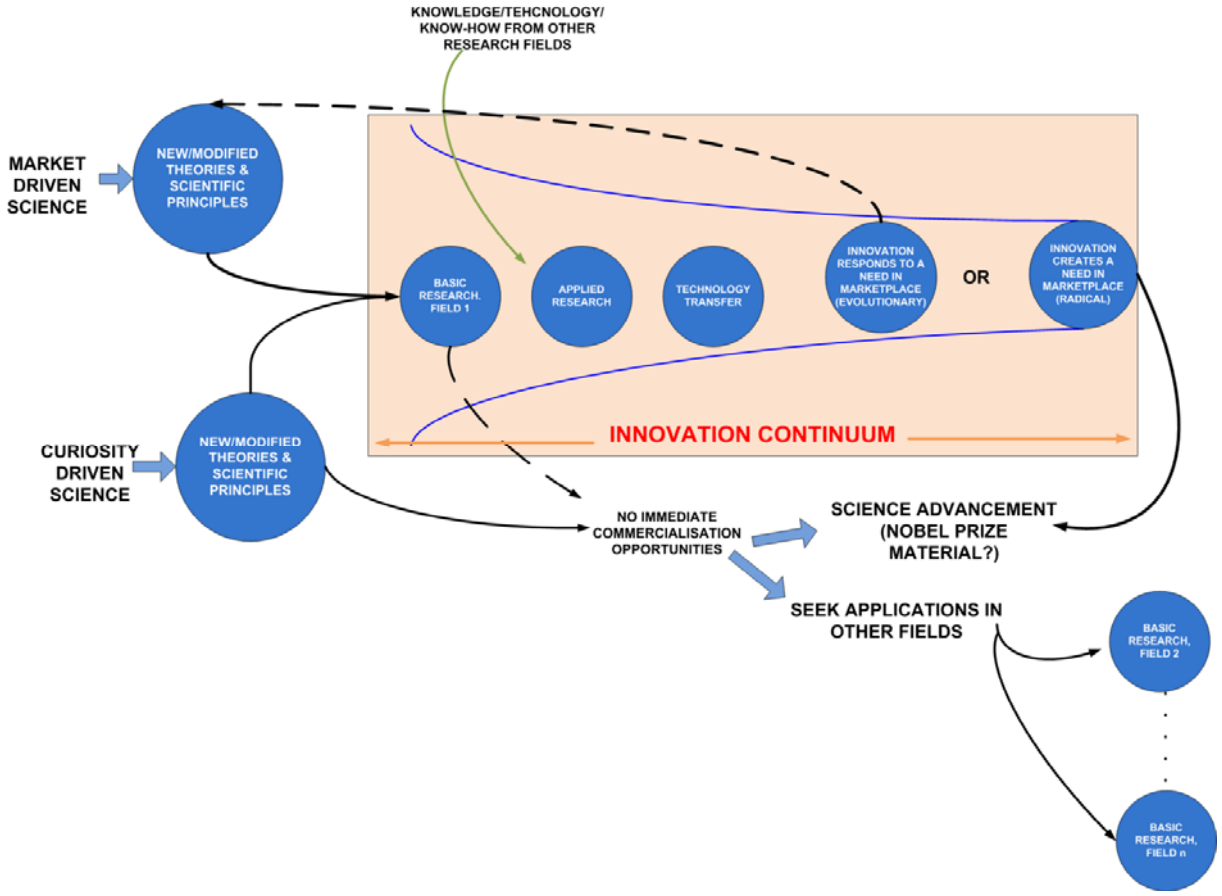



*Figure 1. The innovation continuum and sources of innovation.*

It is clear that some industries will benefit from a market push innovation model than from a technology push innovation model. In the following pages, I will focus on the food supply chains as an example of an area that would benefit from a market push approach. The application of concepts such as "innovation networks", "consumer-led innovation" and "forward commitment procurement" in an innovation framework for the food industry is also discussed. Furthermore, I propose the introduction of an innovation model based on these concepts and the use of consortia

[11] The scientific community have quality assurance systems to ensure that this is the case (e.g. national and international peer reviews, strict use of the scientific methodologies, guidance by senior researchers and other mechanisms).

supplying innovations, buying innovations and creating the market conditions for successful uptake of food innovations.

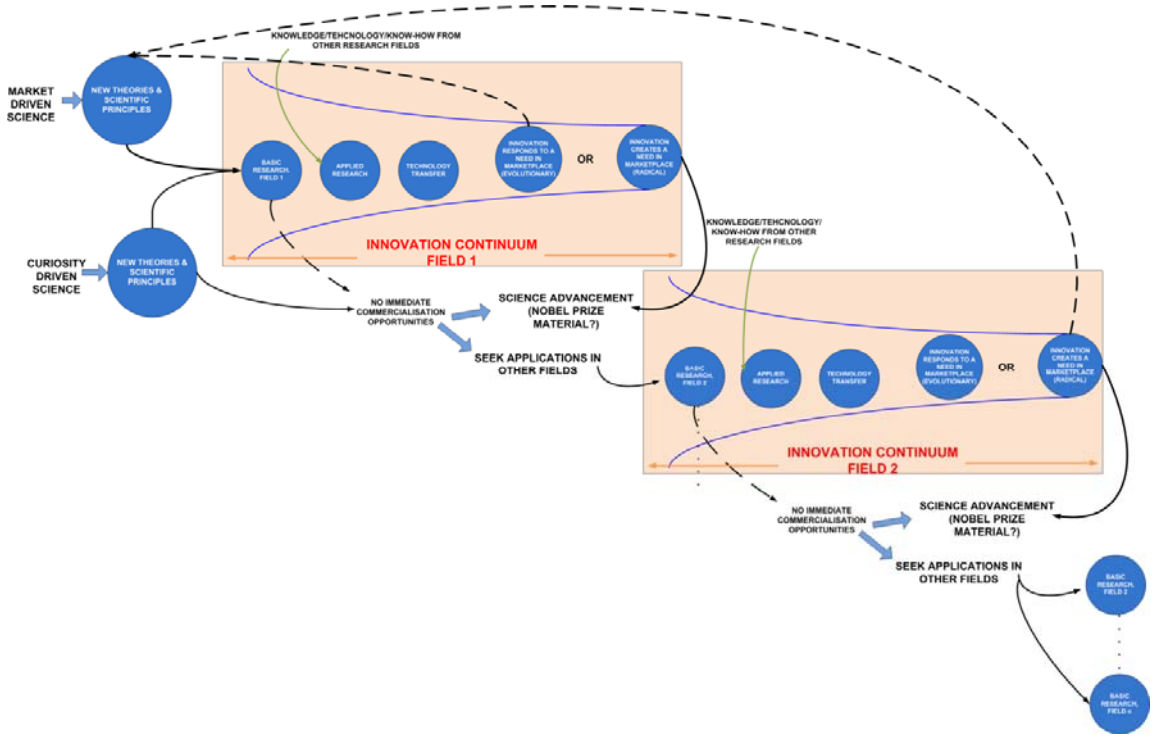



*Figure 1a. The multiplicative effect of science and innovation.*

## 2 THE AUSTRALIAN FOOD SUPPLY CHAIN

The aim of the food industry is to transform agricultural raw materials into safe, convenient, good tasting and nutritious products for consumers, in a profitable and sustainable manner. To reach the consumers, all the participants in a food chain need some sort of integration that allows the flow of product until reaching the final user. Therefore, the food supply chain is defined as a set of interdependent companies that work closely together to manage the flow of goods and services along the value-added chain of agricultural and food products, in order to realize superior customer value at the lowest possible costs[12].

### Structure and Drivers

Food value addition is generated by activities linked to primary and secondary processing, packaging, distribution and retail, as illustrated in Figure 2.

The Australian food industry is strongly driven by the following trends:

- Horizontal issues[13]: Global trends in ageing and health awareness, consumer trust and consumer satisfaction (convenience), food safety and traceability, financial sustainability related to costs of production/packaging/transport, innovation as an engine for growth and sustainability in production systems.

[12] H. Folkerts and H. Koehorst. 1997.Challenges in international food supply chains: vertical co-ordination in the European agribusiness and food industries . Supply Chain Management: An International Journal. 2(1): 11-14

[13] Issues in broad categories applicable to many or all food industries

- Vertical (specific) issues: each link in the chain has particular concerns and drivers. However, some of these have a cumulative effect (e.g. acceptance of GMOs affects both growers and manufacturers).

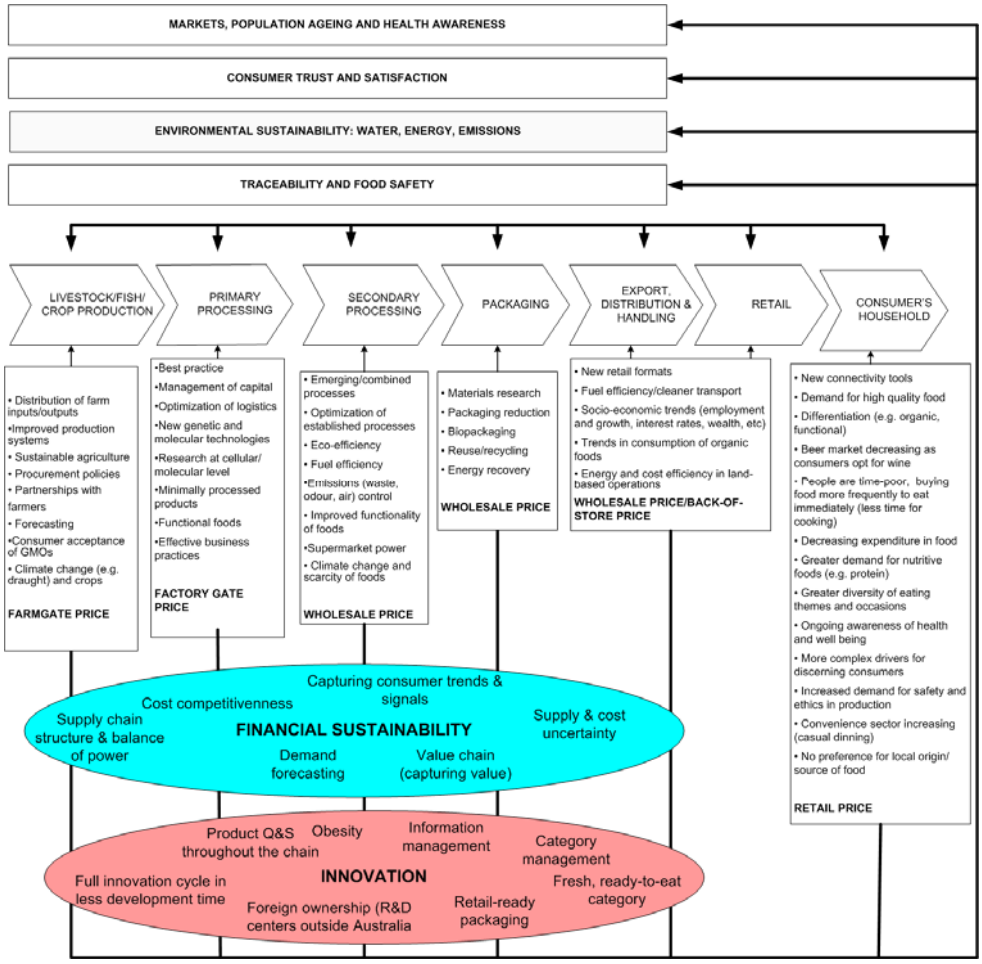



*Figure 2. Interaction of horizontal and vertical issues in the food chain.*

From a supply chain perspective, there are four major sub-chains that characterise the industry:

1. Primary production. In Australia, this sector encompasses a large number of relatively small firms, particularly upstream in the chain. In 2004, about 205,000 agricultural businesses (excluding services, forestry and commercial fishing) were accounted for by the Australian Bureau of Statistics (ABS). About 130,000 of these businesses were farm households or farming enterprises. A large proportion of the remaining businesses include harvesting, primary processors and small road transport units.

2. Food manufacturing. This is a diverse sub-chain, ranging from SMEs to major multinational companies. In 2004, about 9,000 food beverage and tobacco manufacturing businesses were accounted for by the ABS. The food manufacturing industry worldwide tends to be dominated by large, multinational firms and Australia is no exception, with the largest 50 food and beverage global corporations producing close to 75% of the domestic industry's revenue[14]. The implication for innovation is that most R&D activities take place outside Australia, in the global R&D headquarters of the companies.

[14] Short, C. Chester and P. Berry. 2006. Australian food industry performance and competitiveness. ABARE research report

3. Food retailing. This sector includes supermarkets, grocery stores, non-petrol sales of convenience stores at petrol stations, take-away food, and others (e.g. fresh meat, poultry and fish; fruits and vegetables; liquor; bread and cakes, and specialised food retailers). About 65,000 food retail businesses were accounted for during the 2004 survey of the Australian Bureau of Statistics. Food represents about 40% of the total retail sales and 70% of food sales are registered in supermarkets and grocery store retailing.

4. Food exports. Australian farm exports were worth around $23.8 billion in 2005-06, accounting for 15% of total merchandise exports[15]. Australia's profile as an exporter of rural-based products means that this sector's performance is affected by world commodity prices, exchange rates, trade barriers (e.g. tariffs and quotas), domestic support programs (e.g. production and export subsidies), and technical and regulatory barriers (e.g. product labelling and certification standards). Major export markets include Asia (Japan, Malaysia, Korea, Hong Kong, Taiwan), USA and New Zealand. Australia is a net exporter of food, with an export surplus of $17 billion over food imports.

Sectors 1 to 4 can be identified in Figure 3, which illustrates the food value chain in Australia during 2005-06.

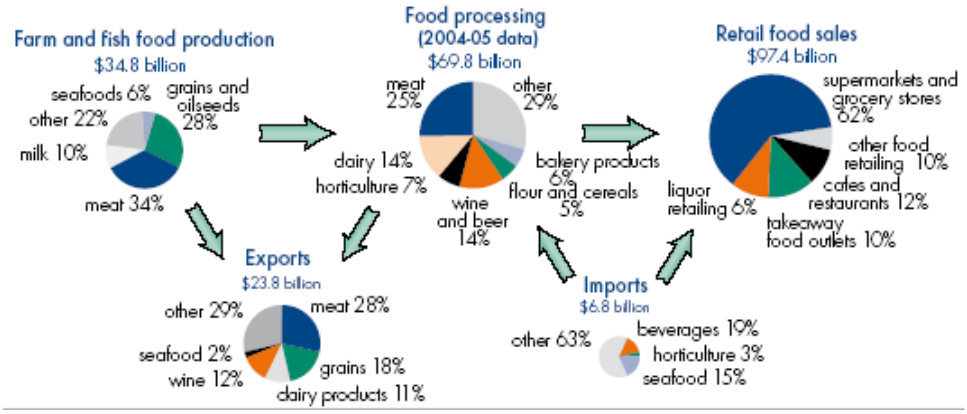



*Figure 3. The food value chain in Australia (2005-06). Source: Australian Food Statistics 2006*

In 2005-06, the value of primary production goods almost trebled by the time the food reached the shelves in supermarkets. The largest increment in value occurred between primary and secondary production.

## Global competitiveness of the Australian food industry

A recent study by the European Commission compared the competitiveness of the European Union, Canada, Australia, New Zealand, US and Brazil. The economic indicators included real value added, export share growth and real labour productivity. Australia's performance was found to be the weakest of all countries analysed (Figure 4).

[15] Agriculture and Food Policy Reference Group , 2006. Creating our future: agriculture and food policy for the next generation. Report to the Minister for Agriculture, Fisheries and Forestry.

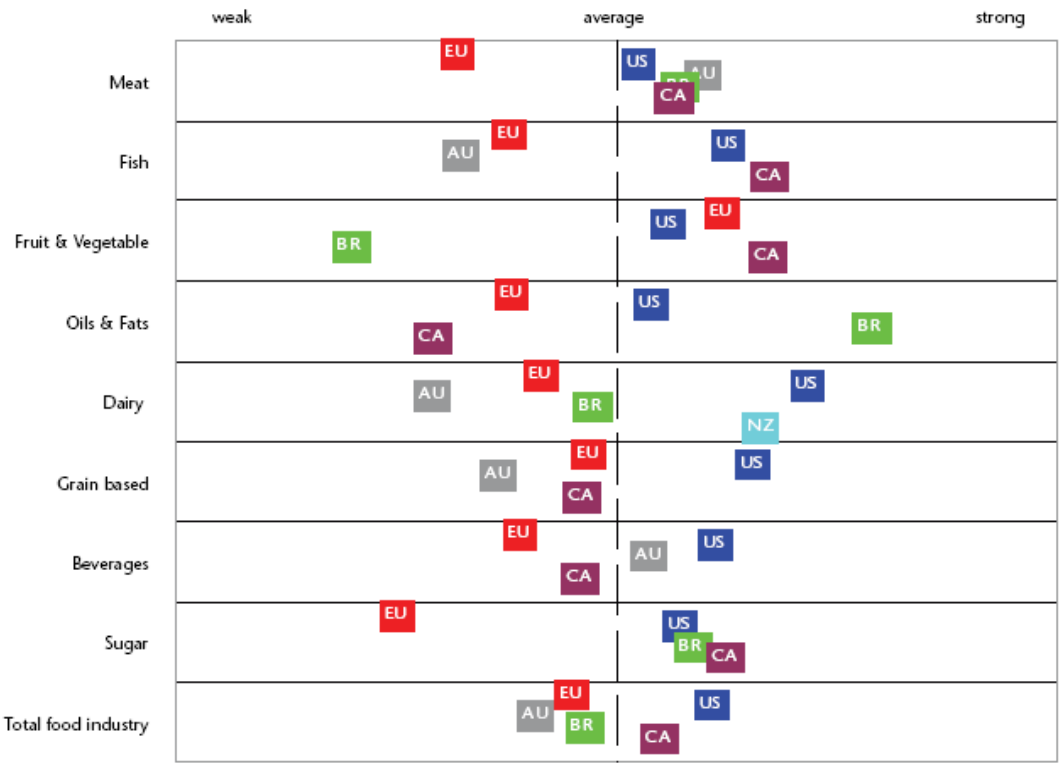



*Figure 4. Global competitiveness of the Australian food industry.*

## 3 GOVERNMENT-LED INNOVATION STRUCTURES FOR FOOD SUPPLY CHAINS

It is difficult to quantify the impact of the historic public expenditure in innovation-related strategies on the modern Australian food industry[16]. One reason is the concept of innovation itself, which encompasses a range of activities (e.g. new or improved products, business practices and processes). These activities are difficult to track and assess through the use of the same performance indicators. Other reasons are the complexity of the industry and its eventful history, which evolved from fierce competition in the 1980's to relentless consolidation and the supremacy of retailers as a market power in present times. Therefore, the effect of innovation structures and funding strategies in the past years is likely to be confounded with the effects of other events, such as the economic outlook, consumption trends and many others.

