

Systemic problems hampering innovation in the New Zealand Agricultural Innovation System

James A. Turner¹, Kelly Rijswijk¹, Tracy Williams², Laurens Klerkx³ and Tim Barnard⁴

¹ *AgResearch Ltd., New Zealand*

² *The New Zealand Institute for Plant & Food Research Limited, New Zealand*

³ *Knowledge, Technology and Innovation Group, Wageningen University, The Netherlands*

⁴ *Scion, New Zealand*

Abstract: This study identifies systemic problems in the New Zealand Agricultural Innovation System (AIS) that affect the ability of participants in the agricultural sectors to co-develop technologies. We integrate structural and functional streams of innovation system enquiry, gathering data through 30 semi-structured interviews with individuals in Government, industry and research. Interviews explored perceptions of the influence of actors, interactions, institutions, infrastructure, and market structure on the effectiveness of AIS functions. Examples of systemic problems were: (i) a lack of facilitative and transformational leadership and systemic intermediaries to support the formation of strategic innovation agendas in vertically and horizontally fragmented industries; (ii) a culture of hunting for funding within research organisations; hindering sustained involvement of researchers in innovation, (iii) a large number of actors in the R&D component of the AIS competing for public resources to pursue uncoordinated innovation agendas; and (iv) a lack of institutional support for interactions between actors and roles that support interactions, such as innovation platforms and innovation brokers.

The existing New Zealand AIS limits innovation to a linear process; restricting opportunities for innovation to occur and fostering competition amongst organisations that collectively have much to contribute to innovation in the agricultural sectors through constructive collaboration and roles in all facets of the innovation process. These findings indicate an urgent need to create a policy and legislative framework, built on a systemic understanding of innovation that more pro-actively stimulates and fosters co-innovation. Such a framework would facilitate the formation and effectiveness of innovation-brokering organisations and multi-actor platforms, enabling coordinated innovation agenda setting and prioritisation of issues in which all actors in the value chain and innovation support system jointly articulate a shared agenda for change.

Keywords: Agricultural Innovation System, co-innovation, systemic innovation policy framework, systemic instruments, interviews, New Zealand

Introduction

The New Zealand Government, through its Business Growth Agenda, has set the goal of doubling the value of New Zealand exports as a share of gross domestic product by 2020. One of the six drivers identified by the Government as needed for achieving this goal is increasing innovation in businesses (Ministry of Business, Innovation and Employment, 2014b). A key component of boosting innovation is increased public science investment through the National Science Challenges (NSC), which are 10 important focuses for innovation identified by the New Zealand public. Challenges related to the agricultural sectors include developing high value foods with vali-

dated health benefits and research to enhance primary sector production and productivity while maintaining and improving New Zealand's land and water quality (Ministry of Business, Innovation and Employment, 2014a). The design of the NSC is similar to the European Innovation Partnerships (European Commission, 2014) in that both aim to enhance the fit between research supply and firms' R&D demands to support innovation, and bring together all relevant actors to increase R&D efforts in a coordinated fashion, thus striving for so-called co-innovation. The effectiveness of the NSC for enhancing innovation in New Zealand will become apparent over the next 2–5 years. Meanwhile, analysis of the barriers and opportunities that hinder or enable co-innovation within the existing AIS is needed to gain insights into how the context within which the NSC operates enables or constrains co-innovation in the agricultural sectors.

An AIS is the network of actors (organisations, enterprises and individuals) that are focused on bringing new products, processes, and forms of organisation into economic use, together with the institutions (policies, rules, and mechanisms) that influence how actors interact when sharing, accessing, and using knowledge (Hall et al., 2006). Institutions in the AIS are important in influencing the ability to co-innovate (Wieczorek & Hekkert, 2012; Klerkx & Nettle, 2013). As such, the functions required to make the AIS work as a system and the actors, interactions, institutions and infrastructure that can best deliver these functions (Ngwenya & Hagmann, 2011; Wieczorek & Hekkert, 2012) need to be identified, and incentives for actors in the AIS to adopt co-innovation practices created (Klerkx et al., 2010; Ngwenya & Hagmann, 2011).

This paper aims to identify the perceived systemic problems in the New Zealand AIS that affect the ability of actors in the agricultural industries to co-innovate. Our analysis of the New Zealand AIS uses a comprehensive framework developed by Wieczorek and Hekkert (2012) – the systemic innovation policy framework. This framework integrates two streams of innovation system enquiry – structural and functional – to enable analysis of the effectiveness of the important functions (or processes) that support co-innovation, along with the presence and quality of the structural components that are needed for these functions to be effective.

