



DRIVERS OF SUSTAINABLE INNOVATION PUSH, PULL OR POLICY

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Abstract: We are living in an era of rapid technological change where innovation rates continue to increase exponentially. Accordingly, countries who wish to be active in the novel technology market will need to understand what drives and ultimately determines innovation. This research is a part of a bigger study investigating the determinants of innovation in the New Zealand biotechnology sector. It reports on preliminary findings of a thematic analysis of interviews conducted with senior figures in research, development and commercialisation businesses in the New Zealand biotechnology field. Specifically, this paper attempts to answer the research question “What are the drivers of innovation in the sustainable innovation paradigm”. In doing so, the constructs of Technology Push, Market Pull and Policy Intervention are explored along with a range of related and contributing management concepts.

Keywords: *business innovation, innovation determinants, biotechnology and sustainable development.*

INTRODUCTION

Innovation and specifically innovation which heralds the coming of sustainable outcomes is of increasing interest. As society, business, academia and policy creating bodies become ever more sensitive to global events and changing attitudes this is likely to continue at an accelerating rate. We are living in an era of rapid technological change where innovation rates continue to increase exponentially. Accordingly, countries who wish to be active in the novel technology market will need to understand what drives

and ultimately determines innovation. This may be even more important for small, developing and geographically disconnected countries that have traditionally seen innovation through early adoption as opposed to active participation.

According to Khilji, Mroczkowski & Bernstein (2006), early innovation theory and models concentrated on a technology push and market pull process with the emphasis on the technology and effectively ignoring market forces. Moreover, little or no account was taken with respect to environmental is-

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sues or that of sustainability in general. Later models started to consider the complexities of the innovation cycle, recognising innovation as a continuous process of events and emphasising the importance of functionality within the business environment.

There is an ever growing body of research surrounding the area of innovation, however, "this is scattered across different academic disciplines" (Bernauer, Engels, Kammerer, Seijas and Seijas, 2006, p.2) and tends to be specific to a few determinants of innovation. This narrow focus extends into the study of "green innovation" or "eco-innovation" where the "literature regarding the determinants of environmental innovations is sparse" (Rehfeld, Rennings and Ziegler, 2007, p.93). This might result in a myopic view which fails to take full account of the complexities and interrelated nature of the innovation process and those drivers which ultimately determine the rate at which innovation is progressed and diffused.

The objective of this research is to report on findings of a qualitatively based interview with senior figures from seven New Zealand Crown Research Institutes innovation drivers that ultimately determine innovation in the area of sustainability. The results presented form part of a bigger study looking at the interrelated determinants of innovation in the New Zealand Biotechnology Sector. Therefore, it is worth noting that the constructs and concepts exposed in this work do form part of a more complex network of interrelated determinants relevant to the New Zealand context. New Zealand appears to have a comprehensive range of macroeconomic and institutional characteristics thought to be ideal for high levels of innovative output yet this has not delivered the anticipated results (Shangquin, McCann and Oxley, 2009). New Zealand continues

to perform poorly across the range of innovation output metrics which might negatively impact on a competitive level in the medium term as developing countries, such as China, play a more active role in New Zealand's traditional industries such as the dairy industry. Finally, this paper provides some ideas on how innovation in the area of sustainability might relate to other broader constructs which will be dealt with more fully in forthcoming works.

ECO-INNOVATION AND ITS RELEVANCE TO SUSTAINABILITY

There can be little doubt that companies, governments and society at large are taking a closer interest in sustainability issues. This is evident in the growing number of organisations, societies, governmental agencies and other bodies whose reason for being is to raise awareness, lobby and raise legislative changes to further the cause of sustainability and eco-innovation. Despite this groundswell of interest and increasing focus, convincing sustainable development resulting from eco-innovation "remains elusive despite intensive efforts and some successes" (Morioka, Saito, and Yabar, 2006, p.65).

So what exactly are eco-innovations? According to Rennings, (2000, p.322), they can be described as "measures of relevant actors (firms, politicians, unions, associations, churches, private households), which (1) develop new ideas, behaviour, products and processes, apply or introduce them and (2) contribute to a reduction of environmental burdens to ecologically specified sustainability targets".