Nevertheless, food industry experts have reached consensus in two issues:

(a) The Australian agri-food industry is in danger of losing markets that were taken for granted in the past (e.g. meat and grains)[17], due to increased competition from countries such as New Zealand, South Africa and China.
(b) Innovation has a key role in stopping the decline in the performance of the food industry sector in Australia.

The expert consensus is better illustrated by the following statements:

[16] Arguably, the most detailed attempt to assess the impact of innovation in the food industry was the report by AEGIS (2001): The Processed Food Product System in Australia. University of Western Sydney. 131 p.

[17] Australian Food Statistics, 2006

> *"Ultimately, for Australian companies to remain competitive in the international marketplace, they will need to boost their commitment to R&D, continue to develop alliances with global brands and supermarkets, and be innovative in their product development and process technologies."* Dr David McKinna, 2006.
>
> *"Posing challenges for some food manufacturers is the impact on category value and the viability of sustaining investments in branded products, including the level of innovation and R&D investment".* DAFF, Australia Food Statistics 2006.
>
> "*The challenge for Australian farmers will be to identify and embrace new market opportunities and to drive competitiveness through innovation in production and processing, enhanced efficiency, improved economies of scale, attracting greater returns through better understanding of markets and changing consumer needs, through achieving greater equity through the supply chain, and through differentiating and developing specialised products"* National Farmers Federation, 2006.
>
> *"Product and process innovation will play a large part in the success that can be achieved. This will add convenience to a product solution rather than the traditional approach of supplying commodity lines in the form also available in retail stores".* Freshlogic, 2007.
>
> *"...food companies must continue to innovate and operate at high efficiency in order to achieve income growth".* Steve Spencer, Whitehall Associates, 2006.
>
> *"Innovation is the key to profitability in competitive world food markets".* NFIS, 2007.

## Historic investment in food innovation

Using Fig. 2 as a frame of reference, research on pre-production and primary production have received much more funding than manufacturing and post-manufacturing research. This is illustrated by the 2004/05 statistics on national R&D expenditure. In 04/05, R&D investment in the primary production of foods was about $1 billion dollars[18], while R&D investment in food manufacturing was just below $300 million. This focus reflects just the opposite of the value chain, where the last stages of the chain (e.g. manufacturing and retail) are the ones that triplicate the value of primary production. Furthermore, the low levels of R&D in the food manufacturing stage are at odds with the knowledge-intensive character of the industry[19].

Most retail R&D is classified as manufacturing or services. There are no specific estimations of how much retail invests in R&D. Therefore, we assume that the food supply chain as a whole had an R&D public and private expenditure of about $1.3 billion during 04/05.

Food manufacturing R&D expenditure increased from $192m in 2000 to $269m in 2005 (Figure 5). The sectors with increased funding are (in decreasing order of gains in the past 5 years): others – mainly sugar, confectionery, prepared animal and bird feed and seafood (+$29 m), beverage and malts (+$28m) and horticultural products (+$16 m). R&D funding for the dairy industry has decreased in about $2.5m per annum in the past 10 years.

[18] This value is the aggregate of plant production & plant primary products plus animal prod. & animal primary products. ABS Research and Experimental Development Summary 2004/05.

[19] Howard Partners. 2005. The emerging business of knowledge transfer. Report of a study commissioned by the Department of Education, Science and Training.

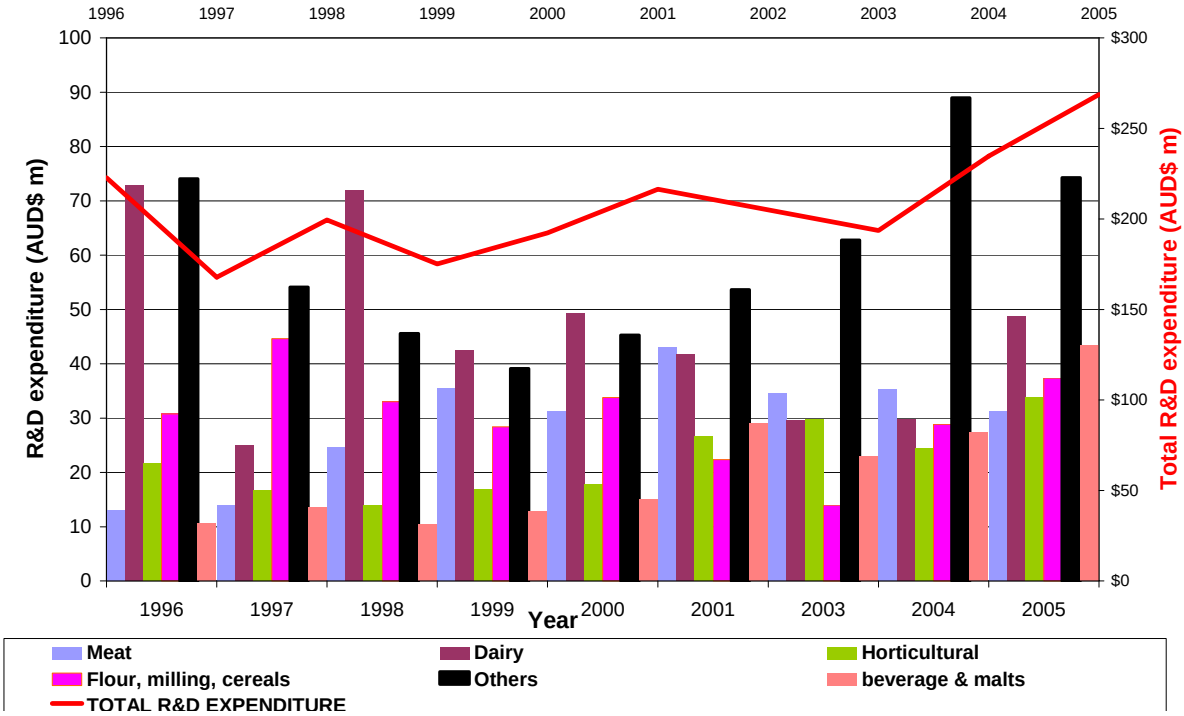



*Figure 5. R&D funding for particular sectors in the food industry. Sources: Australian Food Statistics 2006; OECD 2004, Research and development expenditure in industry.*

Interestingly, these statistics do not necessarily encompass R&D in logistics and supply chain management. These activities are central to the operation of the food chain, yet firms operating in these interstices are not counted as part of the food industry[20] and their innovation and R&D activities are accounted for in different industries. For example, R&D expenditure in retail logistics, transport and storage is accounted as "services"; packaging R&D may be accounted for in manufacturing of chemicals, rubber, plastics, fabricated metal products and others.

## Initiatives supporting food-related innovation

Two major Government funding initiatives for R&D closely linked to market demands were:

- The Supermarket to Asia (STA) Strategy from 1996 to 2002, which had as a main objective the expansion of Australia's agrifood exports to Asia. The Technical Market Access program was created through STA and it is still used by DAFF as a mechanism to enhance market access of Australian foods exports.
- The National Food Industry Strategy (NFIS) Ltd (2002-2007), an industry-led company, funded by the Australian Government to implement most aspects of the National Food Industry Council. The Food Industry Grants (FIG) were the most representative NFIS instruments for R&D funding.

The FIG Program had a budget of $34.7 million over five years. The Program provided support to Australian based food businesses for projects involving technical and scientific R&D. Projects funded needed to present strong prospects for commercialisation.

Grants under the FIG Program were awarded on a competitive, merit-based assessment, with funding provided on a matching dollar-for-dollar funding basis for up to half of the eligible project costs. The majority of FIG proposals involved collaboration between Australian based food

[20] AEGIS, 2001. The processed food product system in Australia. UWS. 131 pp.

businesses and research organisations, including Food Science Australia and other CSIRO divisions, universities and a range of technical consultants[21].

Data published by NFIS in regards to funded projects and grant applications from 2002 to 2004 (Figure 6) shows that a majority of these fall under 'processing', followed by 'consumer value' (22% and 14% per cent, respectively). The fruit and vegetable/horticulture products segment of the industry had the largest representation amongst FIG Program recipients (28%), followed by ingredients (22%).

(a)

(b)

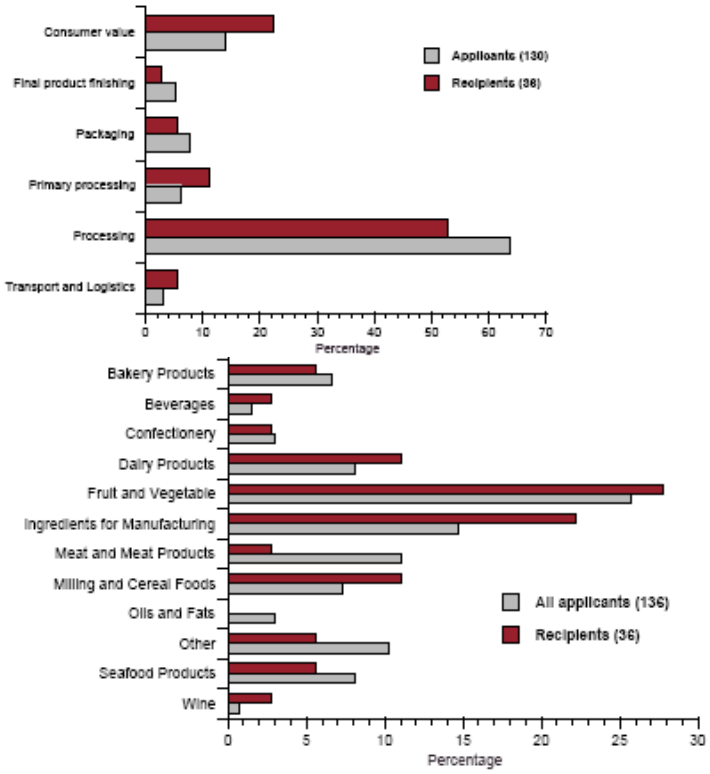



*Figure 6. Innovation and product categories funded by the NFIS (a) by link in the chain; and (b) by product.*

The FIG program was highly successful and well regarded by all the participants. One particular weakness was the relative low participation of SMEs with respect to the participation of larger firms using the FIG grants to undertake research. Given the large percentage of foreign owned/ multinational firms, it is likely that FIG grants supported R&D activities that would otherwise be carried out outside Australia.

Figure 7 shows the past innovation funding and R&D providers[22]. To analyse the split of public R&D funding, this is commonly categorised on the basis of the stage of innovation supported (e.g. basic research, applied research, technology transfer). In Figure 4 I have opted to present the information in the context of food supply chains. The classification of CRCs in a food supply chain context relied on the information available in the CRCs websites (as per list in Appendix 2). Although the categorization in Figure 4 is open to debate, there are some general observations that can be drawn:

- In general, CRCs tend to support heavily the primary production sector.

[21] The Allen Consulting Group. Food Innovation Grants Program Review-2004

[22] As stated in the introduction, past innovation structures have centred in R&D funding. The correctness of this approach is open to debate.

- The intention of CRCs seems to overlap with some RDCs; for example, there is one CRC for dairy, one RDC (Dairy Australia) and schemes such as the Geoffrey Gardiner Foundation in Victoria that also support dairy. For grains, there are two CRCs dedicated to this category, plus one RDC. There are other open funding sources (e.g. RIRDC) that are used to support grains and dairy projects to some extent. One may wonder if this duplication is a result of: (a) poorly managed R&D funding resources; (b) the needs of more R&D investment in particular industries; or (c) the diversity of the dairy and grains industries. Whatever the reasons, the duplication of areas for investment could lead to poor efficiency at the cost of lost opportunities in other industries.
- CSIRO supports various projects across the food supply chain through cofounding. Through Food Science Australia (a joint venture of CSIRO and the Victorian Government), funds for R&D in food manufacturing industry are available in the form of collaborative research contracts. However, available cofounding is directed to strategic areas for CSIRO/FSA (e.g. little emphasis is placed on retail innovations).
- DPIs predominantly support the primary sector, mainly in pre-production and production issues. State-led initiatives have a strong role in the industries relevant to each territory.
- There is a scarcity of funding available to investigate the final stages of the food value chain. There is also a lack of funding sources devoted to create innovations in non-R&D related fields (e.g. business practices, supply chain management, competitive intelligence).
- NFIS had a strategic role in supporting business innovation, manufacturing, supply chain and value addition projects. Additionally, NFIS approached food innovation with a 'whole-of-the-chain' perspective. The termination of this initiative leaves a vacuum in R&D focused to food manufacturing and other areas of knowledge required to introduce food innovations in the marketplace (e.g. supply chain, consumer science and packaging).
- Other food innovation programs are fragmented and do not allow a 'whole-of-the-chain' perspective (e.g. the *Regional Food Producers Innovation and Productivity Program).* However, trends in the global food marketplace indicate that entire supply chains formed by alliances of two or more players (as opposed to lone companies) will be required to compete in the food market. This is also true in other industries

Another observation from Figure 4 is the high level of competition between public and private R&D providers for public funding. This brings the following disadvantages:

1. Wasted time and effort of R&D providers (public and private) in applying for a finite amount of public funding from RDCs and CRCs. R&D providers cannot always recoup the money spent in failed applications.
2. The competition process is not enhancing collaboration between universities and public R&D organisations. Neither is a process that improves communication between R&D providers and food supply chain players. Given the limited pool of funding, competing agencies prefer to apply as sole providers rather than sharing the funding with potential collaborators.
3. In many competitive calls for proposals from RDCs and CRCs, there is a lack of transparency as to how the proposals are evaluated. In addition to this, the timeframes between submitting an expression of interest and receiving the outcome of a full submission varies between 3 to 6 months. However, representatives of the food industry expect innovation projects to produce results in less than 1.5 years[23].
4. The competitive process does not support open innovation.

[23] NFIS, 2005.

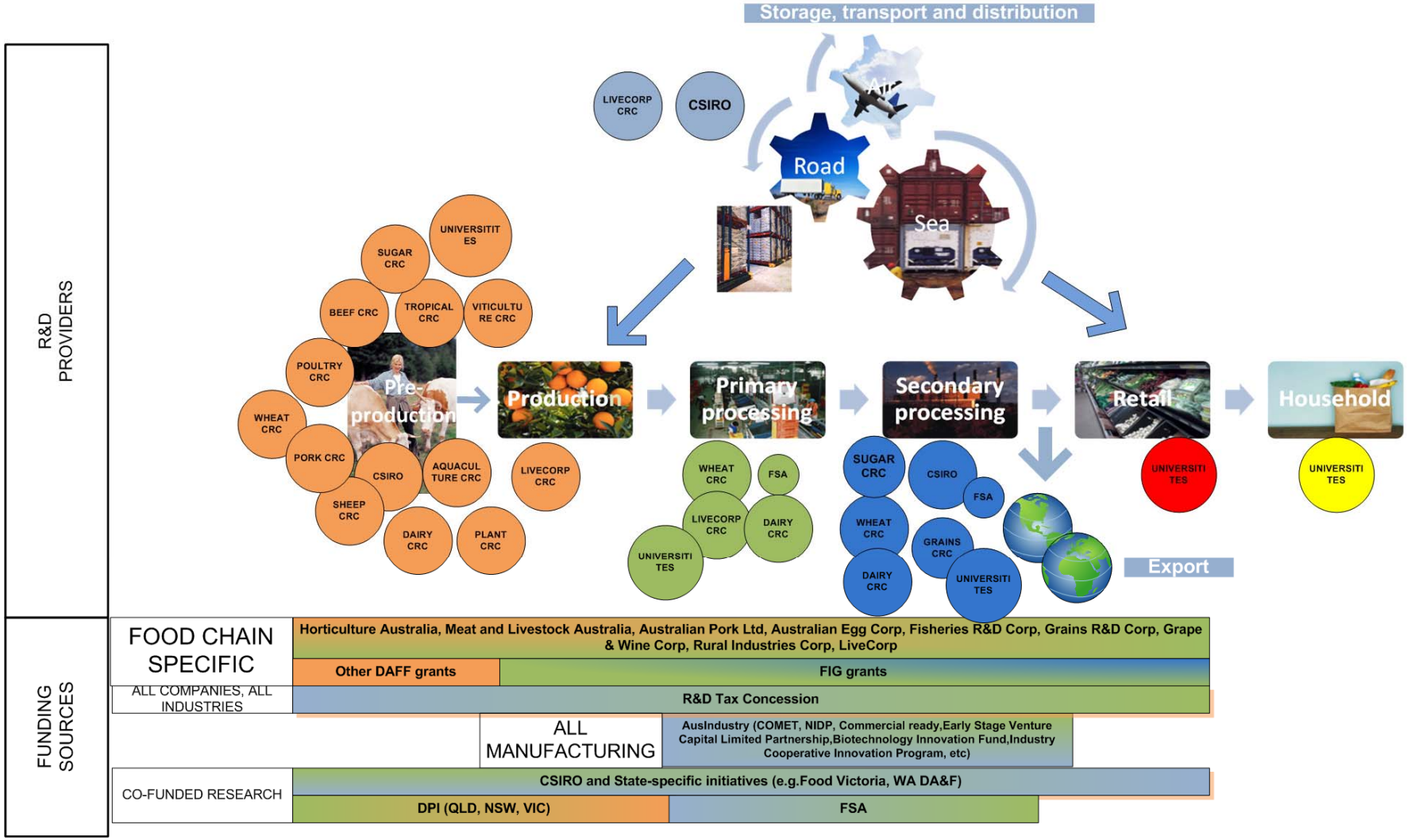



*Figure 6. Funding and R&D provision structures for food innovation.*

## NFIS food innovation models during 2002-2007

Figure 8 presents the food innovation network model proposed by NFIS. The model is self-explanatory, indicating the role of NFIS as a hub coordinator of the activities between the network partners.