Theoretical framework

The theoretical framework for this research combines two analytical approaches to understanding AIS: structural and functional (Wieczorek & Hekkert, 2012). It is this comprehensive systemic innovation policy framework that we have used in our analysis of systemic problems perceived as hampering co-innovation in the New Zealand AIS. The remainder of this section provides a brief description of the seven functions and four structures of the systemic innovation policy framework used in our analysis.

Hekkert et al. (2007) describe seven functions that need to be present in innovation systems for successful innovation to occur. *Entrepreneurial activities* are necessary to address the large uncertainties that follow from new combinations of technological knowledge, applications and markets. *Knowledge development* encompasses the systematic and organised search for new knowledge to acquire 'know-why', such as research, and the trial-and-error practical experience gained when producing a technology, generating 'know-how'. *Knowledge diffusion* is the co-construction of knowledge between users and producers of technology through the use of a technology and persistent face-to-face interaction. In keeping with the definition of the AIS provided by Hall et al. (2006) we refer to 'knowledge diffusion' as 'knowledge exchange'. This latter term more accurately reflects the two-way nature of sharing and co-construction of knowledge. *Guidance of the search* refers to activities that positively affect the visibility and clarity of specific wants among actors in the innovation system. *Market formation* is about creating new markets or redirecting existing markets for new products and technologies. *Resource mobilisation* is about resources, both financial and human capital, that are necessary as a basic input to all activities

within the innovation system, and *creating legitimacy* for change or counteracting resistance to change is about creating opportunities for a new technology to become part of an incumbent regime.

The functioning of each of the seven processes is dependent on the four structural components of the AIS: actors, institutions, interactions and infrastructure (Wieczorek & Hekkert, 2012). We have added market structure to Wieczorek and Hekkert's (2012) four structures, referring to the position and relations among participants in the market (van Mierlo et al., 2010), and enabling examination of the influence of market structure on the presence (or absence) of actors and interactions.

The innovation literature refers to problems that hinder the development of innovation systems as systemic problems (Wieczorek & Hekkert, 2012). These are factors that negatively influence the direction and speed of innovation processes and impede the development and functioning of innovation systems (Klein-Woolthuis et al., 2005). In the systemic innovation policy framework, systemic problems are conceptualised as weak or absent innovation system functions arising from limitations in the structural components of the AIS: (i) the presence or capabilities of the actors, (ii) the presence or quality of the institutional set up, (iii) the presence or quality of the interactions, (iv) the presence or quality of the infrastructure, and (v) the quality of market structures. For example, hard institutions (regulations) or soft institutions (established practices) incentivising research organisations to undertake activities that support uptake of knowledge, practices or technologies may be absent or weak.

The identification of types of systemic problems facilitates the search for strategies to enhance the overall functioning of the innovation system. These strategies are referred to as systemic instruments (Smits & Kuhlman, 2004). In the systemic innovation policy framework, systemic instruments must achieve one or more of eight goals corresponding to the eight types of systemic problems (Wieczorek & Hekkert, 2012): (i) stimulate and organise participation of relevant actors, (ii) create space for actor's capability development, (iii) stimulate occurrence of interactions, (iv) prevent too strong or too weak ties, (v) secure presence of hard and soft institutions, (vi) prevent too weak and too stringent institutions, (vii) stimulate physical, financial and knowledge infrastructure, and (viii) ensure adequate quality of infrastructure. With our addition of market structures to the systemic innovation policy framework, another goal of systemic instruments is to stimulate new market structures.

Methods

The modified systemic innovation policy framework of Wieczorek and Hekkert (2012) described above was used to develop a framework to guide semi-structured interviews with 30 individuals from Government (5), industry (2), industry good bodies (10), research (8) and technology users, such as farmers and growers (5) in the New Zealand pastoral, forestry, cropping and horticultural sectors. These individuals were selected from organisations with key roles in the New Zealand agricultural sectors in undertaking one or more of the seven functions. Twenty of the interviewees were individuals who had indicated an interest in the larger research programme (Ministry of Business, Innovation and Employment, 2012), of which this study is a part. The additional 10 individuals were selected using a traditional snowball sampling technique (Babbie, 2001). Three interviewers conducted the interviews, either one-on-one (16 interviews) or using two interviewers – one to lead and the other following up on themes that emerged during the interview (14 interviews).