Following the same trajectory as research into more general determinants of innovation, research focused on eco-innovation has tended to be confined to a small range

of relationships such as eco-innovation and regulation or eco-innovation and competitiveness for example. Moreover, there is general acceptance that a model which promotes multiple interdependences with the provision of relevant feedback is required to describe and understand the eco-innovation process and little work has been done in this area. “Since existing theoretical and methodological frameworks do not address these problems adequately, research need can be identified to improve our understanding of innovation processes toward sustainability in their different dimensions, complex feedback mechanisms and interrelations” (Rennings, 1998, p.1).

This research builds on the current body of knowledge through the investigation of a

series of interrelated determinants of innovation in the area of innovation in the sustainability paradigm. It confirms four interrelated determinants and a set of influencing or moderating factors that will be discussed in the research findings section of this paper.

CASE STUDY METHODOLOGY AND DATA COLLECTION

This paper reports on semi structured qualitatively based interviews conducted during December 2009 and January 2010 with the Chief Executive Officers (CEOs) or delegated senior managers from seven of the Crown Research Institutes (CRIs) of New Zealand. This cohort was selected as those individuals have responsibility for research and development and some commercialisa-

Table 1 - Participating Company Profile

Co. No.	Main Areas of Research/ Commercial Activity	Approx. No. of Staff	Interviewee
1	Water, Communicable Disease, Pharmaceuticals/Biotechnology	400	GM Research
2	Environmental Research, Primary Production	380	CEO
3	Molecular Biology, Nutrigenomics, Plant & Marine	900	GM Commercialisation
4	Aquaculture, Biotechnology	450	CSO
5	Energy & Materials, Biotechnology	320	CEO
6	Food, Biotechnology, Genetics, Agriculture	1000	CEO
7	Bio Manufacturing, Energy & Power, Health Technologies	324	CEO

Source: Developed by Arthurs

tion activity along with normal business operational responsibility. Moreover, they are all involved with biotechnology or related fields. CRIs in New Zealand are currently required to operate as commercially orientated units with responsibility for generating profit with a high level of interface with governmental departments. CRI Chief Executive Officers bring a broad view of the innovation process which is relevant across the whole sector. Consistent with Yin (1994, p. 23), this approach can be viewed as case based research which is especially useful for practical business situations.

The selected approach has a non-probability design as the sample selected is based on the authors judgement of the "appropriate characteristics required of the sample members" (Zikmund, 2003, p.382). This method is consistent with "Judgement or Purposive Sampling" methodologies described by Patton (1990, pp.169-186) and reflects a combination or mixed purposeful methodology which is thought to promote flexibility and will meet multiple interests and needs. Specifically, Critical Case and Criterion Sampling are the methods used. Table 1 confirms the main areas of research and commercial activity of the participating organisations, it also highlights the size of the organisation and the designation of the interviewee.

DATA ANALYSIS

As part of a separate and larger study surrounding innovation in the New Zealand biotechnology sector, thirteen constructs, thought to determine innovation, have been synthesised from a broad range of literature and are listed below:

- Clustering
- Company Size

- Disruptive Technologies
- Funding
- Management
- Market Pull/Technology Push
- Measurement of Innovation Output
- Partnering other Organisations
- Policy & Regulation
- Sustainability
- The Board of Directors
- National System of Innovation
- Innovation Type (Incremental/Radical)

This section presents results of the analysis carried out on the qualitative interviews and specifically regarding the constructs associated with sustainability issues. Based on a semi-structured questionnaire with open questions this instrument was used to guide the interview only and questions were designed to solicit opinions, views and experiences surrounding the range of determinants of innovation shown above. Moreover, participants were encouraged to talk freely and openly around each construct which guided the process without limiting it.

Data analysis revealed that all participants have positively confirmed that the above represent a comprehensive listing of those constructs which are considered to be a determinant of innovation in the New Zealand biotechnology sector. In addition, a number of moderating or influencing factors surrounding each determinant interrelated to sustainability were also exposed.