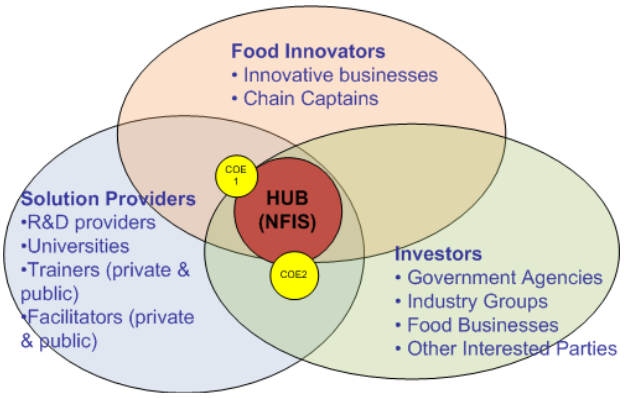



*Figure 8. NFIS Food Innovation Network model.*

*Centres of Excellence (COEs)*

The two existing COEs were created by the National Food Industry Strategy in 2003, to respond to the decreasing R&D funding in the food industry. in the areas that were the most important innovation trends in the early 2000's: functional foods and food safety. The Centres of Excellence operated as virtual hubs of innovation, as illustrated in Figure 9.

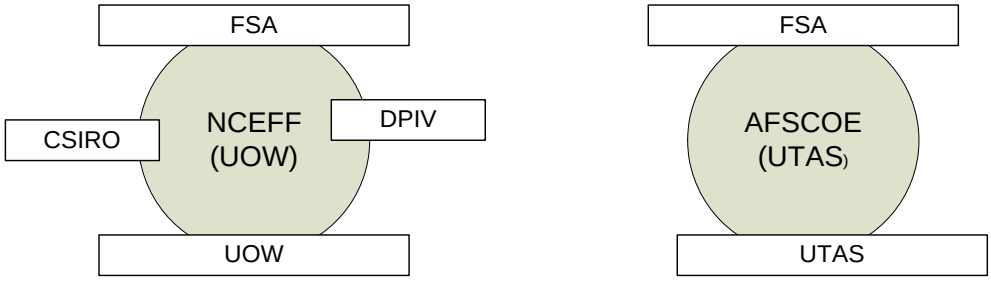



*Figure 9. Centres of excellence created by NFIS in 2003. Notes: FSA= Food Science Australia, a joint venture of CSIRO and DPIV; UOW= University of Wollongong; UTAS= University of Tasmania.*

Figure 10 shows the COEs model, where a virtual network of consortia partners agglomerate around one topic (i.e. functional foods, food safety) and provide a wealth of services to the industry. The review found that the COEs lacked formal mechanisms of engagement with industry: Why industry players should be involved? What is the cost of involvement? What is the motivation? The lack of engagement, the lack of a strong value proposition, weaknesses in governance and the duality of roles of the managers and scientists involved (e.g CSIRO-centre view, as opposed to NFIS-centred view) were highlighted in a critical review undertaken by NFIS in 2005[24].

Recently, AFSCOE (the most promising COE) has changed its affiliation to the Food Safety Centre, a self-sustained food safety information portal. The extent of funding from the host

[24] Ridge Partners on behalf of National Food Industry Strategy Limited (NFISL), 2005. Mid-term review of the National Food Industry Strategy. Final report.

organisations (i.e. FSA and UTAS) to support the Food Safety Centre is unknown. In regards to the NCEFF, it is not known if it is still active.

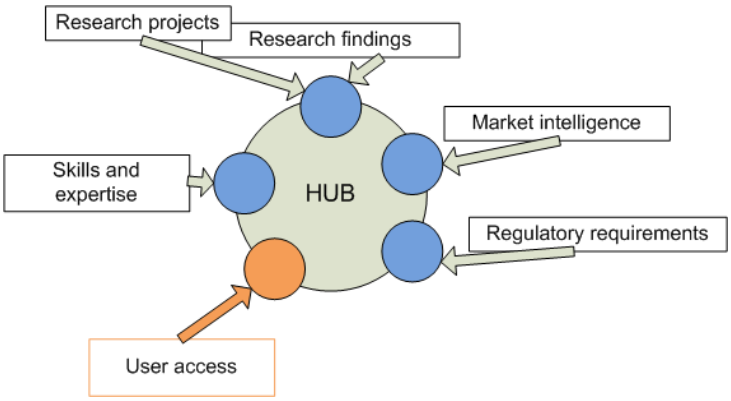



*Figure 10. Hub model used for the NFIS funded Centres of Excellence.*

## 4 CHALLENGES FOR PUBLIC ORGANISATIONS FOCUSING ON FOOD RESEARCH

In Appendix 1, Table A1 summarises the results of an analysis applied to understand the influence of social, technological, economic, ecological and political/legal factors on the strategic directions and competitiveness of public food R&D providers. In Figure A1 (Appendix 1), a "five forces" analysis was used to complete the external environment analysis, outlining the challenges of public R&D providers in competition with private providers.

The analyses revealed the following limitations for the development of food innovations by public R&D organisations:

1. Although the levels of R&D expenditure in the Australian food industry are increasing, R&D funding is decreasing in areas that are heavily staffed in public R&D organisations (e.g. meat, dairy, cereals).
2. *Supplier* issues are basically a human resource issue. In the current job market, finding and sourcing staff with the right mix of business and scientific skills required for public R&D is difficult. Particularly if those skills are in high demand in industries offering better employment conditions. An example of this situation is hiring scientists with expertise in industrial ecology or energy.
3. The role and influence of supermarkets (*buyers*) on the R&D agenda of manufacturers should be considered: The profitability of the retail sector is highly reliant on in-depth customer knowledge and reliable and efficient supply chains that can deliver the food products. Therefore, retail-led innovations focus on improving supply chain aspects. Additionally, the current environment for manufacturers (i.e. increasing productions costs and decreasing sell prices) means that there are fewer margins available for innovation and capability development.
4. The commercialisation requirements for R&D providers can vary significantly. For example, RDCs have as a key priority the development of research that benefits the wider industry. This position does not encourage the use of intellectual property (IP) as a competitive advantage for a particular company[25]. In the other hand, the industry

[25] DAFF has stated that the adoption of agrifood R&D outputs is largely achieved through an 'open-source non-competitive extension approach'. However, DAFF also noted that food producers need to achieve a competitive advantage, 'often through exclusive access to IP or the ability to exploit some particular knowledge'. (DAFF, 2005; Productivity Commission, 2006).

normally expects full ownership (or full entitlement of licences) of the IP developed with an R&D provider. Therefore, R&D providers needs to have several strategies and business/IP models that accommodate these situations.

5. The levels of rivalry in the industry are high, as public food R&D organisations compete for decreasing industry and government funding with universities and private providers. Universities in particular are now competing in applied research grants, in addition to their traditional role of basic research providers.

# 5 POTENTIAL INNOVATION MODELS FOR THE FOOD INDUSTRY

I believe that open innovation models that:

(a) bring together the necessary roles and players for innovation;
(b) 'connect the dots' between the key innovation players; and
(c) create the necessary market conditions for the commercialisation of innovative products

would be more successful than current approaches. There are three concepts that I would like to introduce at this point: co-innovation, consumer-led innovation and forward commitment procurement. I believe that these concepts are essential to develop a sound innovation framework for the food supply chain.

## Collaborative Supplier-Manufacturer-Retailer Innovation

In the context of this paper, cooperation is defined as similar or complementary coordinated activities performed by different firms in a business relationship to produce superior outcomes, with expected reciprocity over time. In a cooperative framework, the relationship between partners is driven by the need of profitability and by strategies that are congruent within each company involved and within the relationship[26]. Co-innovation is one of those strategies, where the success of a new product or service in the market means success for all the supply chain partners. Co-innovation seeks to extend the scale and scope of external partnerships and alliances to access and exploit new technologies, knowledge, and markets. Collaborative innovation requires early involvement of all chain players in the new product development (NPD) and the development of 'innovation networks', or clusters of collaborators working at every stage of the product cycle and at every link of the value chain.

The challenge of co-innovation is better understood if we take into account the balance of market power between food suppliers, manufacturers and retailers: in the Australian and UK environment, retailers (with emphasis on the supermarkets) are perceived as having more influence and control in the food chain. This influence received significant attention in the UK, which led to the introduction of a Supermarket Code of Practice, introduced in 2002. The Code explicitly mentions that all supply chain participants would benefit if they worked together to expand the market for their products and develop a profitable and sustainable business[27]. In Australia, the ACCC is seeking to investigate the nature of the relationship between suppliers and retailers in a similar manner[28]. Therefore, creating the required level of communication, trust, commitment and interdependence required for co-innovation calls for significant political and organisational efforts.

Appendix 3 shows examples of innovation spheres for manufacturers and retailers, showing some of the areas where co-innovation could be a successful approach.

[26] Shaw, S. A., and Gibbs, J. Retailer-supplier relationships and the evolution of marketing: two food industry case studies. Int. J. Retail & Dist. Mgmt. 23(7): 7-16

[27] Fearne, A. 2005. Justice in UK supermarket buyer-supplier relationships: an empirical analysis. Int. J. Retail & Dist. Mgmt. 23(7): 7-16.

[28] http://www.accc.gov.au/content/index.phtml/itemId/809228

## Consumer-led innovation

Consumer-led product development arguably offers the best platform for co-innovative projects between suppliers, retailers and manufacturers. The aim of consumer-led product development is to create product differentiation, leading to higher consumer satisfaction, increased levels of consumption of specific products, or increased overall value of the given level of consumption[29]. In a consumer-orientated approach, the development of new products, processes or services begins with consumer and market research to identify the specific characteristics required by consumers. The next step is the organisation of the cooperative framework and information exchange among all the actors in the production chain. An important aspect in this process is the translation of descriptive and qualitative terminology in which consumers express themselves into technological specifications for all the chain players participating in this form of co-innovation [30].

Consumer-led innovation also opens new doors of collaboration. Consider the highly perishable fruit and vegetables category, which have a shelf life of sometimes days only. The shelf life of the product dictates the speed the supply chain should operate at. Therefore, for these products, some retailers plan their resourcing more than once a day, because the potential wastage cost exceeds the savings through economies of scale in transportation and warehousing activities. In this case, the flow benefits of co-innovation can be captured simply with information sharing and forecasting collaboration. For less perishable items, say, canned food, a highly efficient supply chain depends on low inventory levels and high capacity utilization. In a co-innovative environment, sharing of information has more probabilities of success than in the case of a traditional, manufacturer-led innovation.

Figure 10 presents a co-innovation model proposed by Dr Andrew Fearne, the Director of the centre for Supply Chain Research at the Kent Business School, United Kingdom. Dr Fearne recently toured the Asia-Pacific region to explain his views on co-innovation and food supply chains.

*Figure 11. Co-innovation framework (Source: A. Fearne, 2007. Co-innovation for sustainable competitive advantage. ABARE Outlook conference 2007).*

[29] Grunert, K., and Valli, C. 2001. Designer-made meat and dairy products: consumer-led product development. Livestock Production Science 72 (2001) 83–98.

[30] Linnemann, A. R.Benner, M., Verkerk, R. and van Boekel, M.A.J.S. 2006. Consumer-driven food product development, Trends in Food Science & Technology, 17:184-190.

Fearne suggests that there are three drivers to undertake co-innovation:

(a) It allows the development of new (value added) products/services for distinct customers and targeted consumer segments
(b) Process improvement occurs for existing products/services beyond organisational boundaries
(c) Innovation at the interfaces in the value chain are much more difficult for others to copy, thus increasing the competitive advantage

Since co-innovation quite often requires global innovation networks, there are further advantages, such as:

(d) Supporting collaboration among geographically dispersed teams of suppliers, manufacturers and retailers
(e) Speeding time-to-market and reducing costs for all the parties involved in the NPD process (due to resource pooling and reduction of learning curve)
(f) Meeting customer expectations in a more close manner, due to the direct input of retailers into the main purchase drivers of products
(g) Enforce consistency and quality of brands and innovations
(h) Creating a compliance audit trail through sharing of quality documentation
(i) Most importantly, creating a repository of protected know-how and intellectual property, only available to the chain participants.

How can organisations achieve the right environment for co-innovation? Several authors agree that the following are key aspects to achieve this:

(1) Have a consumer focus and enforce collective responsibility
(2) Promote value chain visibility and information flows (vertical and horizontal) across the chain
(3) Promote the management of inter-personal and inter-organisational relationship
(4) Align the required resources (physical, financial and organisational) with the final demand and process integration.

## Forward commitment procurement model

Forward commitment procurement (FCP) is another type of demand side driven innovation, although this process is specifically led by the Government. It is defined as "a commitment to purchase, at a point in the future, a product or service that does not yet exist commercially, against a specification that current products do not meet, at a sufficient scale to enable the investment needed to tool up and manufacture products that meet the cost and performance targets in a specification"[31].

In an FCP model, a public sector organisation commits to purchase a pre-defined quantity of a product\ technology, currently under development but not yet available as a commercial offering. The commitment is for a future date and is based on a specified product performance being achieved. When the product has been developed meeting this performance specification within the agreed timeframes and framework, the organisation purchases the product at a specified volume and cost, at levels that encourage supplier investment to ensure economies-of-scale. The private sector would react by freeing investment to search for innovations that respond to those specifications. Once the product/service has entered the market, normal market conditions will determine competition and price[32].

[31] http://www.cambridgenetwork.co.uk/news/article/default.aspx?objid=16135

[32] http://www.endsdirectory.com/index.cfm?action=articles.view&articleID=200704

The FCP model has been highlighted as the most promising model to encourage environmental innovations, where the government itself acts as an early adopter. The procurement process is also supported by regulations that enhance the market conditions to create a demand for the innovations. A key aspect of FCP is the focus on needs and outcomes, rather than placing the focus on the product.

The European Commission investigated the FCP model for driving innovation in 2005[33]. The major advantages that the EC has noted about FCP are:

- Firms are given the incentive to spend money on research in the knowledge that an informed customer is waiting for the resulting innovations and thus the risk of investing in R&D is reduced.
- Competition is shifted from a sole focus on price to the provision of solutions which offer the greatest advantage to users over the whole life use of the purchase.
- FCP opens up opportunities to improve the quality and productivity of public services offered to the citizens through the deployment of innovative goods and services.
- Technologies launched in this way may then move on to further deployment in private sector markets. Other policy objectives (e.g. sustainability, food safety) may also be achieved by procurement of innovative solutions.

Recently, the European Commission published a second document outlining the pre-commercial procurement process in the EU, reflecting their intention to use this approach for their strategic sourcing of innovation (Figure 11). Two European FCP models are shown in Figures 12 and 13.

The Australian Government is extremely knowledgeable about procurement strategies. However, there is a lack of guidance in regards to the use of procurement to drive innovation. Bridging this knowledge gap through enhancing public knowledge on the role of procurement to drive innovation is the first key step towards using FCP.

I raise the issue of the roles of CRCs and RDCs in regards to the role of “innovation procurers”: although RDCs align closely to what FCP is about, CRCs do not quite match this profile. CSIRO has a role as an R&D provider in basic areas of research, but it may well be that CSIRO can have a role as a procurer in seed/incubations stages. In any case, CSIRO could not sit in both (supplier and procurer). The role of public R&D organisations needs to be discussed in the light of any FCP initiatives in the future.

A crucial element of the FCP model is the identification of market needs and the translation of these into specifications for the tendering process. The needs may arise from policy changes, budget structures, operational/efficiency reasons or other sources. To illustrate the concept, we have used some of the challenges identified by DAFF[34] for the food industry to suggest some FCP statements of needs (Table 1).

[33] EC 2005. Public procurement for research and innovation. Developing procurement practices favourable to R&D and innovation.