The interview questions were designed to cover three aspects of the systemic innovation policy framework: (i) functions, (ii) structural components that deliver each function, and (iii) the pres-

ence/absence or capability/quality of structural components. The last aspect enabled identification of systemic problems. The interviews were transcribed, provided to interviewees that had requested a copy of the transcript for review, and then coded in Nvivo v. 10 (Bazeley & Jackson, 2013) using the systemic innovation policy framework as the coding structure (see Table 1 for the coding structure). The interviewers jointly conducted thematic analysis of the coded interviews (Merriam, 2009) to identify systemic problems by exploring recurring themes across interviewee sectors and organisation types and exploring links among problems. A follow-up workshop with interviewees provided a check on the validity of the identified systemic problems against their own experiences (Suter, 2011).

Results

Table 1 presents the coupled functional-structural analysis for identifying systemic problems in the New Zealand AIS based on the perceptions of interviewees. The weakness of a function is identified as being related to actors, institutions, interactions, infrastructure or market structure, and whether the problem occurs because these are missing or lack capacity. This analysis is carried out for all of the functions necessary for successful innovation to identify the functions that are weak and the systemic problems contributing to this weakness (Wieczorek et al., 2013). Many of the systemic problems perceived by interviewees and presented in Table 1 are interrelated. A systemic problem hampering a function can be related to the presence and/or quality of multiple structural factors, and can simultaneously also affect other functions.

The systemic problems identified from the coupled functional-structural analysis in table 1 are described in more detail, by function, below.

Systemic problems in entrepreneurial activities

Interview participants perceived there to be a lack of both firms and research organisations undertaking entrepreneurial activities in the New Zealand AIS. The former was due to the large share of businesses in the New Zealand agricultural sectors being small to medium enterprises (SMEs). SMEs were perceived as lacking the financial and human resources to undertake entrepreneurial activities. The latter was perceived as being due to two systemic problems. First, research organisation cultures and capability are focused on knowledge development, with users of technology viewed as having the role of implementing science through entrepreneurial activities. Second, the Government-owned research organisations, Crown Research Institutes (CRIs), are perceived as focusing more on attracting grants from Government for R&D than funds for commercialisation, with the latter considered less accessible and therefore less of a priority.

4.2 Systemic problems in knowledge development

All of those interviewed referred to the importance of interactions among research organisations, industry, and farmers/growers for effective knowledge development. Many perceived a number of important systemic problems hampering this interaction in knowledge development (as well as knowledge exchange). The first was an historic research culture of working in disciplinary silos. A second systemic problem was the use of very prescriptive, linear and milestone-focused innovation management by funding organisations. This hinders emergent and co-evolutionary innovation by locking in particular sources of knowledge and innovation pathways from the outset. Interviewees identified drivers of prescriptive linear innovation management as conservatism and risk aversion in funding while businesses tend to view innovation as a cost that needs to be controlled.

Systemic problems in knowledge exchange

While participants highlighted the importance of interactions in knowledge exchange, there was a perception by industry and Government interviewees that research organisations had limited interaction with end users in extension or technology transfer. This was viewed as hampering knowledge exchange, leading to science not reaching end users and creating a mismatch between technology supply from research organisations and demand by end users. This has created the perception within industry that knowledge needed to address sector problems already exists within research organisations. Industry participants described the challenge as being to access existing knowledge in research organisations and package it for deployment with funding for these processes being a particular tension between research organisations and industry.

Another systemic problem identified by interviewees as hampering effective interaction in knowledge exchange was continued competition for funding among CRIs leading to a focus on revenue generation from research grants. This was seen as contributing to a culture of researchers as “hunters and gatherers”, resulting in innovation processes not being completed as researchers moved on to pursuing the next research grant. This focus on pursuing and securing research grants was described as leading to science quality being measured by the ability to secure research grants. This was perceived as creating a focus on knowledge development within research organisations (at the expense of knowledge exchange and entrepreneurial activities) as funders focus on academic criteria when evaluating research proposals.