Data collected from interviews were qualitatively coded and analysed in a "systematic and logically rigorous" way (Neuman, 2006, p. 457) using a computer based programme (NVivo8). Based on the three levels of coding suggested by Strauss (1987), that is, Open Coding, Axial Coding and Selective Coding, this process was effective in reducing large amounts of data into "small man-

ageable piles” (Neuman, 2006, p. 460). The emerging interrelated concepts and themes form the basis of this section when contrasting sustainability with innovation in the New Zealand biotechnology sector.

DATA ANALYSIS

Analysis has revealed four interrelated determinants of innovation when considering sustainability issues in the New Zealand context, they are, Technology Push/Market Pull, The National System of Innovation, Policy & Regulation and Funding. Accordingly, this section expands on each interrelated determinant and influencing factors whilst presenting examples of primary data in the form of quotations (in *italic*) as supporting evidence.

TECHNOLOGY PUSH/MARKET PULL

The influence of technology push and market pull on innovation has been well documented and “empirical research has shown both to be relevant” (Bernauer et al., 2006, p. 6).

In all but one case market pull has been cited strongly as the most powerful and relevant construct surrounding sustainability related innovation outcomes in the New Zealand biotechnology sector. There is strong evidence that consumers by way of direct influence or by indirect advocacy tend to shape the innovation trajectory of organisations.

“If our biotech industries are going to continue to be successful, it is all about responding to the market, sustainability is a market initiative”.

“Sustainability innovation has been predominantly driven by the customer and is a market pull, it is not a technology push”.

There is a strong relationship to the retail sector as guardians of sustainable innovation adoption. Primary industries are impacted strongly by supermarket chains who act as regulators in the sustainability debate. This may be indicating a lack of governmental intervention on behalf of the public, choosing instead to allow the market to shape the acceptable technological offerings.

“If you look at our primary production industries, the consumers are, via the supermarket chains in particular the drivers, they are the regulators”.

This may also be true for the importation and export of products as markets around the world set their own standards in the interests of and for the consumer.

“But I think the consumers clout and gate keepers through the big supermarket chains on behalf of the consumers are setting the barriers higher and higher in the export and import space”.

Evidence that exports can be significantly impacted based on the need for detailed documentation and supporting information was found. It is becoming more important to prove to customers through well researched means that innovation is meeting their sustainability expectations.

“So for example, we had a seafood company who came to us recently and said they had a large supermarket chain overseas that we were providing a certain fish species to. Suddenly they said we don’t want to take anymore product because they didn’t believe it is being sustainably fished. They were saying that we don’t want your product because you haven’t collected the appropriate data”.

A common theme emerged surrounding Regulatory Push/Pull Effect that supports a view that there is an important role here for government (Rennings, 1998). Specifically, the implementation of appropriate regulation designed to a) generate a demand based on a sustainable outcome and b) in creating the appropriate regulatory environment to allow organisations to react to this demand.

“It is a mix of technology push and market pull, however, people need to be assisted with some of their choices. So they need to be easier, easier to choose the right thing to do”.

There was some evidence to suggest that absorptive capacity in New Zealand might be an issue and limiting innovation pathways. New Zealand is a small market and opportunities to adopt new technologies are limited in this respect.

“I think in New Zealand there is an imbalance in favour of technology push. Two reasons for that. Lack of absorptive capacity and also lack of future foresight and thinking”.

THE NATIONAL SYSTEM OF INNOVATION

The Innovation pathway is now understood to be a non-linear and complex process. Moreover, the process is nearly always progressed by multiple actors and very often “between the innovative firm and other organisations and institutions” (Abrunhosa, 2003, p.1). Abrunhosa (2003) further states that “the behaviour of the agents is influenced by the institutional set up, by cultural and historical factors that are country specific” (p.3).

If we accept the definition developed by Freeman (1988) who generally describes the

National System of Innovation (NSI) as a network of institution in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies, innovation is by definition a collaborative act “rooted in processes of interactive learning” (Andersen and Lundvall, 2002. p. 187). One of the basic principles of a NSI is “successful innovation depends on long term relationships and close interactions between the innovative organisation and external organisations and institutions” (Abrunhosa, 2003, p. 6), this is thought to include governmental input.

There was considerable evidence in the data suggesting that the role of government in the innovation process was critical yet misunderstood. This is consistent with the views of the OECD (2008) who cite a fragmented system of governmental support and a lack of coherence across the full range of innovation policies.