[34] Australian Food Statistics 2006

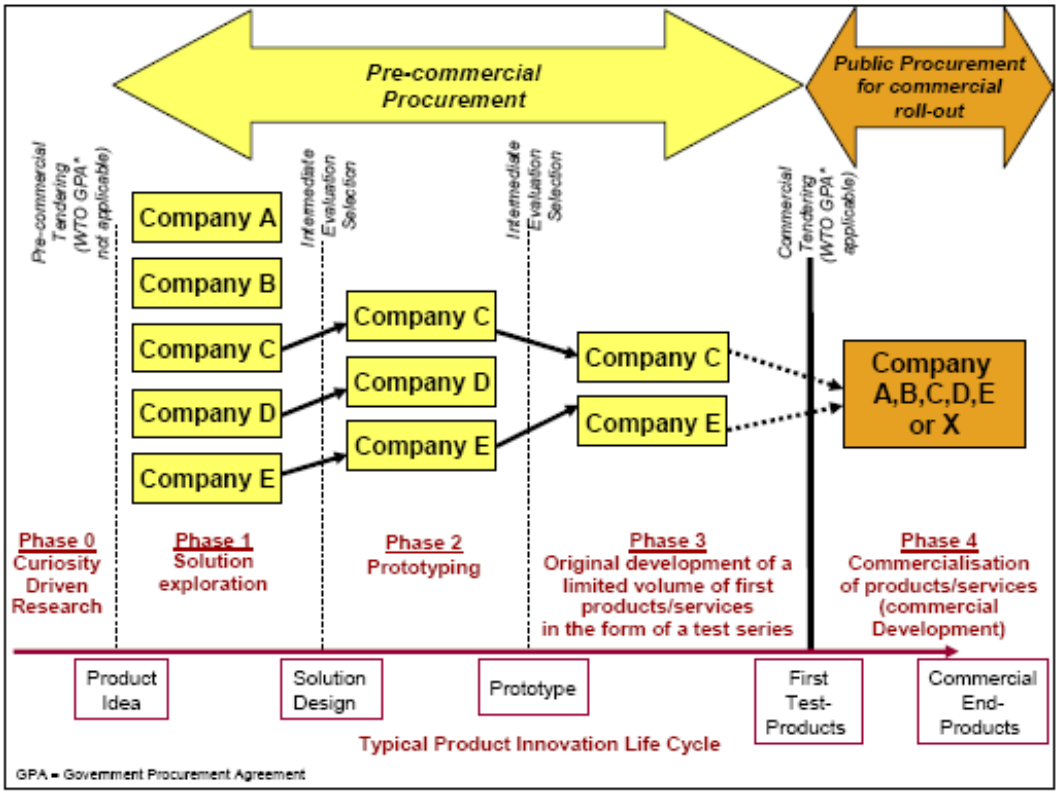



*Figure 12. An European example illustrating a phased pre-commercial procurement process (Source:* EC. 2007. *Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe.*

Table 1. Examples of innovation challenges in the food industry and their translation into market needs.

| **Product/process** | **Challenge** | **Potential need** |
|---|---|---|
| Food value chains | Identifying improvement opportunities on food value chains | "Increase in 1% the margin profit of tomato growers, without increasing the product price at retail and without sacrificing other margins in the chain" |
| Fresh, ready-to-eat meals | Developing solutions to overcome the cost–time tradeoffs made by consumers, while also addressing quality and variety demands. | "Develop a range of chilled retail ready-to-eat salads that extend the product shelf-life to 10 days" |
| Logistics | Finding ways to add value in more than the supply of product | "Develop a logistics system that brings the shop to the consumer, rather than bringing the consumer to the shops" |
| Supply chain management | 1. Manage production in an environment of unreliable climate, including managing the supply and cost of water.<br>2. Added complexity in food marketing and distribution will require the use of demand signals and fostering relationship management to better understand customer trends and preferences. | 1. "Develop horticultural varieties that require x% less water for growth and yet, maintain their desirable nutritional and quality attributes"<br>2. "Develop a forecasting tool for predicting the monthly demand of highly perishable, ready-to-eat sandwiches in petrol stations". |

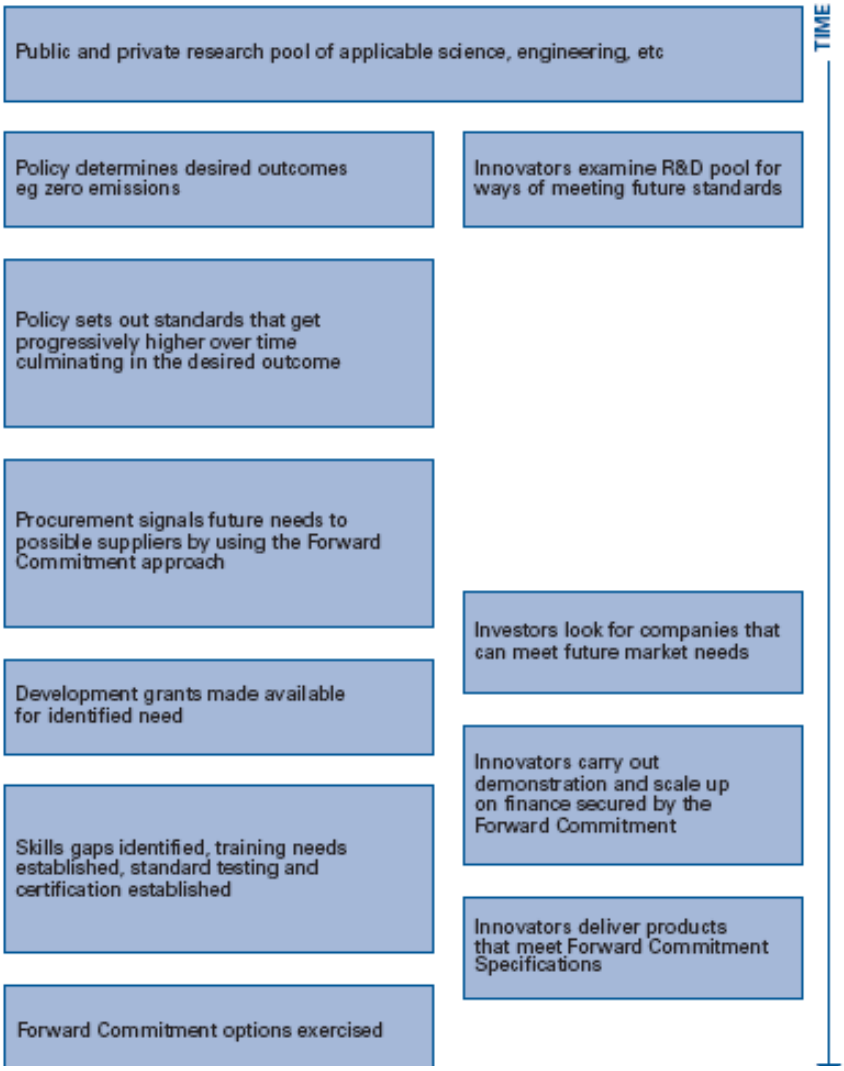



*Figure 13. FCP model for environmental innovations (Source: DTI & DEFRA, 2006. Bridging the gap between environmental necessity and economic opportunity. 1st report of the Environmental Innovations Advisory Group. P.15)*

## 6 A NEW MODEL: SUSTAINABLE CO-INNOVATION

In this section, I use the three concepts discussed in the previous section to propose an innovation model for the food industry. I do not propose that this innovation model supersedes all innovation-related initiatives and it does not offer a solution to maintain curiosity driven R&D. However, the model proposed tackles the issue of innovation, or R&D with a purpose. I do believe that this model can replace the fragmented innovation attempts currently undertaken by CRCs and RDCs in the food supply chains.

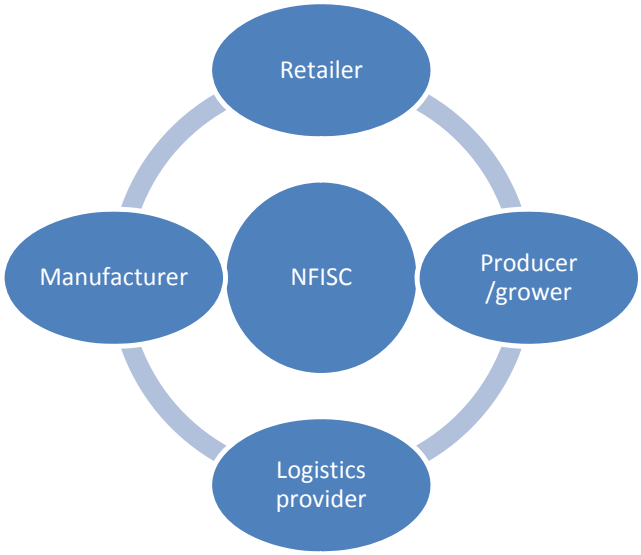
I will use the term “sustainable co-innovation” (SCOI) model to identify the proposed structure. The SCOI model follows closely the FCP model, adding the concepts of co-innovation and innovation networks.

The SCOI model requires a central overseeing organisation. This organisation (which we will indentify in this proposal as “National Food Innovation Strategic Council” (NFISC), can be modelled after the successful NFIS and NFIC. However, we envisage that NFISC would amalgamate the two roles.

NFISC should receive funding from private and public partners (e.g. joint venture). NFISC would:

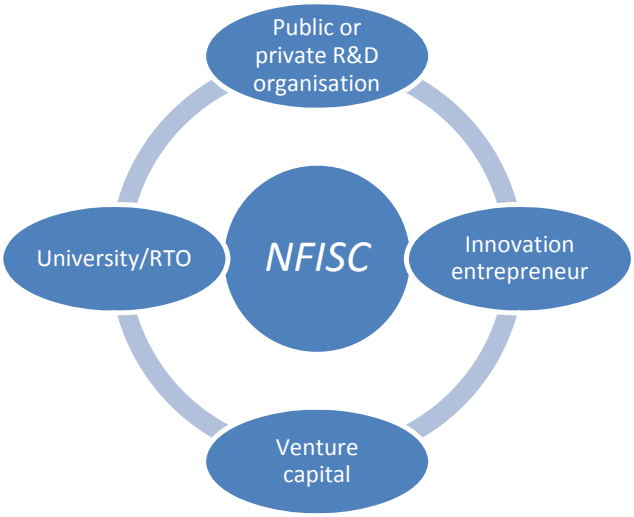
(a) Provide a strategic framework for food innovation in Australia, from a market-led, supply chain perspective.
(b) Coordinate the activities required to introduce new technology in the marketplace, following an FCP approach.
    - Engage with Government departments and food supply chain players to develop the buyers needs into specifications for tenders
    - Act as a technology broker, bringing venture/equity capital and innovator companies together
    - Coordinate legislative activities that provide adequate market conditions for adopting innovations in the wider industry.
    - Promote technology demonstrations and case studies to show the business case.
(c) Coordinate government-led food innovation activities (e.g. grants and strategic directions for public R&D), from a supply and value chain perspective. This would avoid the lack of supply chain focus and would increase critical mass in the initiatives undertaken.
(d) Provide timely competitive and technical intelligence to all stakeholders about the particular FCP projects targeted, bringing to the stakeholder's attention current and emerging technologies in the targeted technology markets.

The NFISC role is crucial in the SCOI model, which is based on the development of three types of consortia:



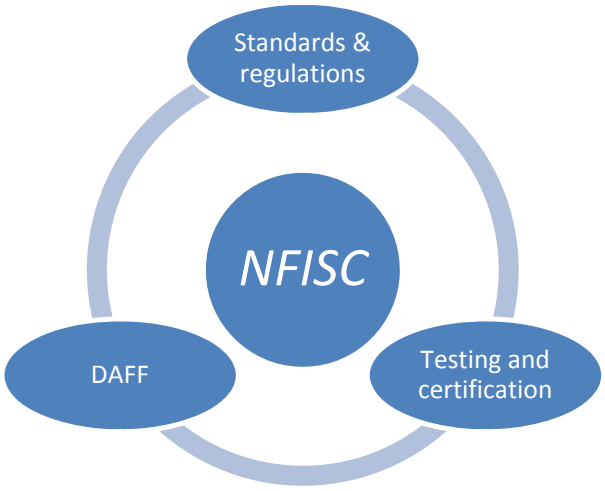

**The buyer consortia**

A *buyer* consortium is formed by two or more supply chain partners that establish an alliance to contract/purchase the new process/ product/ service developed by a supplier consortium. Examples of alliances may be: (a) a retailer and a cooperative that have mutual benefit in purchasing a new retail-ready format for fresh produce that is also environmentally friendly; (b) a fast-food chain, a third party logistics provider and a food manufacturer that all mutually benefit with the use of new logistics systems that allow direct dispatch of home delivery orders from the manufacturer to the consumer. This type of consortia becomes effectively a supply chain innovation network.




### The supplier consortia

A *supplier* consortium is formed by two or more organisations that seek to deliver the innovation at the specifications (e.g. cost, time, performance) set by the legislative consortia. Public and private R&D organisations supply solutions and showcase their R&D to innovation entrepreneurs looking to develop the new product/ technology, eotehr as a start-up company or as a product in an established company. Universities and RTOs contribute with gap analyses of required skills and deliver training and education programmes to address these gaps. Venture capital is sought to help innovation entrepreneurs to start the company, continue R&D in collaboration with the public/private R&D organisations and prepare case studies highlighting the business case. A crucial aspect of this consortium will be the willingness of public R&D organisation to transfer intellectual property rights to the innovation entrepreneur. We may well question why a public R&D organisation wants to own patents, given that the organisation itself is unlikely to commercialise inventions in many cases. Fair arrangements and payments should be negotiated to ensure that inventors and developers are rewarded.




### The legislative consortia

A legislative consortium, which aims to increase the receptiveness of the market to new technologies/processes/products by introducing standards, regulations and laws that increase performance targets in certain areas. For example: we would expect increased innovation in water utilization if toughest regulations on water usage are introduced; innovation in food safety would be aided by increased regulations on the limits of food poisoning cases per State; innovation in refrigeration systems would be increased by limiting the energy rating of commercial and domestic appliances even further.

The SCOI model encompasses the steps and processes shown in Figure 14.

In the SCOI model, a buyer consortia (which may or may not include a public sector organisation) commits to purchase a pre-defined quantity of a product\ technology\service, currently under development but not yet available as a commercial offering. NFISC and the buyer consortia agree in the performance sought for the innovation. The supplier consortium is formed and solutions are sought, based on past innovations or completely new concepts. Meanwhile, the legislative consortium develops standards, regulations and certification processes that enable fair competition and enhance the chances of the uptake of new solutions at the agreed performance specification. When the innovation has been developed, meeting all performance criteria, the buyer consortium purchases the product at a specified volume and cost, at levels that encourage other supplier

consortium to enter the market. The private sector would react by freeing investment to search for innovations that respond to those specifications.

In the context of SCOI, I do not necessarily advocate for the government to become the early market buyer that executes the forward commitment options. This may be effective in some areas, such as food safety (related to public good). However, the Government may not be the ideal buyer innovations that lead to new products, new markets or new processes. Instead, I propose that food supply chain players form alliances that commit to buy the new product / service/technology when this is developed. The drivers for such commitment could be based in (a) superior value proposition (including financial, environmental and social performance); (b) new regulations encouraging the uptake of the innovation; and (c) a demonstrated increase of competitiveness in the marketplace if the innovation is adopted.