Systemic problems in guidance of the search

Interviewees from research organisations described the need to invest significant time to gain a good understanding of the innovation agendas of industries they are aligned to. This was described as being hampered by limited opportunities to interact with industry in setting strategic agendas for innovation, with research organisations not part of this process. This was particularly the case for CRIs due to them working across multiple industries and organisations with different, sometimes competing, innovation agendas.

Difficulties encountered in guiding the search for a shared innovation agenda were described as especially acute in industries with vertically and horizontally fragmented market structures. Vertical fragmentation refers to different parts of the value chain being in separate ownership. Horizontally fragmented industries are characterised by a large number of separate owners. In these fragmented sectors interviewees from across industry, Government and research organisations frequently referred to multiple actors with different goals seeking to influence guidance of the search to resource and achieve their particular innovation agendas.

Systemic problems in market formation

Participants perceived there to be a lack of firms undertaking market formation in the New Zealand AIS. This was attributed to conservatism within some businesses, leading them to stick to traditional markets rather than exploring opportunities in new markets. However, participants from Government agencies referred to CRIs as undertaking market formation, as well as entrepreneurial activities. This contrasted with those interviewed from research organisations who did not perceive market formation as their role. This appears to be due to CRIs focusing on revenue generation from research grants rather than the perceived higher risks of revenue from commercialisation. This has contributed to limited capability within CRIs for undertaking market formation, or entrepreneurial activities, as described above.

Systemic problems in resource mobilisation

A key systemic problem in resource mobilisation is competition among industries and research organisations for funding (and other resources) allocated to different innovation agendas, and between industry-led versus research-led innovation. According to industry, Government and research organisations, this competition for resources to support different innovation agendas was due to two systemic problems: a lack of strategic leadership in coordinating resource mobilisation and guidance of the search, and fragmentation of innovation funding. Strategic leadership was described as the ability to take a systemic view, interact with multiple organisations, understand each organisation's individual circumstances, and identify their own organisation's role in achieving a wider strategy.

Fragmentation of innovation funding arises from the variety of mechanisms used by Government and industry bodies to fund different innovation activities and agendas, frequent changes in Government mechanisms for funding innovation, and because disbursements from these funds tend to be small. This results in funding being applied to innovation programmes that address sub-components of larger problems, with these sub-components not necessarily fitting together to effectively address wider problems. The Ministry of Business, Innovation and Employment has recently begun the National Science Challenges to align existing public-funded research and provide strategic direction for future public-funded research in an attempt to reduce fragmentation of innovation funding.

Systemic problems in creation of legitimacy

Few of the interviewees referred to creation of legitimacy as part of the innovation process. When interviewees referred to this function it was viewed by Government, industry and research organisations as being related to entrepreneurial activities and market formation. Therefore, creation of legitimacy was commonly perceived as being the role of industry.

Discussion and Conclusions

Institutions in the AIS are an important influence on the ability of actors to co-innovate in large-scale innovation platforms such as the European Innovation Partnerships and the New Zealand National Science Challenges. Applying the systemic innovation policy framework (Wieczorek & Hekkert, 2012) to a coupled structural-functional analysis of the New Zealand AIS has facilitated a comprehensive study of the functioning of the AIS as well as the presence and capability of actors, interactions, institutions and infrastructure to deliver these functions in order to support co-innovation practices. The identification of perceived weaknesses in actors, interactions, institutions or infrastructure that result in systemic problems that hamper the effective functioning of the AIS is particularly useful.

This study identifies a number of perceived systemic problems hampering the effective functioning of the New Zealand AIS and its ability to support co-innovation (Table 1). Our findings imply there is a need for systemic instruments focused on enhancing multi-actor interaction and preventing too weak or too strong institutions in the AIS (Smits & Kuhlmann, 2004; Wieczorek & Hekkert, 2012). Potential instruments for stimulating the occurrence of interactions include cooperative innovation programmes, conferences for setting innovation agendas, and innovation brokering organisations (Wieczorek & Hekkert, 2012). In the New Zealand agricultural sector we recommend that these facilitate interactions in which all actors in the value chain and innovation support system jointly articulate the innovation agenda (Klerkx & Leeuwis, 2009; Klerkx & Nettle, 2013). Organisations performing these functions are often not yet well recognised or resourced (resembling findings by Klerkx & Nettle (2013)), with resourcing potentially drawing

funding away from other functions (e.g., fundamental and applied science), in a constrained funding environment.

