SYSTEMS THINKING, MARKET FAILURE, AND THE DEVELOPMENT OF INNOVATION POLICY: THE CASE OF AUSTRALIA

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Abstract

Innovation policy is increasingly informed from the perspective of a national innovation system (NIS), but, despite the fact that research findings emphasize the importance of national differences in the framing conditions for innovation, policy prescriptions tend to be uniform. Justifications for innovation policy by organizations such as the OECD generally relate to notions of market failure, and the USA, with its focus on the commercialization of public sector research and entrepreneurship, is commonly portrayed as the best model for international emulation. In this paper we develop a broad framework for NIS analysis, involving free market, coordination and complex-evolutionary system approaches. We argue that empirical evidence supporting the hypothesis that the 'free market' can be relied upon to promote innovation is limited, even in the USA, and the global financial crisis provides us with new opportunities to consider alternatives. The case of Australia is particularly interesting: a successful economy, but one that faces continuing productivity and innovation challenges. Drawing on information and analysis collected for a major review of Australia's NIS, and the government's 10-year plan in response to it, we show how the free market trajectory of policy-making of past decades is being extended, complemented and refocused by new approaches to coordination and complex-evolutionary system thinking. These approaches are shown to emphasize the importance of systemic connectivity, evolving institutions and organizational capabilities. Nonetheless, despite the fact that there has been much progress in this direction in the Australian debate, the predominant logic behind policy choices still remains one of addressing market failure, and the primary focus of policy attention continues to be science and research rather than demand-led approaches. We discuss how the development and elaboration of notions of systems failure, rather than just market failure, can further improve policy-making in the future.

Keywords: Innovation policy, National Innovation Systems, market failure, systems thinking, complex-evolutionary perspectives, Australia

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1. Introduction

One of the most striking features of innovation policy discussions in national governments and international policy organizations has been the adoption of the terminology of systems thinking and in particular the language of National Innovation Systems (NIS). Recent examples include innovation policy reviews in the UK and Australia (DTI, 2003; HM Treasury et al 2007; Venturous Australia, 2008) and the publication by the OECD of a series of country specific innovation policy reports which explicitly adopt an NIS framework (see, for example, OECD, 2005). This apparent capture of the innovation policy agenda by NIS thinking might be considered surprising in view of the criticisms to which it has been subjected at the same time as it became respectable in policy circles.

Questions have been raised, for example, about the contemporary relevance of national, rather than global, regional, sectoral and technological influences on innovation performance. There is a tendency to confuse innovation systems with invention systems and the latter with the generation of fundamental science. Critical views have also been expressed about the theoretical status of the NIS approach and the extent of its explanatory powers (see e.g. Sharif, 2006), and the methods used to assess how innovation systems work and their performance (e.g Edquist 2005). There is also a tension in the NIS literature between studies that explore national differences and those that attempt to develop unified comparative indicators (Balzat and Hanusch, 2004). Moreover it has been argued that the policy debate focuses too much on the identification and pursuit of chimerical 'optimal' innovation systems when the underlying conceptual and empirical analyses reveal great variety and persistent differences in system characteristics (Edquist et al 2008:3).

The problems with the NIS approach have not prevented it from influencing policy thinking through its capacity to produce a shared framework of analysis, by spanning academic and policy boundaries and providing a versatile tool for decision-making (Sharif, 2006). Comparative indicators and methodologies continue to be developed to study innovation systems (see e.g. Gault, 2007 and more generally OECD, 2005). Even so difficulties remain with a reliance on highly piecemeal and often misleading indicators of performance, such as US patenting, found in some analyses (see e.g. the observations of Smith, 2005; Freeman and Soete, 2009).

A more fundamental critique is based on the view that applications of the NIS approach are often too static, descriptive and mechanical, and focus disproportionately on science and technology as opposed to other loci of

innovation. Instead, it is argued that what is required is an approach that emphasizes the dynamic, emergent, and evolving nature of systems and the multiple and distributed sources of knowledge for innovation (Lundvall, 2007). Evidence collected on innovation systems leads readily to the view that we are dealing with a complex, evolving system and that successful economies are those which have robust, but adaptable, network connections that enable organizations to translate new knowledge into viable innovations and enhanced productive capacity (see, for example, Malerba, 2004; Edquist, 2005; Edquist and McKelvey, 2000; McKelvey and Holmen, 2006). The reduction of the NIS to an application of static economic theory, as pointed out by Lundvall (2007), leads to policy prescriptions based primarily on limited and constrained notions of market failure, which do not capture the dynamic complexity of the systemic combinations that emerge to address innovation problems in particular national contexts.