## Selection criteria of publicly funded food innovations

Figure 15 is provided as a framework of analysis to enhance decision-making on the food innovation areas that would be able to compete in the marketplace. In the view of this author, the following general areas that should be assessed for R&D funding are:

***Health areas***

R&D examples:

- *Role of human nutrition, genetics and food trends in health trends (nutrigenomics)*
- *Functional foods*
- *Delivery technologies of health ingredients*
- *Evaluation of functionality for Australian native foods*
- *Portion control and obesity*

***Food processes***

R&D examples:

- *Non-thermal processes*
- *Micro-machine processing and production-descaling*
- *Biotechnology (e.g. development of high value bioproducts from food industry waste streams)*
- *Nanotechnology in food production and manufacture*

***Food supply chains***

R&D examples:

- *Information and Communication Technologies in modern food supply chains (e.g. track-and-trace systems)*
- *Food logistics and packaging systems adequate for specific chains (e.g retail-ready, convenience markets, ageing population)*
- *Quality keeping in perishable food chains*
- *Sustainability of food supply chains, with emphasis in water, energy and food waste (e.g. carbon-neutral supply chains)*
- *Improvements in food transportation and storage (cost, quality and energy)*
- *Pandemic scenario and contingency planning*
- *Tamper-resistant and sanitary packaging*

- *Automation in the food industry(including robotics/machine vision systems for production and quality grading)*
- *Biodegradable packaging*
- *Low cost alternatives for the transport of perishables*
- *Role of retail in market led innovations*

***Food safety***

R&D examples:

- *Detection of biological and chemical food contaminants*
- *Innovations to counter food bioterrorism threats*
- *Authenticity analyses*
- *Track-and-trace technologies for food safety*
- *Decontamination systems for the food industry*

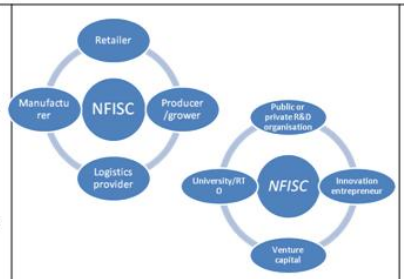
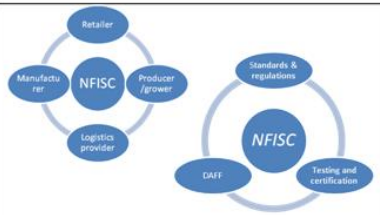
| PROCESS | WHO DRIVES THE PROCESS | INPUTS TO THE PROCESS | WHO IS CONSULTED | OUTCOMES |
|---|---|---|---|---|
| OUTCOME SETTING, SPECIFICATION AND AWARD CRITERIA |  | -Competitive and technical intelligence<br>-Risk management procedures<br>-Potential structures to manage contracts, IP and other business areas<br>-Appropriate development time and human resources (this is critical)<br>-Analysis and assessment of the innovation<br>potential and cumulative effects |  | -Development of precise, tight performance specifications and selection criteria<br>-Promotion of networking and supply chain partner selection |
| POLICY SETTING |  | -Screening of current regulations to identify domains in which to integrate a performance based approach<br>-Certification bodies and laboratories to develop testing methods and standards for the criteria established | -Relevant associations, companies interested in developing the innovation as a product, companies interested in the uptake of the product | -Improve legal certainty and consumer confidence<br>-Adopt an initiative to promote application and<br>Enforcement of specifications<br>-Develop voluntary performance targets to enable the implementation of incentives and other policy measures to promote the innovation<br>-Establishment of the legislative transition from voluntary to mandatory measures |
| SEED-TO-MARKET ENTRY STAGE |  | -Mobilization of private parties to place an expression of interest<br>-Mobilization of R&D providers to link them with venture capital<br>-Support access to R&D funding for those consortia selected for the next round<br>-Transfer of knowledge and IP to innovation entrepreneur company |  | -Development of pilot plant/prototypes<br>-Development of case studies to show the business case<br>-Anticipate the future qualifications and skills needs to uptake innovation<br>-Deliver the innovation at a commercial-ready stage to the FC buyers |
| COMMERCIAL ROLL-OUT |  | -Revisited competitive and technical intelligence<br>-Reviewed risk management procedures<br>-Innovation developed as per specifications in tender<br>-Approved certification and testing processes |  | -Forward commitment options excersised |

*Figure 14. SCOI model*

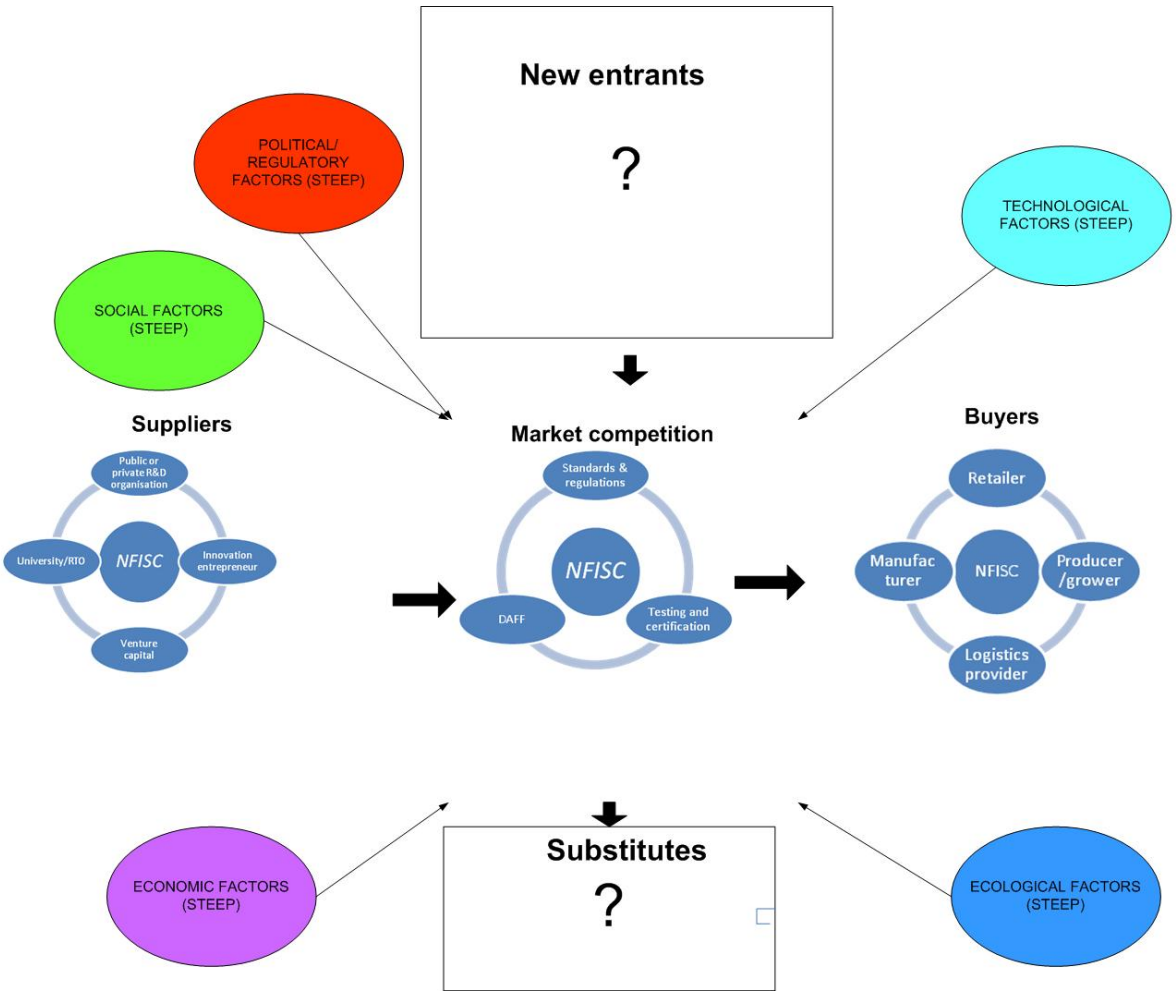



*Figure 15. "Five forces" framework for the analysis of future innovation areas*

Although I propose that the SCOI model replaces current funding sources to the food chain (including RDCs and CRCs), I also propose that funding should be available to establish "innovation networks" in key areas affecting the food supply chain environment (e.g. environmental impacts, economics of global supply chains, consumers and markets, social impacts). The innovation networks should be created in an '*ad hoc*' basis and should serve a specific purpose.

For example:

- Brainstorming on particularly challenging issues affecting the Australian food industry (e.g. market barriers, cost effectiveness, labour) and possible innovative solutions.
- Sharing learnings and insights in discussion forums around particular industries (e.g. dairy, meat, horticulture), in a secure environment.
- Providing guidance to food supply chain players, in the form of workshops, seminars and competitive intelligence reports.

These networks should be dismantled as soon as their goal is accomplished. The lifecycle of these networks is likely to be shorter than current CRCs (e.g. months rather than years) and with input from a larger representation of supply chain players than CRCs structures currently allow.

## TO SUMMARISE....

1) Innovation is a process that goes beyond theoretical conception, through technical invention to commercial exploitation. Therefore, R&D is an element of innovation.

2) One key distinction between R&D and innovation is that in the former, we don't necessarily know the outcomes. To create an innovation, the desired outcome must be known before tackling the problem with R&D.

3) All research has a purpose. However, a commercialising purpose is very different from a knowledge-seeking purpose. Funding mechanisms to deliver in both areas will have to follow very different rationale. My view is that grants investing in knowledge-seeking endeavours should be discussed separately from the discussion of a national innovation system.

4) It is clear that some industries will benefit from a market push innovation model than from a technology push innovation model. The food supply chain is an example of an area that would benefit from a market push approach.

5) There is a need for a concerted approach to innovation in the food industry, from agricultural production and rural based manufacturing to retail, thus adopting a value chain perspective. Such a concerted approach should recognise the highly dynamic nature of the food manufacturing industry, the benefits of market driven innovation and the usefulness of policy as an instrument to encourage innovation in the marketplace.

6) The current innovation system, which focuses on CRCs, RDCs, public R&D organisations and universities, has delivered a small number of innovations to the marketplace.

7) NFIS had a strategic role in supporting business innovation, manufacturing, supply chain and value addition projects. Additionally, NFIS approached food innovation with a 'whole-of-the-chain' perspective. The termination of this initiative leaves a vacuum in R&D focused to food manufacturing and other areas of knowledge required to introduce food innovations in the marketplace (e.g. supply chain, consumer science and packaging).

8) A new "sustainable co-innovation" (SCOI) model is proposed for the food industry. The model is similar to the Forward Commitment Procurement model, but the concepts of co-innovation and innovation networks have been added.

9) The SCOI model requires a central overseeing organisation similar to NFIS. However, it is proposed that the organisation becomes a joint venture between private and public partners. This organisation would:
    a. Provide a strategic framework for food innovation in Australia, from a market-led, supply chain perspective.
    b. Coordinate the activities required to introduce new technology in the marketplace
    c. Coordinate government-led food innovation activities (e.g. grants and strategic directions for public R&D), from a supply and value chain perspective. This would avoid the lack of supply chain focus and would increase critical mass in the initiatives undertaken.
    d. Provide timely competitive and technical intelligence to all stakeholders about the particular innovation areas targeted, bringing attention to current and emerging technologies and innovation trends in the targeted markets.

10) The SCOI model also requires the following types of consortia:

    a. A buyer consortium, formed by two or more supply chain partners that establish an alliance to contract/purchase the new process/ product/ service developed by a supplier consortium.
    b. A supplier consortium, formed by two or more organisations that seek to deliver the innovation at the specifications (e.g. cost, time, performance) set by the legislative consortia.
    c. A legislative consortium, which aims to increase the receptiveness of the market to new technologies/processes/products by introducing standards, regulations and laws that increase performance targets in certain areas.

11) In the SCOI model, a buyer consortium (which may or may not include a public sector organisation) commits to purchase a pre-defined quantity of a product\ technology\service, currently under development but not yet available as a commercial offering. NFISC and the buyer consortium agree in the performance sought for the innovation. The supplier consortium is formed and solutions are sought, based on past innovations or completely new concepts. Meanwhile, the legislative consortium develops standards, regulations and certification processes that enable fair competition and enhance the chances of the uptake of new solutions at the agreed performance specification. When the innovation has been developed, meeting all performance criteria, the buyer consortium purchases the product at a specified volume and cost, at levels that encourage other supplier consortium to enter the market. The private sector would react by freeing investment to search for innovations that respond to those specifications.

12) In the context of SCOI, I do not necessarily advocate for the government to become the early market buyer that executes the forward commitment options. This may be effective in some areas, such as food safety (related to public good). However, the Government may not be the ideal buyer innovations that lead to new products, new markets or new processes.

13) Instead, I propose that food supply chain players form alliances that commit to buy the new product / service/technology when this is developed. The drivers for such commitment could be based in (a) superior value proposition (including financial, environmental and social performance); (b) new regulations encouraging the uptake of the innovation; and (c) a demonstrated increase of competitiveness in the marketplace if the innovation is adopted.

## APPENDIX 1
## STEEP and Five Forces analyses for public R&D organisations (food-related)

The five forces analysis in Figure A1 needs to be examined in the light of the factors analysed in Table A1. The combination of Table A1 and Figure A1 allows both the identification of the main forces operating in the food R&D sector and theeffect of these on the public R&D organisations.

*TABLE A1. Social, technological, economic, ecological and political factors affecting public food R&D organisations*

| VARIABLE | TREND | IMPACT ON PUBLIC R&D PROVIDERS |
|---|---|---|
| **Social** | **1.** Global trends in ageing and health awareness.<br>**2.** Global trends in sustainability and ecology.<br>**3.** Consumer trust and consumer satisfaction (convenience).<br>**4.** Added complexity in food marketing and distribution will require supply chain relationship management and forecasting tools to better understand customer trends and preferences.<br>**5.** Public R&D providers are seen as having a moral and ethical responsibility to service the food industry and not as a profit-making organisation.<br>**6.** Government stakeholders expect that public R&D providers continue delivering R&D for the public good, but also demonstrating industry relevancy, by raising external funds. | **1 & 2.** Current R&D focuses on health and nutrition, functionality of ingredients, and environmental sustainability of the food industry.<br>**3.** Convenience as a major driver for new product development.<br>**4.** Food distribution and related activities seen as an activity outside the food manufacturing industry and thus, not part of the R&D science investment strategy.<br>**5.** Public R&D organisations are required to attract commercial income, but most have not developed a profit strategy that matches their social image and client's expectations.<br>**6.** Scientific staff feel that there is an unresolved conflict between the mission of public R&D and the drive to earn external funding. This conflict extends to the dilemma of publishing *vs* patenting/commercialising technology |
| **Technological** | **1.** Innovation as a way forwards to grow and sustain production systems.<br>**2.** If a product moves away from being 'fresh', it loses potential revenue and quality advantages from local production.<br>**3.** Growth of new applications of nanotechnology and other emerging technologies (e.g. plasma, ultrasound and others) in food manufacturing.<br>**4.** The role of public R&D providers leads to support "open source" innovation, rather than closed innovation models preferred the by industry. | **1.** Public R&D has not clearly delivered "innovations" to the food industry.<br>**2.** Extension of perishables shelf-life at odds with "food miles" and freshness concepts. However, increasing shelf-life is vital for Australian exports.<br>**3.** New technologies that may not have a commercial future in Australia are embraced in R&D centres, to maintain a "high tech" R&D organisation profile<br>**4.** Recent initiatives by public R&D organisations include engagement with companies versed in commercialisation, IP and innovation management. Although helpful, it is not a complete solution for successful innovation. |

| | | |
|---|---|---|
| **Economic** | **1.** Supermarket power leads to lower margins for growers and manufacturers, thus leading to a decreased R&D budget.<br>**2.** Multinationals with in-house R&D dominate the food industry, but SMEs are often more innovative (i.e. higher tolerance to risk taking)<br>**3.** Escalating manufacturing and supply chain costs in Australia<br>**4.** Many multinational food companies are shifting their production to low-cost countries.<br>**5.** Pressure from competition with imported processed foods.<br>**6.** Australia's profile as an exporter of rural-based products continues.<br>**7.** Australia increased its food R&D expenditure from $192m in 2000 to $269m in 2005.<br>**8.** The sectors that increased R&D funding in 2000/05 were: sugar, confectionery, prepared animal and bird feed, seafood, beverage and malts and horticultural products.<br>**9.** R&D funding for the dairy industry has decreased in about $2.5m per annum in the past 10 years.<br>**10.** During 2002/04, the horticulture segment had the largest representation amongst FIG Program recipients (28%), followed by ingredients (22%).<br>**11.** In Australia, logistics costs have been reported to be between 9.9% and 21.1%[35]. | **1a.** Public R&D providers have not successfully engaged with supermarkets, partly due to a mismatch between R&D offered (e.g. new processes and products) and retailers needs (e.g. new forecasting tools, supply chain, category management).<br>**1b & 6.** Public R&D organisations normally have a specialisation approach to problems, rather than a 'whole-of-the chain' perspective.<br>**2 & 7.** See profit aspect in "Social– impact 5"<br>**2, 3, 4 & 5.** Innovations such as cost reduction and efficiency in the food industry are not 'sexy' enough for R&D organisations, unless it is linked to new technologies. For example, the performance of CSIRO's divisions is assessed in terms of science impacts. Some R&D with efficiency drivers has negligible science impact but high industry impact.<br>**8, 9 & 10.** Public R&D has strong capabilities in primary industries, but food R&D expenditure indicates that science capabilities need to be re-directed to confectionery, beverages, seafood, supply chain and other non-traditional areas.<br>**11.** See food distribution aspect in "Social– impact 4" and 1b in this box. Supply chain management is not considered a research area in public R&D organisations. |
| **Ecological** | **1.** Managing production in an environment of unreliable climate, including managing the supply and cost of water, is a major challenge for Australia (DAFF, 2006).<br>**2.** The use of agricultural products (e.g. grains) for the creation of biodiesel is at odds with the use of grains for human and animal consumption.<br>**3.** R&D funding to CSIRO and DPI was increased to tackle sustainability/climate change issues. | **1, 2.** R&D organisations will need to acquire skills in the environmental area (through re-training or recruitment). A re-direction of funding also leads to decreased funding in R&D areas that are still important for the development of the food industry. |

[35] BTRE (October 2001) Logistics in Australia: A preliminary Analysis, Working Paper 49.

| | | |
|---|---|---|
| **Political/ regulatory** | **1.** Disease-free livestock and plant industries remain critical to supply chain integrity.<br>**2.** Food safety and traceability regulations are increasing<br>**3.** Bioterrorism appears a new driver post-September 11, 2001.<br>**4.** New functional foods with health claims face regulatory hurdles, increasing the cost and time to commercialise new products/ingredients.<br>**5.** Pressure in R&D organisations to align better with the market development needs of suppliers and producers | **1.** Although there are public R&D organisations that focus into primary production issues, the perspective of a whole-of-the-chain food safety approach is lost.<br>**2 & 3.** In CSIRO, there is a paucity of this type of work due to a rearrangement of budget funding priorities.<br>**4 & 5.** Functional foods and ingredients are heavily funded, but basic market research and business plans are also necessary to prove that commercial exploitation is feasible. Public R&D tends to create new knowledge first and then explore possible paths for commercialisation. I suggest that innovation should start with a statement of a need, the business case and then R&D to seek for a solution. |