“The government is completely confused as to what it is trying to do with the National System of Innovation. You get factions of the government who just want us to stand alone and just look after ourselves but that is not why we exist. This has been a constraining factor for the biotechnology industry”

“Standing back and letting the market innovate is in my view is admitting that your getting used to losing. If you look at countries that we might take some hard lessons from, the government plays a much stronger role in this area”.

“The issue comes down to the quality of how you discharge your responsibilities in the areas of relationships with other organisations and the access those entities have to investment capital, skills, equip-

ment and information especially what's happening overseas".

Strategic direction should come, in part, from the government's contribution to the NIS but for various reasons may be missing. A coherent strategy has been called for which would enable a symbiotic relationship to be developed across CRIs, Universities and the Private Sector which is the essence of any NSI. Unfortunately, there appears to be a significant level of scepticism between state and private research organisations which may be limiting the development of the right environment for innovation to flourish.

A common theme to emerge was the notion of short-termism. This was based on the perceived risk profile associated with innovative and novel research leading to innovative output.

"One issue is that the private sector tends to want to take a low risk profile so you tend to get less. You tend to get pushed towards shorter term incremental change. The policy construct from the government is unclear at this stage so private industry can't see a value proposition so they have been relatively short term and opportunistic in their actions".

If we subscribe to the view that incremental change is a barrier to sustainability this is a relevant theme. Increasingly, there is a view, supported by the analysis that incremental change is not believed to deliver the scale and pace of change required to support innovation in the quest for sustainability and is therefore relevant (Elzen and Wieczorek, 2005). What drives short term strategies is of interest and the evidence appears to suggest that this is a feature apparent in the behaviour of all actors and agents

in the NSI in New Zealand from private companies to governmental attitudes on return on investments.

"The science system has become very end user focused and as a result it has become too driven by the needs of today as opposed to thinking what the needs might be tomorrow.

"We are in a particularly difficult situation because government are our owners and wants a good return but they are our clients also and want the cheapest price, that's why life is never dull here".

Strong evidence has emerged that the private sector was not engaging strongly with the NIS and particularly weak in the area of investment. There was a very strong message that private industry was very risk averse and to a large extent relied on the CRIs to pass on innovation as it becomes available.

"I don't think our industries are even close to being linked into that (NSI). Look at Federated Farmers for example, how well are they linked..? but I do suspect the horticultural industry is one of the better ones".

"So, it's not about making wholesale changes to improve the system but I do believe one of the biggest cultural change is needed in the private sector".

POLICY & REGULATION

"The question of what drives environmental innovation in industry and what role environmental regulation can or should play in this regard has become ever more policy relevant in recent years" (Bernauer et al., 2006, p.2). Commenting on the Porter and van der Linde (1995) win-win posture regarding reg-

ulation and industry, Bernauer et al. (2006) posits that a properly structured environmental regulation may benefit the environment, firms and society as a whole, a notion not always supported by neoclassical economists.

There was a strong view that government was not necessarily creating the right environment to foster innovation in the area of eco-innovation. Examples cited focused on policy surrounding financial risks associated with novel technologies along with the recent removal of R&D tax credits. There was broad agreement that there was sufficient understanding of environmental issues and how innovation might assist in the work of reducing environmental burdens, however, current policies and regulations did not deliver sufficient inducement for organisations to proactively follow this route. "National policies often provide structure to NSIs, particularly mission orientated systems. These policies include procurement policies, R&D subsidies, tax credits for R&D, intellectual property policies and the like" (Niosi, 2000, p. 6).

"I mean, basically, in other jurisdictions the government steps in to de-risk, to share risk, whether it's through long guarantees or whether it's other schemes".

"We have created a tax system that rewards us for investing in property and not in the industrial markets, we should at least have a neutral investment environment but we don't so it's not just holding back biotechnology, its holding back everything".

FUNDING

The lack of or availability of suitable levels of funding was a consistent theme throughout most of the interviews and was felt to be one of the most critical determinants of innovation.

There was broad agreement that larger countries such as the US were having greater success in the funding of environmentally driven biotechnology companies. Venture capital as a means of funding was a reoccurring theme but consistently this method of funding was stated as being hard to secure.