The systemic innovation policy framework focused analysis on perceived systemic problems in the New Zealand AIS. Our application of the framework may, therefore, have missed systemic opportunities to enhance the direction and speed of innovation processes (van Mierlo et al., 2010). A follow-up workshop with interviewees from the pastoral, forestry, cropping and horticultural sectors was used to reveal opportunities to address these challenges. Workshop participants identified and explored the circumstances within their own sectors in which systemic problems were absent, in order to identify potential opportunities to enhance AIS functions. The systemic problems identified in our analysis (Table 1) are undoubtedly connected. Listing them in the systemic innovation policy framework does not readily reveal interconnections that might lead to the identification of key leverage points for achieving change in the innovation system. Using tools to further unravel cause and effect relationships among problems, such as causal loop diagrams (Van Mierlo et al., 2009), could be one way to reveal key points for intervention in the New Zealand AIS that may enhance the direction and speed of innovation.

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Table 1: Perceived systemic problems based on a functional-structural analysis of the New Zealand Agricultural Innovation System

System function	Structural element	Problem type	Description
Entrepreneurial activities	Actors	Presence	Limited instances of key actors undertaking entrepreneurial activities
		Capability	Lack of entrepreneurial capability in firms and research organisations
	Interactions	Quality	Research organisations do not interact with firms early enough Lack of individuals in research organisations with capability to interact with firms in entrepreneurial activities
	Institutional	Presence	Public funding of innovation perceived as being risk-averse in setting technology development priorities
		Quality	Research organisations mandated by Government to undertake entrepreneurial activities, but rarely do
	Infrastructure	Presence	Historically has been an absence of organisations to support business-research interactions
	Market structure	Quality	Large number of SMEs, which lack financial and human resources to undertake entrepreneurial activities
Knowledge development	Actors	Presence	Limited instances of innovation brokers
		Capability	Presence of intermediary organisations that act as gatekeepers between researchers and users, rather than as innovation brokers
	Interactions	Presence	Absence of interactions over the joint development of knowledge
	Institutional	Presence	Lack of time and resources to support individual relationships in knowledge development
		Quality	Innovation management is linear, planned and milestone-focused, locking in particular innovation pathways
Knowledge exchange	Actors	Presence	Limited instances of individuals that can work across industry, Government and research cultures
		Capability	Limited capability within industry to interpret science
	Interactions	Presence	Limited interaction between research organisations and industry in knowledge exchange, creating a mismatch between technology supply and demand
	Institutional	Presence	CRI's are required to remain economically viable, leading to a focus on revenue generation and less on knowledge exchange with industry
		Quality	Innovation management is linear, planned and milestone-focused, locking in a particular innovation pathway
	Infrastructure	Presence	Limited infrastructure to ensure industry has access to a skilled and technically competent workforce
		Quality	Limited financial and human resources in SMEs to support science-industry interactions
Guidance of the search	Actors	Presence	Limited instances of research organisations participating in industry guidance of the search activities
		Institutional	Presence
	Infrastructure	Presence	Absence of infrastructure to support one-to-one relationships in guidance of the search

	Market structure	Quality	Vertical and horizontal fragmentation leads to heterogeneous innovation needs among actors. Large number of SMEs that lack resource to participate in guidance of the search
Market formation	Actors	Presence	Businesses are seen as having a key role in market formation
		Capability	Research organisations lack capability to contribute to market formation
	Institutional	Presence	Culture within research organisations that market formation is the role of industry
		Quality	New Zealand's market economy creates a culture that does not see Government as having a role in market formation
	Infrastructure	Presence	Limited resources mobilised to support SMEs to form markets
	Market structure	Quality	Vertical and horizontal fragmentation in some sectors hampers market formation
Resource mobilisation	Actors	Presence	Large number of intermediary organisations perceived by research organisations as capturing resource for administration rather than innovation
		Capability	Lack of facilitative and transformational leadership in coordinating resource mobilisation
	Interactions	Presence	Interactions among actors tend to be focused on resource mobilisation
		Quality	Competition among actors to ensure resources are allocated to their own innovation agendas
	Infrastructure	Presence	Less resources available to guide the search, form markets and support entrepreneurialism
		Quality	High number of research grants with low funding
	Market structure	Quality	Large number of SMEs that have limited resources to undertake or participate in interactions
Creation of legitimacy	Actors	Presence	Industry is viewed as having a key role in creating legitimacy around innovation, though limited instances were identified of this occurring