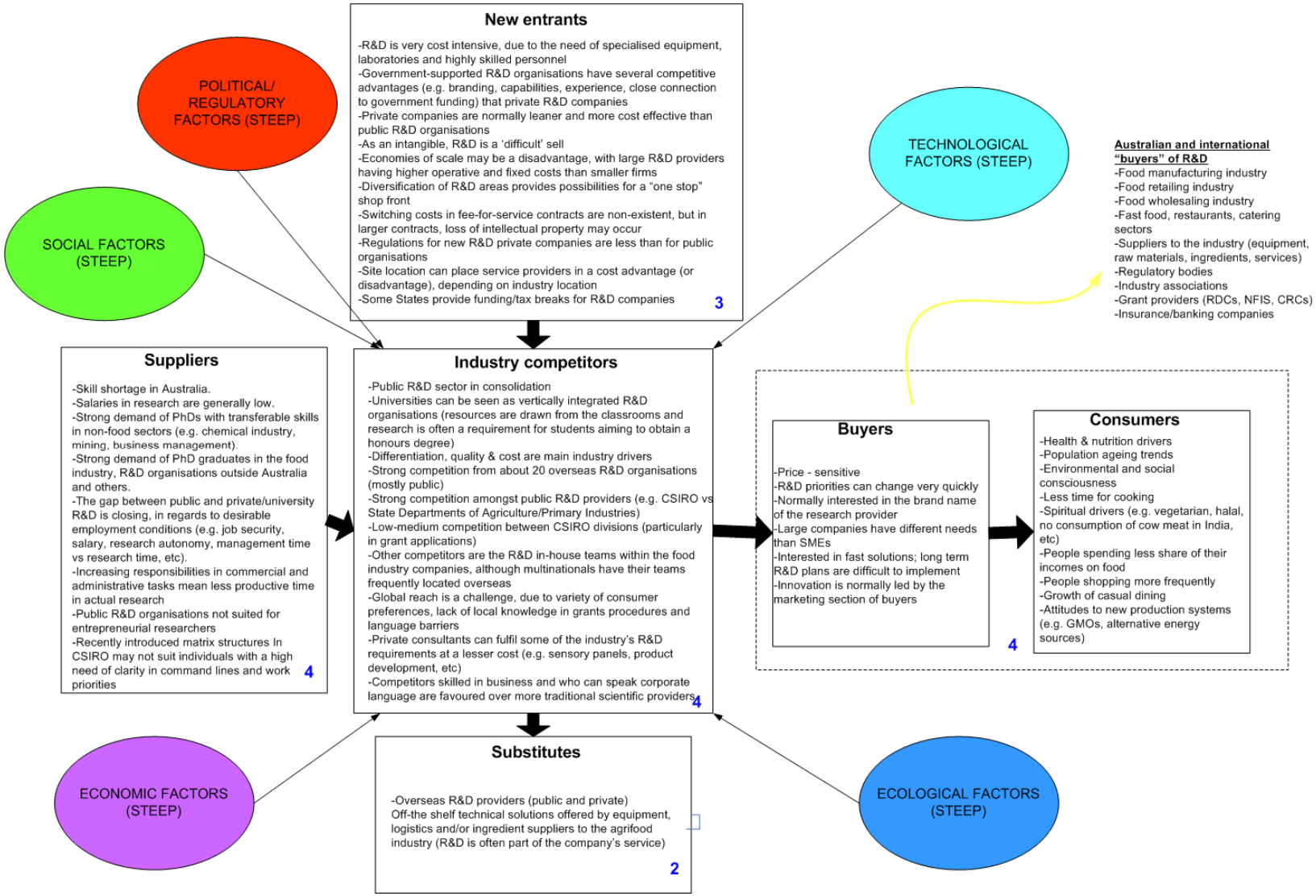



*Figure A1. The Five Forces analysis for the public food R&D sector. The numbers in blue fonts indicate the strength of these influences (in a scale of 1 to 5; 1= weakest and 5= strongest)*

## APPENDIX 2.
## List of CRCs supporting innovation in the food chain

• Agriculture and rural-based manufacturing
• Cotton Catchment Communities CRC
• Australian Sheep Industry CRC
• CRC for Beef Genetic Technologies
• CRC for Innovative Dairy Products
• Molecular Plant Breeding CRC
• CRC for Sustainable Aquaculture of Finfish
• CRC for Forestry
• CRC for National Plant Biosecurity
• CRC for Tropical Plant Protection
• CRC for Value Added Wheat
• CRC for Viticulture
• Australian Biosecurity CRC for Emerging Infectious Disease
• CRC for Australian Poultry Industries
• CRC for Innovative Grain Food Products
• CRC for Sugar Industry Innovation through Biotechnology
• CRC for an Internationally Competitive Pork Industry

## APPENDIX 3.
## Innovation spheres of manufacturers and retailers

Most of the retail-led innovations in supermarkets have focused on improving supply chain aspects and ensuring that the shopping experience is enjoyable. This is hardly a surprise, as supermarkets are highly dependent on reliable and efficient supply chains that can deliver the products offered. Table 1 shows some of the global retail-led innovations in the past years.

*TABLE 1. Retail-led innovations worlwide*

| Innovation | Outcome targeted |
|---|---|
| Air conditioning control | Comfort in supermarkets |
| Scanner systems | Efficient inventory |
| Bar codes | Traceability, supply chain management |
| Electronic cash register | Efficiency, shopping experience |
| Electronic data interchange | Paperless management of supply chain, reduced order lead time, fewer out-of-stick situations, lower inventory costs, reducing errors in ordering, shipping and receiving, reduction in labour costs, higher service levels |
| Category management | Vertical integration, matching of consumer's preferences by sellers offerings and growth of categories |
| Cross-docking | Cost efficiency in distribution |
| ECR | Efficiency gains in store assortment, promotion, new product introduction and replenishment, through constant flow of product and information between suppliers and retailers |
| CPFR | Coordination of supply-demand |

*Sources: Dappiran and Hogarth-Scott (2003);Keh (1998).*

Innovations in the manufacturing side tend to gravitate towards new products, packaging and processes. Table 2 presents the most common types of manufacturing-led innovation initiatives.

*TABLE 2. Types of manufacturer-led innovations*

| Innovation | Outcome targeted |
|---|---|
| New product development (NPD) | ▪ *'Me-too' products*: a product that replicates characteristics of existing successful products in the market, thus avoiding some NPD risks. The objective is to erode the market of a competitor<br>▪ *Line extensions*: variations of a well-known product (e.g. favours, colours, etc). The aim is to increase market share and improve product positioning with relatively little effort and development time, plus small changes in manufacturing processes, marketing strategy and storage and/or handling operations.<br>▪ *Repositioning of products*: changing the promotion strategy of current products in the market, to reposition these as products responding to current consumer's demands. The major efforts are, thus, in marketing. For example, repositioning of products as 'health' or functional products. The aim is to capitalize in niche markets.<br>▪ *New form/formulations for existing products*: these encompass products that have altered to another form (e.g. solved, dried, granulated, concentrated, spreadable, dried or frozen) or products that have been reformulated. For the former category, extensive R&D and development time may be required, plus changes in the supply chain operations. Formulation changes can have various impacts on the supply chain, according to the degree of variation in the product. The outcomes sought refer to: convenience, value addition, cost reduction, unreliable supply of some raw materials, or the availability of better/less costly ingredients.<br>▪ *Evolutionary innovative products:* substantial changes in an existing product, otherwise than described above. The changes must add |

| | |
|---|---|
| | value/functionality in a significant manner to the original version. R&D times, costs and risks are generally larger than for other modifications. Marketing can also be costly.<br>▪ *Radically innovative products:* a 'never seen before' product. These require extensive product development, have high R&D, marketing and capital (new equipment) costs and have the highest failure chance of all categories. Having said that, these products potentially offer greater rewards than others. The products can be potentially disruptive, but not all are. |
| New packaging development | Added functionality, better preservation of foods, variety in volumes/portions, more attractive designs for targeted consumer segments, labelling, convenience, **retail-ready formats.** |
| New processes | Cost reduction (e.g. less labour, energy efficient), OH&S compliance, reduction of environmental impact, requirement for manufacturing new product |
| New supply chains | **Response to changes in client's (e.g. retail, foodservice, etc) business formats, supply chain initiatives, traceability (e.g. RFID).** |

*Sources: Linnemann et al (2006);Keh (1998).*

In Table 2, the items in blue fonts highlight the most common areas of collaboration between manufacturers and retailers. It is evident that innovation in transport and distribution has significant synergies between these two parties. Nevertheless, little collaborative approaches in this area take place currently.

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KNOWLEDGE…INNOVATION…ACTION

# The environmental dimension of food supply chains

## Submission to the Garnaut Review Forum

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**Declaration of interests and affiliations**

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**Confidentiality status:** **PUBLIC DOCUMENT**

# The environmental dimension of food supply chains

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## I. Introduction

From production through to processing to retail, food supply chains have an often unmeasured impact on the environment. This impact is observed upstream and downstream the chain, as illustrated in Figure 1. Aspects that have environmental impacts include:

- Direct energy use on-farm, during manufacturing and during cooking at the household level.
- Indirect energy use during storage and transportation.
- Greenhouse gas (GHG) emissions associated with fertiliser production; pesticide production and production of packaging.
- Potential toxic effects from the use of chemical agents.

- Use of water for farming and processing, and land use for agricultural production.
- Food and packaging wastage at each stage of the chain.

Increasing regulatory efforts are putting pressure on companies to report environmental performance by July 2008. Simultaneously, businesses offering commercial solutions to assess environmental footprints and recommendations on how to 'green' supply chains have emerged. Companies will need to tread carefully on these matters: the diversity of supply chains and products means that there are no effective 'one fits-all' types of solution in the market. Once software has been used to optimise carbon footprints and consultants have recommended new supply chain strategies, companies must be prepared to implement the planned actions. These steps may involve reorganising supply chain channels, people and activities. In some cases, changes may involve the purchase of more energy-efficient equipment to replace less efficient infrastructure. Therefore, proposed solutions need to be tempered with the level of preparedness of the industry to implement these.

In this submission, I aim to provide a bird's eye view of the environmental issues associated to food supply chains. I make a distinction between operational (performance) related issues, consumer (market) issues and corporate issues, as illustrated in Figure 2. This categorisation could be used as a framework to assess the usefulness of 'greening' solutions and services at different company levels. For example, a particular commercial solution may aid compliance with regulatory reporting. Will this solution also evaluate how 'greening' measures will affect product quality/shelf-life during the chain? Will the solution measure the efficiency of the chain before and after applying environmental improvements? Will it also anticipate consumer's reactions to these changes? Most likely, a combination of approaches will be required to tackle each of the three suggested categories.


Figure 1. Environmental impacts of food supply chains.

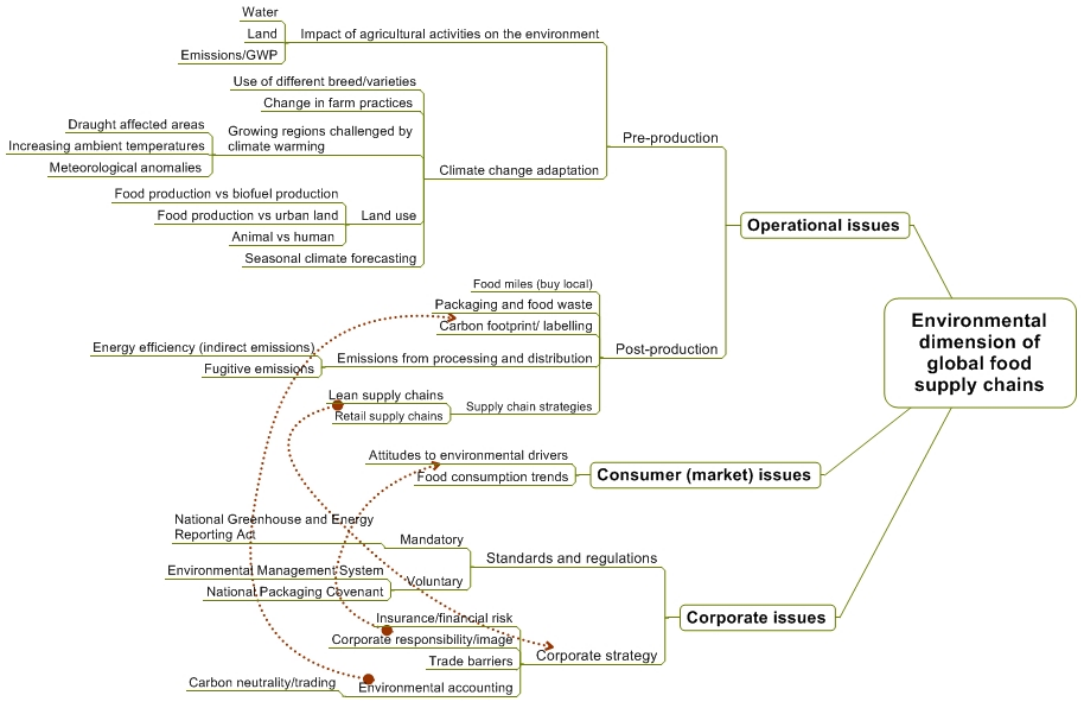


Figure 2. Environmental issues associated with food supply chains.

## II. Pre-production performance issues

In the context of this paper, pre-production issues refer to the operations required to grow or farm foodstuff, previous to the actual collection or harvest.

Currently, there are no accurate estimates of the global impact of agriculture on the environment. This gap in information arises from the lack of published environmental data and statistics per country. Extrapolation of published results (mostly related to European food chains) would be inadequate, given the diversity of eating habits, production systems and efficiencies of supply chains around the world. Furthermore, there is no agreed methodology to perform environmental benchmarking.

Although Life Cycle Assessment (LCA) methodologies have been extensively used as a benchmarking tool, LCA has limitations on the assessment of impacts of supply chain operations on biodiversity and water use (1). Furthermore, LCA analyses offer a 'static' view of systems, as opposed to the dynamic nature of supply chains. All LCA impacts are potential, rather than factual. Finally, the accuracy of LCA calculations depends on the quality of available data and the modelling assumptions.

Having said this, LCA remains as the only tool that can provide insights in a variety of industries with a minimum of data and with the greatest confidence. In Table 1, most of the scenarios present LCA estimations of the environmental impact of agricultural activities.

### TABLE 1. EXAMPLES OF ENVIRONMENTAL IMPACTS OF PRIMARY PRODUCTION OF FOODS

| ACTIVITY | IMPACT | | |
|---|---|---|---|
| | ***WATER*** | ***LAND*** | ***EMISSIONS/GLOBAL WARMING POTENTIAL (GWP)*** |
| **Livestock (Australia)** | ---- | 58% of the land mass is used for agriculture, mainly for grazing animals and the production of crops used in animal feed. | Livestock emissions were 62.1 Mt CO2-e in 2005, which represents 70.7% of the agriculture sector's emissions and 11.1% of net national emissions (2). |
| **Agriculture (Australia)** | ---- | ---- | Agriculture contributed 16.8 % of Australia's GHG emissions in 2005, making it the 2nd largest emitting sector behind stationary energy. |
| **Agriculture (UK)** | Agriculture accounted for 18% of the most serious water pollution incidents. Estimated environmental costs due to damage to water quality: £203 million (3). | Estimated environmental costs due to damages to soil quality: £264 million (3). | Entire food chain contributes 18% of total UK GHG emissions – some 116 Mt CO2-e (1). Agriculture alone contributes 40% of the total methane emissions. Estimated environmental costs due to damages to air quality: £760 million (3). |
| **Entire food chain (Sweden)** | 49% of total eutrophication[1] sources (4). | 13% of total terrestrial toxicity sources (4). | 18% of the country's GWP (4) |
| **Agriculture** | --- | --- | Agricultural sources accounted |

| | | | |
|---|---|---|---|
| **(US)** | | | for<br>76% and 30% of total U.S. nitrous oxide and methane emissions in 2005, respectively (5). |

Notes:[1] Eutrophication is the increase in chemical nutrients -typically compounds containing nitrogen or phosphorus -in an ecosystem. It may occur on land or in water; [2]CO2-e is the CO2 equivalents or the amount of CO2 that would have the same GWP, when measured over a specified timescale (generally, 100 years).

It is also believed that the Australian horticultural sector contributes with significant emissions of nitrous oxide (and perhaps methane) per unit area. However, there are no data sets on emissions from annual or perennial horticulture (6).

There is a symbiotic relationship between food supply chains and climate change: the activities of the former accelerate climate change and the latter will have a drastic impact on food resources in the near future (7). Some of the expected negative effects of climate change on food chains are:

- Increased temperature extremes. It is expected that temperatures will increase in 1 to 6$^{o}$C by 2070 (8). This in turn will increase our dependence in refrigeration and airc-conditioning technologies for food preservation and human comfort.
- Lower rainfall in the world's southwest and southeast, with up to 60% reductions in some areas and some seasons. There are possibilities of more monsoonal rain in the north and reduced soil moisture and river flow. Countries in the lower latitudes are likely to experience the worst effects of climate change, including drought or flooding, or both.
- Countries in Northern Europe and North America may find that initially warmer temperatures and longer growing seasons actually favour agricultural production, but by 2050 the negative impacts of high temperatures and water shortages will be more evident. Negative impacts may include a higher proliferation of insect pests in warmer climates and a greater number of insects' reproductive cycles due to longer growing seasons (9). Other effects could be changing patterns of crop and livestock disease.
- Higher potential evaporation from the soil and accelerated transpiration in the plants themselves, which will cause moisture stress. As a result, there will be a need to develop crop varieties with greater drought tolerance.
- Extreme weather events, including spells of high temperature, heavy storms, or droughts. Disruptions in crop production, transport and distribution systems are likely consequences.
- Sea level increases ranging from 3 to 17cm by 2030. Coasts are projected to be exposed to increasing risks, including coastal erosion.

The Intergovernmental Panel on Climate Change (10) described a number of specific effects for the Australian and New Zealand agriculture. These have been summarised in Table 2. In a recent report (11), ABARE estimated that the global production of wheat, beef, dairy and sugar could decline in 2 to 6% by 2030. In Australia, production of these commodities could decline by 9 - 10% in the same 22-year period. This decline means that Australian agricultural exports would decrease by 11 - 63%. ABARE concluded that "Australia is projected to be one of the most adversely affected regions from future changes in climate in terms of reductions in agricultural production and exports".