"That's where a lot of venture capital money in the United States is going into biotechnology as the environmental problems are growing so fast that biotechnology certainly has a significant contribution to make here".

"Countries such as America are prepared to invest in high risk innovation but it is hard to do that in New Zealand".

Of the funding available, there was consensus that this was used on a number of projects which tends to dilute the overall outputs and impact. Prioritisation of research was thought to be a major area for improvement.

"We still smear too thinly, too widely. So I think New Zealand is going to be forced to pick winners and say well actually, we're going to spend \$20 Million on topic X instead of Y".

Similarly, there was a clear view that the funding systems are heavily proceduralised and therefore slow to react. This issue may be compounded by the relatively high number of requests on a relatively small pool of available funds and the apparent need to see a return in a short period of time. This situation was cited as a major cause of short term thinking which is not a compatible mindset when considering the big environmental issues which will take many years of quality R&D to positively impact.

"The system is too slow and too disjointed,

we have got the ongoing problem of access to capital and so on. The funding system I think suffers from too many players and too many small pots of money so we can't transact business with private companies quickly enough to get real market traction".

"The whole thing becomes fire fighting orientated, short term and it has been difficult to get to the long term stuff. Particularly with industry, once things get tight economically, they start to focus on short term not long term".

There was evidence to suggest that private companies are generally reluctant to fund significant levels of R&D. Typically, the risk of failure is high in R&D with many projects only having a 20% chance of success.

"If you're saying that this is going to be the best thing in 20 years but it's got an 80% chance of failure, there are not many companies will stick with this"?

Once projects had travelled through the innovation pathway and have been substantially de-risked, private companies tend to be more accommodating with regard to the final pre-commercialisation activities. There was a strong view, however, that offshore companies from larger countries will take more risk, becoming involved with R&D at a much earlier stage. One participant summarised this by suggesting that New Zealand private industry was conservative in its approach to R&D funding and would rather move towards the desired outcomes in a more incremental and ad hoc way. It is argued that an incremental approach may not be the most appropriate methodology in the sustainability arena and may not work well generally in a knowledge driven sector such as biotechnology.

"It's about risk, they want to have whatever

the innovation is sufficiently de-risked so that they will be interested in it but this is actually a long way down the development track. I would definitely say that offshore companies we have dealt with are prepared to take on more risk".

"There is a definite conservatism in the New Zealand market place and I think some of it goes back to the number 8 wire approach which I don't think works in the biotechnology sector. We are trying to get industry involved and getting them not to take shortcuts and invest appropriately but it is difficult".

"There is a project we were trying to get industry interested in at an early stage but they resisted. Now that the project has been de-risked and we have got something to roll out they are becoming interested".

"The amount of private sector investment in R&D is one of the lowest in the OECD".

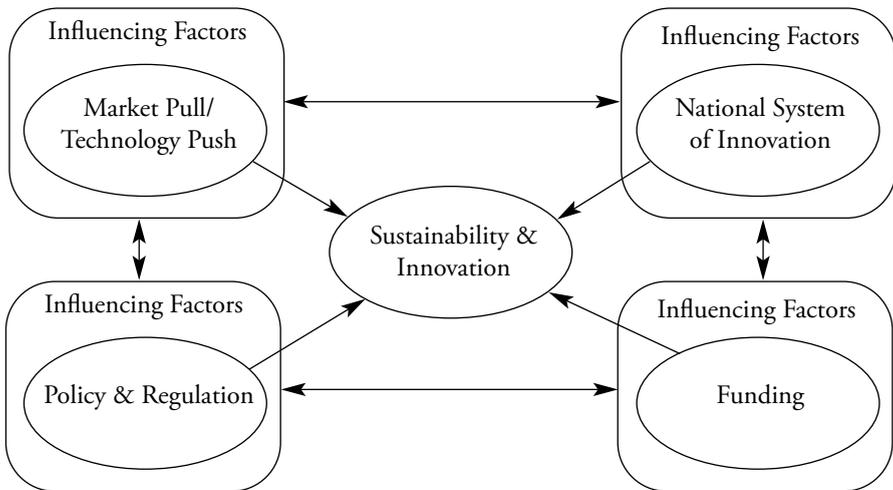
SUMMARY OF FINDINGS

Analysis of the data has confirmed that the issue of sustainability is a major determinant of innovation. More specifically, four interrelated determinants have consistently emerged where participants have highlighted these constructs as major drivers and/or barriers to this determinant, in the sector under consideration in New Zealand. These constructs are, Technology Push/Market Pull, The National System of Innovation, Policy & Regulation and Funding. Moreover, a series of influencing factors are also exposed for each interrelated determinant which appear relevant according to the analysis. Table 2 summarises the main findings of the analysis highlighting influencing factors when contrasted against the four interrelated innovation determinant drivers surrounding sustainability.