## TABLE 2. FUTURE VULNERABILITIES OF AGRICULTURAL ACTIVITIES IN AUSTRALIA AND NEW ZEALAND

| INDUSTRY | IMPACT |
|---|---|
| **Horticulture –Temperate fruits and nuts (AUS)** | Production likely to be negatively affected by warmer conditions because they require winter chill or vernalisation. |
| **Horticulture –Fruit (AUS)** | Proliferation the Queensland fruit fly *Bactrocera tryoni*, a significant threat to southern Australia |
| **Horticulture –Crops reliant on irrigation(AUS)** | Production threatened where irrigation water availability is reduced. |
| **Horticulture –apple, orange and pear (AUS)** | Growers in endemic Queensland fruit fly areas are likely to have cost increases of 42 to 82%, and 24 to 83% in the current fruit fly-free zone. |
| **Horticulture –Hayward kiwifruit (NZ)** | Warmer summer temperatures are likely to increase vegetative growth at the expense of fruit growth and quality. Northern Production of current varieties is likely to become uneconomic by 2050 because of a lack of winter chilling.<br><br>Kiwifruit budbreak is likely to be delayed, reducing flower numbers and yield in northern zones. Production may depend on the use of dormancy-breaking agents and varieties bred for warmer winter temperatures in the Bay of Plenty. |
| **Horticulture –apples (NZ)** | Production likely to flower and reach maturity earlier, with increased fruit size, especially after 2050. |
| **Horticulture – all (NZ)** | By 2080, the oriental fruit fly is likely to expand to much of the North Island. |
| **Viticulture (AUS)** | Earlier ripening and reductions in grape quality and value are likely by 2030, e.g. price per tonne drops 4 to 10% in the Yarra Valley and 16 to 52% in the Riverina. |
| **Viticulture (NZ)** | Increased warming and longer growing seasons may lead to shifting the production of red wine to the south, with higher yields |
| **Wheat (AUS)** | Southwestern regions are likely to have significant yield reductions by 2070. North-eastern Australia is likely to have moderate increases in yield. The substantial risk to the industry is likely to be offset by changing planting dates and varieties.<br><br>Significant increases in nitrogenous fertiliser application or increased use of pasture legume rotations would be needed to maintain protein levels. |
| **All foods (AUS and NZ)** | Warmer temperatures and increased rainfall variability are likely to increase the intensity and frequency of food-borne and water-borne diseases.<br><br>Food security is very likely to remain robust with both countries able to produce more food than they require for internal consumption.<br><br>Some food imports may be needed temporarily to cover shortages due to extreme events. |

### The competition for land

Biofuel production is generally seen as a green alternative to diesel. However, conversion of crops that would be otherwise used for animal or human consumption to biofuel can also lead to competition between food and fuel uses. Negative consequences of this competition include an increase in food prices, deforestation, damage to biodiversity, excessive use of fertilisers and pesticides and degradation of land and water (12).

The Garnaut review (13) recognises that a conflict between the use of land for food production, agriculture and forests needs to be addressed by establishing a market mechanism (e.g. a minimum land quota used for food purposes). My view is that policy is also needed to ensure that land use is balanced between food production, urban development and fuel production.

## III. Post-production performance issues

Post-production encompasses all activities from primary transformation of foods (e.g. harvest, slaughter, packing house operations) through to manufacturing to retail. Therefore, the issues discussed in this category are related to what we commonly recognise as the "food industry".

Food manufacturing is likely to be affected beyond the expected shortages of raw materials. For example, by 2020 perishable food chains are expected to depend more in refrigeration, in order to maintain the same quality and safety standards at higher ambient temperatures than those experienced currently. Food safety in particular may become even more important, due to its strong link with product temperatures during storage and transport. Scarcity of water may force manufacturers to change formulations and processes to decrease water consumption. Furthermore, more energy-efficient processes will be required to comply with future carbon targets.

Retail and consumers in 2030 may find that perishable products will have a reduced window of consumption, where shelf-life is likely to become shorter as products are subjected to more risks of temperature abuse. Insurance premiums and shrinkage rates may increase.

The need for more energy-efficient domestic appliances will need to be balanced with the fact that food products will become more expensive and therefore, more valuable. Thus, consumers will demand that domestic refrigerators, freezers and other storage solutions maximise product shelf-life.

The overarching food distribution system will be critical to ensure that food losses are kept to a minimum. Simultaneously, it is likely that the refrigerated transport industry will need to comply with tighter restrictions in the use of diesel. Reduction of diesel for cooling purposes could be achieved by: (a) more efficient insulation (e.g. vacuum panels); (b) refrigeration transport systems powered by cleaner energy alternatives than diesel (e.g. solar panels, electric, $CO_2$ cycles); (c) increased insulation thickness. The latter may be the push needed to change current Australian road legislation that limits truck's width to 2.5 m (14), as opposed to the 2.6 m width limit used in Europe, Canada and the US.

However, the issues discussed above are not currently been highlighted in the media. I will discuss below the aspects that are of current concern, identified in Figure 2.

## Shortage of raw materials

Some future disruptions expected in the supply of horticultural products were mentioned before. I should highlight that the effects of climate change on milk production are already being felt. In 2006/07, milk production decreased in 5%, due to the severe draught that affected the production areas, particularly the farms across the Murray Darling Basin. As a consequence, 06/07 prices rose from AUS$2,000 per tonne to AUS$4,800 per tonne (15).

In regards to crops, the Australian Bureau of Agricultural and Resource Economics (ABARE) expects wheat production in 2008 will double the amount produced in 2007, after rains hit key production areas. However, ABARE has also pointed out that production outlooks are becoming extremely volatile, due to extremely variable weather conditions.

## Food Miles (buy local)

Freight transport consumes nearly 25% of all the petroleum worldwide and produces over 10% of the carbon emissions from fossil fuels. Transport is considered to be the largest user of energy in the food chain, due to its direct GHG emissions, but also due to its role in congestion (16). Thus, several British environmental organisations raised the issue of imported foods and their contribution to global warming in the mid-1990s (17).

“Food Miles” is a concept that supports the evaluation of environmental friendliness of foods on the basis of the transportation distances required to bring products to consumers from the farm/grower. The concept ignores the contribution of non-transport activities, such as production. The Food Miles concept has evolved from an European issue to a worldwide issue, where even countries such as Australia, a country whose economy heavily relies in exports, has started to discuss the impact of food imports (18).

Numerous reports have been produced recently, either supporting the introduction of the Food Miles concept as an indicator of sustainable food products (19) or refuting its validity (20) (21). For economies that largely depend in agricultural exports, such as Australia and New Zealand, it will become critical to demonstrate that the Asia-Pacific food supply chains are aligned with good environmental practices. It is unlikely that ‘food miles’ in its present form will be used as a trade barrier (17), but it may become a significant consumer driver for selecting food purchases (22).

## Packaging and Food waste

Packaging waste is generated from:

1. The discarded primary packaging or the wrapping or containers handled by the consumer.
2. The discarded secondary packaging or the larger cases or boxes that are used to group quantities of primary packaged goods for distribution and for display in shops.
3. The discarded transit packaging, such as wooden pallets, board and plastic wrapping and containers. These are used to collate the grouped packaged goods into larger loads for transport, which facilitates loading and unloading of goods.

There are different methods to manage packaging waste. These included reuse, recycling (mechanical, chemical and feedstock), composting, thermal treatment and landfill. Some world statistics below show that worldwide, more than 50% of packaging materials are recycled:

- Europe generates about 78.6 million tonnes of packaging waste. About 54% of this waste is recycled (23).
- Packaging represents 10 to 14% of the solid waste going into New Zealand landfills (24). The average recycling rate is 49%.
- In Australia, the total packaging waste in 2005 was about 4.2 million. The recycling rate was 56% (25).

The relationship of packaging waste and food waste is a complex one: packaging plays a key role in avoiding food spoilage and maximising shelf-life and it is therefore pivotal to avoid food waste. In the other hand, food and beverages packaging is the largest contributing category to the total packaging waste.

Food wastage is not particular to developing nations. In fact, a study correlating national estimates of food losses and gross national product per capita showed that there were fewer end use food losses at countries with low levels of income than in high income countries. In the latter category, the estimated losses were 30 to 60% of the total food available for consumption (26).

Food waste is an issue that appears at all levels of the food supply chain and right through to the consumer. In the US, supermarkets, restaurants and convenience stores annually discard $30 billion worth of spoiled goods (27) . In the UK, recent studies indicate that household food waste is 6.7 million tonnes per year, with an estimated retail value of £8 billion (28). A Swedish study (29) found that about 20% of the food delivered to food service institutions is lost. The authors found that the economic value may demand arable land equivalent to 1.5% of the area under cultivation in Sweden. In Australia, the amount of food waste is about 3.3 million tonnes with an estimated value of $5.3 billion (30).

As mentioned before, food waste avoidance is correlated with the use of preserving technologies (e.g. cooling, freezing, drying, canning), which in turn contribute to global warming through the use of energy and direct emissions. The only way to avoid food preservation is the consumption of foods as soon as these are farmed or harvested. This option is currently unachievable in a global scale for many reasons, including crops seasonality, food trade balances and mismatches between food needs and available resources per country, among others. Even with the application of basic preservation technologies, it is estimated that about 300 million tonnes of produce are wasted annually due to deficient refrigeration worldwide (31).

Although food processing is a necessity, low energy efficiencies in food processing and distribution are not. The food industry has substantial potential for energy efficiency improvements. The re-design of logistics networks can also help reducing the carbon footprint of transport operations. These options are discussed later on this article.

## Carbon footprint and labelling

There are several interpretations of what is a carbon footprint. In this paper, a carbon footprint is "the total amount of CO2 and other greenhouse gases, emitted over the full life cycle of a process or product. It is expressed as grams of CO2 equivalent per kilowatt hour of generation (gCO2-eq/kWh), which accounts for the different global warming effects of other greenhouse gases" (32). Carbon labelling is simply the expression of a product's carbon footprint in the form of a label. A carbon label (or eco-label) may have information such as grams of CO2 –e, plus declarations of other GHG produced during the life cycle of the product.

Carbon footprinting requires the use of LCA methodology that assesses the inputs (e.g. materials and energetic resources) and outputs (i.e. methane, nitrous oxide, kg CO2 –e), from the point of production of raw materials to the disposal of the product/service. Therefore, carbon footprinting is closely linked to the knowledge and mapping of supply chains. The Carbon Trust, a private company set up by the UK government in 2001 to accelerate the move to a low carbon economy (33), advocates the use of a common carbon footprint methodology consistent in the following steps:

1. Analysis of internal product data (e.g. formulation, packaging, manufacturing process, storage conditions).
2. Development of a product supply chain process map similar to Figure 1. The individual supply chains of the raw materials used to manufacture the product also form part of the analysis. For example, the manufacture of bread requires wheat flour; although flour is an input to the bread supply chain, flour is also a finished product that has been manufactured from wheat grains. The Carbon Trust proposes that the boundaries are defined by tracing the supply chain back until primary raw materials with zero associated GHG in the final product are identified.
3. Definition of boundary conditions and identification of data requirements. This is an extension of step 2, where a final selection of operations is made. For example, the domestic transport of purchased products from the shop to the consumer's house is not accounted for, as it would be difficult to determine the specific shopping basket per consumer and the attribution of GHG per product.

   Data collection is based on the mass balance of the process diagrams developed in the previous step. Each mass flow stream is associated with direct emissions (e.g. refrigerant leakage, chemical reactions, methane production) or indirect emissions (e.g. electricity, diesel, bio diesel, gas).

4. Collection of primary and secondary data. Ideally, primary (actual) data should be collected. Top down energy consumption data at a plant level is preferred. However, bottom up estimates where individual machinery is monitored for a period of time and the results extrapolated to the energy requirements of a product unit are also useful. To avoid effects such as seasonality and variable production capacities during the year, the analysis of the data collected needs to follow specific methodologies designed for each process. For example, reference (34), provides top down and bottom up approaches to evaluate electricity requirements in industrial refrigeration systems. Similar references exist for other food processes.

When it is not possible to measure the actual direct and indirect emissions of processes, secondary data from databases or other sources can be used. Examples of databases that contain food manufacturing processes are the LCA Food Database (35) and the Australian LCA inventory database (36).

5. Calculation of GHG emissions for the entire supply chain map. This basically consists on solving the mass balances and calculating the direct and indirect GHG emissions. First, the balances are resolved per supply chain step and later for the whole chain.

In step 4, the exclusive use of secondary data should be avoided, as data drawn from the databases represent an industry average. Secondary data and LCA modelling may have low resolution to distinguish specific business strategies with an effect on their carbon footprint. For example, companies A and B manufacture exactly the same products. But company A produces more units per year than company B. An LCA methodology is likely to determine that company A has a higher carbon footprint than company B, based on production rates. But perhaps company A has better incentives for workers or better management. In this example, the LCA approach needs to be complemented with field observations and insights on the companies involved, so specific actions or processes that are helping company A can be identified.

The carbon footprint methodology should be closely aligned with the company's environmental accounting system. Furthermore, the carbon footprint may vary from year to year, depending on the circumstances of the company and the changes affecting production. Therefore, carbon footprinting is a dynamic activity that needs to be performed whenever there are significant manufacturing changes that are expected to decrease (or increase) the environmental impact of the product.

## Emissions from processing and distribution.

Emissions from food processing and distribution arise from two sources:

(a) Direct emissions resulting from releases of GHG to the atmosphere (e.g. refrigerant leakage, emissions from diesel engines).
(b) Indirect emissions resulting from the consumption of energy (e.g. electricity, gas, LPG, diesel).

Typical energy-intensive operations performed to process foods are:

A. Heat transfer processes. Typical examples are cooling (e.g. chilling, freezing, cold storage) and heating (e.g. sterilisation, pasteurisation, steaming, cooking).
B. Mass transfer processes. Typical examples include mixing, centrifugation, grading or moving items through conveyor belts.
C. Combined heat and mass transfer processes. Typical examples include evaporation, drying, and distillation.
D. Air-conditioning at retail and at convenience shops.

Refrigerated transport occurs at every step of the supply chain, connecting production centres, warehouses, export destinations, retail outlets and consumer's homes. Refrigerated transport in Australia uses diesel as the main source of energy for both motion and refrigeration purposes. The

energy consumption of refrigerated transport is significant: it is estimated that in 2000, road food transport in Australia was responsible for 5.2 megatonnes of CO2-e (37), excluding the use of diesel for refrigeration purposes.

The UNEP Working Group for Cleaner Production in Food, based in the University of Queensland, have carried out substantial work in assessing the opportunities for energy efficiency in the Australian food industry. Specific information for various industries can be found in their website (38).

Refrigeration-related processes (e.g. cooling, freezing, air-conditioning, cold storage) are undoubtedly a large contributor to carbon emissions in food-related industries. It is estimated that refrigeration consumes about 15% of all electricity consumed worldwide (put coulomb ref). Estrada-Flores and Platt (39)investigated the electricity usage in the Australian cold chain. Their estimations suggest that the total energy spent to keep an unbroken cold chain from farm to consumer is about 19,292 GWh/year. To add some context to this number, this amount is the equivalent of taking approximately 5.8 million cars off the road each year (or 40% of the total number of cars registered in Australia in 2006).

Some trends in electricity consumption are presented below.

**Meat industry**

Australia has an annual production of just over 2 million tonnes of beef and 380,000 tonnes of lamb. About 65% and 45% of the production are exported, respectively. Meat products are one of the major contributing categories to the Australian food value chain, representing 38% and 23% of the total value of primary production and processed food, respectively.

Refrigeration uses the largest amounts of electricity in the meat industry, accounting for 40 to 50% of the total use. It is estimated that, in a typical meat plant, refrigeration uses 22,222 kWh/day (40).

**Dairy industry**

Dairy is Australia's third largest rural industry, with a farmgate value of $3.2 billion during 2006/07. It is also the largest value-added food industry, with ex-factory sales valued at almost $9.2 billion each year. The major products are drinking milk, cheese, butter and milk powders. About half of Australia's milk production is consumed on the domestic market, and half is exported. Dairy products generate $4.2 billion annually in supermarket sales (41).

The energy use of dairy factories depends on the types of products manufactured. For example, the production of market milk uses energy for heating and pasteurisation, cooling and refrigeration, lighting, air-conditioning, pumping, and operating processing and auxiliary equipment. Factories producing concentrated milk products, cheese, whey or powders require additional energy for churning, pressing, separation, concentration, evaporation and drying. Table 1 shows typical percentages of electricity supplied per product.

### TABLE 3. ELECTRICITY USE IN THE DAIRY INDUSTRY

| Products | Electricity (%) |
|---|---|
| Milk only | 66 |
| Cheese and whey products | 27 |
| Mainly powders | 21 |

*Source: P. Prasad, R. Pagan, M. Kauter and N. Price. 2004. Eco-efficiency for the dairy processing industry. Dairy Australia. P.44.*

**Fruit and vegetable industry**

Australia produces over 6,000 kilotonnes (kt) of fresh fruit and vegetables per year, with a value of $5.8 billion at farmgate. The production of grapes is the largest of all horticultural products, due to the use of these in the wine industry. The vegetable sector is the largest part of the horticultural industry (40).