Table 2 - Innovation Drivers: Summary of Observations and Findings

Innovation Determinant	Interrelated Determinant	Influencing Factors
Sustainability	Technology Push/ Market Pull	Retail Market Overseas Retail Market Need for Information by Markets Impact of Regulatory Push/Pull Country's Absorptive Capacity Market Foresight
	National System of Innovation	Multiple Actors Long Term Relationships Interactive Learning Skills, Equipment and Information Strategy and Direction IP Issues Short-termism Industry Engagement
	Policy and Regulation	Win-Win Outcomes Creation of Correct Environment Short-termism Management of Risk
	Funding	Type of and Availability of Funding Management of Risk Dilution Effect Procedures and Process Short-termism Private Sector Reluctance to Invest

Source: Developed by Arthurs

Fig. 1 – Determinant Interrelationship Model

Source: Developed by Arthurs

RECOMMENDATIONS & CONCLUSION

This paper builds on previous work investigating the determinants and drivers of innovation and has specifically contributed to the literature surrounding innovation in the sustainability paradigm and in relation to the New Zealand biotechnology sector. Through a detailed thematic analysis, four determinants of innovation are confirmed as being interrelated with innovation directed at sustainability issues, they are Technology Push/Market Pull, the National System of Innovation, Policy and Regulation and Funding. In addition, a range of influencing factors thought to impact each of the interrelated determinants were developed. This study has attempted to develop a more relevant and integrated view of innovation issues. Some of the findings appear to be similar to other studies in this area, however, this research has built on previously identified determinants impacting sus-

tainability innovation and is significantly different to most other work as it has highlighted a range of influencing factors in a New Zealand context. We believe this study has provided a unique insight to the understanding of what drives and hinders innovation in the sustainability determinant.

Drawing heavily on the knowledge and experience of a small population in the research and commercialisation sector, this paper is, to some degree limited. Any attempt to generalise findings should proceed with caution as this work is, to a large extent, qualitative in nature and as such reflects the reality of those who contributed. The subject of innovation and particularly the determinants of innovation are complex and highly interrelated. Therefore, further opportunities to research this complexity exist enabling a more comprehensive picture of this important area of study.

BIOGRAPHY

Stephen Liddle is currently the National Facilities Manager for one of the largest research organisations in New Zealand. He holds a Masters in Business Administration from Durham University (DUBS) in the United Kingdom and a Bachelors Degree in Engineering from Sunderland University (UK). He is currently progressing with his Doctorate in Business Administration with the Southern Cross University (Australia) and in association with the Manukau Institute of Technology (MIT) in New Zealand. Stephen Liddle has worked in senior technical and operational roles for some of the largest “blue chip” pharmaceutical companies over a 25 year period and has been active in many industry forums including Validation Policy and Good Automated Manufacturing Practices GAMP). His current interests surround innovation in the biotechnology sector, specifically in small, remote and open economies such as New Zealand.

Dr Siham El-Kafafi is a Senior Lecturer in Management at the Faculty of Business, Manukau Institute of Technology, Auckland, New Zealand. She is the regional editor for World Journal of Science, Technology and Sustainable Development (WRSTSD), the World Journal Entrepreneurship, Management and Sustainable Development (WJEMSD) (www.worldsustainable.org), the Intermodal Transportation Research Journal, Inderscience Publisher, and editor and reviewer for other international journals. She is also a Member of the Award Committee for the International Society of Management Science and Engineering Management (ISMSEM) Advancement Prize for Management Science and Engineering Management (MSEM). Besides Dr El-Kafafi’s academic and research experience, she has got wide consultancy experi-

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