The fruit storage sector presents an outstanding opportunity for energy efficiency. Refrigeration systems account for most energy use at these facilities, and potential for savings can range from 10% to over 50% (40). At facilities with no packing line, refrigeration can use 90% to 95% or more of total utility energy use. With a packing line, refrigeration energy use can range from 70% to 80% of total facility energy, with the balance required by packing lines and lighting.

**Seafood industry**

Seafood represents about $1.9 billion of the total food primary production (see Fig.2). In recent years, Australian production has fallen due to over fishing, tighter fisheries management, higher fuel prices and ageing fleets, amongst other factors. No published data was available in regards to Australian consumption of energy in seafood-related industries. However, Norwegian studies (42) estimate that frozen storage has an energy requirement of 300 to 500 kJ per storage cubic meter per day. Chilling of fish is normally achieved by the addition of ice and a total energy consumption of 80 to 100 kJ/kg fish. A published survey (43) of a seafood processing plant in Auckland (New Zealand) reveals that a cold storage facility with a capacity of 1,000 tonnes expends about 1.1 GWh per year. This represents about 92% of the total electricity used in the plant. This energy usage is probably comparable to Australian energy figures. A Canadian survey estimated a lower percentage of electricity use for refrigeration purposes (65% to 85%) (44).

## Supply chain strategies

It is widely recognise that supply chains are formed by alliances of two or more players (e.g. growers, manufacturers, logistics providers and retailers) to deliver products. However, each company has its own supply chain strategy. It is worth the considering the effect of individual strategies on the overall carbon footprint of a product.

For example, we have the perception that lean supply chains should be ‘green’ by definition. But, Is that so?

Although it is reasonable to expect that lean processes (which aim to eliminate wasteful activities) should align by definition with a lower carbon footprint, Venkat and Wakeland (45) found that this is not necessarily true. The authors investigated the relationship between lean supply chain strategies and their effect on carbon emissions. Lean supply chains typically have lower emissions due to reduced inventory levels. However, they also require frequent replenishment at every point in the supply chain. If a lean supply chain is located entirely within a small region, then it would have low levels of inventory and short shipping distances. As distances increase along the supply chain, lean chains may be in conflict with low carbon footprints, thus leading to tradeoffs as well as additional opportunities for optimization. This issue needs to be further explored in the case of Australia, where long transport distances are the rule rather than the exception.

In their search for cost-reduction, supermarkets are always looking for opportunities to make their transport networks more efficient, by moving goods in larger quantities and optimising their delivery schedules. This had led to a decrease in distribution centres around the country, which is what good supply chain practices dictate to decrease inventory costs. However, as mentioned above, this strategy also needs to be considered in the light of carbon footprints.

Supply chain strategies also include the use of refrigerated warehouses and transport for the distribution of perishable foods. Michael Luscombe (CEO, Woolworths Limited), admitted that "Woolworths is the largest operator of refrigeration in Australia –both in stores and in our supply chain" (46), consuming about 3.2 million CO2 –e in refrigeration and air conditioning. This represents about 8% of the total GHG emissions from the Australian refrigeration and air conditioning sector (47).

Mr Luscombe is targeting a 40% reduction in Woolworth's energy consumption, through a range of innovations that include the use of co-generation, the installation of cascade systems using carbon dioxide as refrigerant and other measures. Although no comments have been made in regards to carbon reductions in refrigerated transport, this sector has an untapped potential to further decrease supermarket carbon footprints.

## IV. Consumer (market) issues

The category "consumer issues "encompasses those activities beyond retail and through to the consumer's households.

### Consumer attitudes to environmental drivers

The interpretation of market research in regards to consumer attitudes towards environmental drivers needs to take into account what David McKinna identified as "schizophrenic consumerism" (48). Dr McKinna stated that the major choice drivers for consumers are taste, value for money, convenience and nutritional benefits. But during market research surveys, consumers tend to overstate the importance of nutrition and price (i.e. "good" attributes), and understate the importance of taste and enjoyment (i.e. "superficial" attributes).

"Schizophrenic consumerism" in market research may erroneously lead to an over prediction of the importance of environmental drivers in the consumer's food purchase choices. The contradictory information circulating in publicly available reports seems to support this. For example, a publicly

available source reports that in the US, at least 50% of consumers consider one or more sustainability features when purchasing packaged goods (49); in the UK, a second report states that 54% of consumers are influenced by environmental concerns when purchasing foods and drinks (50). However, ACNielsen has reported that consumers are unlikely to be influenced by the environmental friendliness of grocery shops. Other factors, such as good value for money, are more influential in selecting the choice of a store (51).

Food supply chain players may not be able to pass the costs of an improved environmental footprint to the consumers. However, improving the environmental efficiency of the food industry is an alternative to offset escalating energy and waste disposal prices. Those industries that have made an effort to decrease their environmental footprint before 2010 will be more likely to benefit from the emission trading scheme, proposed by the Australian government to cut carbon emissions.

### Food consumption trends

Research on the relationship between the emission of GHG and food consumption trends has provided evidence on the higher environmental impact of protein-based diets (e.g. meat, dairy) over diets high in pulses and root crops (52). However, the greenhouse potential of a meal depends in other variables such as degree of processing, choice of processing, preparation technology and transportation distance (53). There is disagreement about which of these factors weights more in the environmental footprint of diets. Furthermore, food consumption patterns vary widely due to geographical limitations, cultural differences, the choice of ingredients and gender differences.

## V. Corporate issues

Corporate strategies are strongly linked to both operational and consumer issues. As any manager in private or public practice knows, there are corporate forces that may make or break initiatives that may seem logical or even mandatory. Environmental initiatives are not the exception.

### Corporate strategy

Recently McKinsey surveyed 2,192 executives around the world about their views and attitudes to global warming (54). The survey found that 60% of global executives view climate change as important to consider within their companies' overall strategy. Further, nearly 70% see it as an important consideration for managing corporate reputation and brands, and over half say it's important to account for climate change in areas such as product development, investment planning, and purchasing and supply management. In the regulatory arena, 82% of executives expect some form of climate change regulation in their companies' home country within five years.

Although we would expect that these views would translate into action, the same survey found that climate change is considered only occasionally when managing corporate reputation and brands, developing new products, or even managing environmental issues. Furthermore, 36% of executives say their companies seldom or never consider climate change when developing overall strategy.

In the case of food supply chains, the gap between executive opinion and implementation can be partly attributed to the diversity of the industry. Although the food industry would benefit from a united, strategic approach to the issue of climate change, group interests in the supply chain are not

always aligned. The creation of an overseeing public body that helps the industry in designing a value chain-based strategy, incorporating innovation as a key factor for survival, could help.

At a business level, climate change and adaption measures are seen as another cost to the company. However, some companies encourage environmental initiatives because there is a good business case behind. Benefits could include saving money through energy efficiency and waste minimization, marketing low-carbon products, or entering early into the future carbon offset markets.

The Australian Industry Group (55) proposes ten steps to bring climate change into the corporate agenda. These are:

1. Obtain board and senior management understanding and commitment.
2. Establish a baseline for sustainability performance.
3. Establish sustainability measurement and reporting systems.
4. Establish sustainability objectives and integrate these into corporate strategy.
5. Take leadership on big issues (i.e. relevant key topics).
6. Initiate whole-of-company engagement incorporating sustainability objectives into individual KPIs.
7. Establish multi-disciplinary teams ensuring all areas of the business are engaged.
8. Engage with stakeholders and develop partnerships, including internal and external stakeholders, suppliers, customers and financiers.
9. Foster a culture of innovation and institute appropriate rewards.
10. Build skills capacity of all employees.

Having investigated other sustainability strategies (56), I would like to add the following to this list:

11. Build a business case for environmental initiatives.
12. Change the vision of sustainability from a project-based issue to a core value issue.
13. Share the progress and communicate environmental activities and outcomes widely.
14. Having the stakeholders' expectations in mind, take the steps required to ensure the survival and success of the company in a climate-challenged future.

In this section, I would like to discuss the following issues:

- The current corporate obligations, in the context of recent developments on regulating national emissions.
- The implications of these developments on the financial position of the company and the need to integrate these developments into strategic planning.

## Standards and regulations

In Australia there are several environmental monitoring and reporting initiatives, both mandatory and voluntary. A non-exhaustive list includes the National Greenhouse Gas Inventory (NGGI), the National Pollutant Inventory, the Greenhouse Challenge Plus, the Greenhouse Friendly programme, NSW & ACT Greenhouse Gas Abatement Scheme, the South Australian Greenhouse Strategy and the Victorian State Environment Protection Policy (Air Quality Management), among others.

In regards to voluntary programmes, an important environmental agreement is the Greenhouse Challenge Plus Program (57). This is a cooperative partnership between government and industry to improve energy efficiency, reduce greenhouse gas emissions, and integrate greenhouse issues into business decision-making. Membership into this programme ensures access to fuel tax credits of more than $3 million in a financial year.

The regulatory National Pollutant Inventory (NPI) is an internet database that concentrates data from the Federal Government, States and Territories. All individuals can access the database, which provides information on the concentration of certain substances that are emitted in Australia to the environment via air, land and water. Only companies that exceed certain threshold levels of the chemicals on the NPI list are required to provide information (58).

Another self-regulatory measure that is relevant to the food industry is the National Packaging Covenant (NPC), developed between the industry and the Australian Government (59). The Covenant is designed to minimise the environmental impacts arising from the disposal of used packaging, conserve resources through better design and production processes and facilitate the re-use and recycling of used packaging materials. Therefore, food manufacturers, retailers, packaging manufacturers and fast food companies are involved in this initiative. The NPC requires that its membership submit documents, action plans and annual reports that demonstrate their aims and achievements against Covenant goals and targets. The 632 Covenant Signatories have very specific plans, with targets developed by each company, using the specific environmental performance goals and indicators designed by NPC.

The most recent legislative effort to establish a single, national reporting system is the National Greenhouse and Energy Reporting Act (NGER). The Act requires corporate reporting of greenhouse gas emissions, abatement actions, and energy consumption and production, starting from 1 July 2008. The corporations that need to comply from this date are:

(a) those that control facilities that emit 25 kt or more of CO2 -e, or that produce/consume 100 terajoules (TJ) or more of energy; or,
(b) their corporate group emits 125 kt or more of CO2-e, or produces/consumes 500 TJ or more of energy.

Lower thresholds for corporate groups will be phased in by 2010-11.

To place context on the initial thresholds that require compliance by July 2008, I refer again to the Woolworth's case, where the corporate group produces about 4,000 kt of GHG, with 80% of those emissions associated with refrigeration and air conditioning systems (46). Other equally large supermarkets are alos likely to be above the initial threshold, as well, as large food manufacturers. For example, in 2005 Murray Goldburn was consuming more than 1,080 TJ of electricity annually, across 8 manufacturing and other sites throughout rural Victoria, including their logistics complex in North Laverton (60). Other example is AMCOR's bottling business, which spent about 108 TJ in 2005 (60).

It is worth pointing out that a corporation that controls two or more facilities may need to comply with the mandatory reporting for those sites that fulfil threshold (a). However, the corporation would only need to report the entire corporation's emissions if the cumulative expenditure of their

facilities fulfils threshold (b). Likewise, a corporation may have facilities that, individually, do not fulfil threshold (a). But if the site's cumulative impact fulfils threshold (b), the corporation will still have to report the entire corporation's environmental impact.

To aid NGER compliance, companies could implement environmental management systems (EMS), which provide a managerial framework for continuous improvement and benchmarking of a company's environmental performance. The establishment of an accredited EMS normally precedes full ISO 14001 certification. The benefits of an ISO 14001 accreditation are: (a) ISO accredited companies are seen to be more proactive than others that wait for mandatory regulations; (b) ISO methodologies allow a systematic assessment of environmental activities in the company; (c) the framework is "management-friendly", thus management feels that they can highlight improvements in their area and cost savings due to reduction of waste, energy and others; and (d) ISO paper trail allows its use as a tool to handle legal liabilities and demonstrating due diligence.

## Insurance/financial risk

The insurance industry is one of the world's largest industries, collecting US$4.3 trillion in annual premiums worldwide in 2005. In fact, only two countries (U.S. and Japan, with GDPs of $12.5 trillion and $4.5 trillion respectively), have GDPs that are in excess of worldwide insurance premiums (61). Predictably, the insurance sector is exposed to significant financial losses with global warming, where extreme weather conditions (e.g. floods, hurricanes, severe thunderstorms) will increase catastrophic risks to properties and individuals. For example, weather-related insurance claims in 2005 represented about 2.1% of the global value of annual premiums. Nearly US$60 billion were triggered by hurricane Katrina, alone (62).

In response to the Katrina event, many insurers moved out of the US coasts. Other risk management measures implemented by insurers include decreased insurance coverage through increased deductibles, reduced limits, and new exclusions.

However, some insurers have moved into a proactive approach, capturing the emerging opportunities arising from alternative energy sources. An example is the AIG Global Alternative Energy Practice, which will insure US-based clients engaged in biofuel, hydroelectric, geothermal, solar and wind operations (63). In Australia, IAG has developed the Climate Help website, which is an online tool that enables users to offset their carbon emission by buying carbon credits. Dr Evan Mills, from the IPCC working group, suggests more innovative insurance products (64), such as:

- Energy savings insurance: protects the installer or owner of an energy efficiency project from under-achievement of predicted energy savings.
- Reduction of insurance premiums to adopters of 'green' technologies or those companies that prove a low risk profile, through carbon emission disclosure.
- "Green-buildings" insurance: covering disruption of energy services, where energy is supplied by solar or other alternative sources. Green upgrades are also an attractive insurance market.
- Directors and officers liabilities due to underperformance in carbon management.

- R&D funding: the insurance sector has had a limited role in funding R&D to seek for an overall reduction of the impacts of climate change. However, in the US there has been some collaborative research between public R&D organisations and insurance firms.
- Offering Carbon Risk-Management and Carbon-Reduction Services. These services may include risk management of companies investing in emissions trading markets.

### Carbon trading/offsetting

Emissions (or carbon) trading schemes allow the Government to regulate the amount of emissions produced in aggregate, by setting an overall cap. The carbon trading scheme allows companies to determine how and where the emissions reductions will be achieved.

Participating companies are allocated a number of carbon credits or allowances, each one of these being equivalent to one metric tonne of CO2-e emissions. Companies that emit in excess of their credit allocation will need to purchase further credits from the market. Similarly, a company that emits less than its credit allocation can sell its surplus allowances. Therefore, emissions trading gives companies the flexibility to meet emission reduction targets by: (a) reducing emissions on site or (b) by buying allowances from other companies who have excess credits. The overall environmental outcome is not affected because the amount of credits allocated is fixed.

Under an emission trading scheme, the impact of carbon emissions becomes clearly linked to the internal cost of doing business and therefore visible in the profit & loss and the balance sheets of a company.

## VI. Innovation strategies to reduce the environmental footprint of food supply chains

It is clear that food supply chains will face tough conditions that can only be challenged successfully through increased accountability, transparency and innovation. We have discussed the first two aspects in the previous sections. This section will discuss aspects of environmental innovation.

In Europe, Forward Commitment Procurement has been highlighted as a model capable of accelerating the commercialisation of environmental innovation. Forward commitment procurement (FCP) is defined as “a commitment to purchase, at a point in the future, a product or service that does not yet exist commercially, against a specification that current products do not meet, at a sufficient scale to enable the investment needed to tool up and manufacture products that meet the cost and performance targets in a specification” (65).

In an FCP model, a public sector organisation commits to purchase a pre-defined quantity of a product\ technology, currently under development but not yet available as a commercial offering. The commitment is for a future date and is based on a specified product performance being achieved. When the product has been developed meeting this performance specification within the agreed timeframes and framework, the organisation purchases the product at a specified volume and cost, at levels that encourage supplier investment to ensure economies-of-scale. The private sector would react by freeing investment to search for innovations that respond to those specifications. Once the product/service has entered the market, normal market conditions will determine competition and price (66).

Although in the FCP framework a government department acts as an early adopter, there is a growing interest of private investors in the environmental innovation market. Globally, the development of 'green' technologies attracted an estimated US$3 billion venture capital last year. Eighty four percent of the capital originated from the US (67). The areas that have attracted more attention from investors are solar energy, transportation and biofuels. Potentially, insurance companies could contribute to offset R&D costs. We have already discussed innovative possibilities in which the insurance sector could encourage environmental innovations.

Some specific innovative technologies and practices that have been discussed recently are:

- Use of food waste to produce biogas. Rotting food releases methane, a more potent greenhouse gas than CO2. Methane can be used to produce biogas. Biogas-fueled cars can reduce $CO_2$ emissions by anything from 75% to 200% compared to cars powered by fossil fuels (68).
- In primary production, more efficient production methods that give a higher yield would lead to a better utilisation of fodder and less soil tillage.
- In packaging technologies, the development of biodegradable films and boxes has also been investigated. Some examples include the use of corn-derived polylactic acid and edible milk protein skins, among others (69).
- The reduction of fuel consumption of transport systems (specifically ships and road transport) is also a subject of research. In Australia, a company has developed a two-cycle orbital combustion process (OCP) engine, which is is 50% lighter, takes up 70% less space, and consumes 30% less fuel than a four stroke engine. The power source is suitable for motorcars, inboard and outboard marine engines (70).
- The use of multimodal transportation in Europe has been highlighted as an immediate measure to decrease the emissions of food transportation. For example, road transport of produce from Italy to Stockholm produces twice the emissions than transportation by rail. To facilitate rail transportation, containers that can be easily transferred from one mode of transport to another can be used (71).
- Rethinking our diets is not out of the question. A Swedish study in 2003 suggested that organic beef, raised on grass rather than concentrated feed, emits 40% less GHG and consumes 85% less energy (52).

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