The OECD, for example, while noting the variation in system characteristics across countries still continues to emphasize conventional market failure justifications focused on R&D and related human capital and science base inputs for policy intervention despite attempts to incorporate wider institutional and socio-legal issues in conceptual discussions (e.g. see Jaumotte and Pain, 2005 and Box, 2009). When it comes to justifying public intervention through innovation policy, acknowledgements of systemic and evolutionary considerations are mentioned but explicit policy conclusions are far less well developed than familiar market failure arguments. Arguments for intervention focus on setting broad 'market framework' conditions and assessing market failures as a rationale for policy. Systemic failures are mentioned but policy prescriptions are less clear (see e.g. Box, 2009). Edquist and Hommen's (2008:479) observation is apposite.

'"policymakers have proclaimed the adoption of the SI approach as a framework and guide for designing future innovation policy. What this means, however, for the design and implementation of innovation policy is certainly not clear - and policymakers often do not even know themselves."

In these circumstances the return to the safe haven of market failure justifications for policy intervention may reflect the fact that many professional economists working in this domain are trained in neo-classical economics rather than systems approaches to policy design. Equally the tools and policies to deal with market failures are more readily described and understood than systemic failures that have received less attention from economists.

The analysis underlying the market approaches boils down to some basic propositions concerning distinctive properties of information and ideas that lead the 'normal' neo-classically specified set of markets to malfunction. Knowledge is viewed as cumulative, reproducible at negligible cost, only partially excludable in use and an intangible asset. Although it is acknowledged that the generation of new knowledge involves fundamental uncertainty, researchers are viewed as engaged in a probabilistic process of finding new ideas that can then command monopoly rights when sold to innovators in an 'imperfectly competitive' market. The use of any probability calculus, of course, implies that a complete list of all possible new ideas can be specified in advance of their occurrence; there can be no residual list of ideas or surprises, nothing that reflects true uncertainty. But then there can be no new knowledge, no innovation that is not already anticipated. This is a limitation that relates directly to the notion of complexity as we explore below.

The standard conundrum is then posed: how can a market-based solution be found when social efficiency apparently requires free access to knowledge based on the characteristics of cumulativeness, non-excludability and costless reproduction?

The answer, it is claimed, is to be found in public expenditure on basic research and patent protection and subsidization for R&D (see eg Dasgupta and David, 1994). The latter, in turn, is justified on the basis of spillover leakages from the imperfect protection which patents yield. Finally, the inherent uncertainty and intangibility of knowledge is used as the basis for justifying a public subsidy for venture capital financing. This is deemed necessary to solve capital market failures in the supply of finance to new firms whose innovative and economic potential is rooted in the development and exploitation of new knowledge.

This rather narrow view of the domain of policy can be offered to policy-makers for any economy at any time. It leaves unanswered key institutional design questions concerning the nature of public sector intervention in innovation support. System wide issues, concerning the particular way that resource coordination and allocation takes place and how they evolve in the specific historical, structural, institutional and changing conditions facing particular economies, do not have a place within the analytical framework used. If they are mentioned, then they are referred to in an *ad hoc*, storytelling kind of way when a prediction of market failure theory is at variance with reality.

In this paper we argue that linking systems thinking into policy design does have great potential and helps us to develop a more coherent and fruitful approach to policy. We argue that to do this a more fully developed notion of the systems approach based on the theory of complex systems. We do not reject the notion that markets can fail, it is clear that they can and do. But, by itself, market failure is too narrow a perspective to provide an adequate analytical or empirical basis for an innovation policy. Nor do we reject the notion that nations may be characterized at any point in time as having certain common system characteristics. However we find it remarkable that, whilst much research into NIS and national variety, such the "varieties of capitalism" literature, has emphasized important differences between countries, innovation policy prescriptions have increasingly focused on a single 'one true way' based on market failure. This is based on a particular interpretation of US economic history that regrettably permeates the approach to innovation policy adopted by the OECD. It focuses on an arrow range of factors deemed central to the US innovation system (Hughes 2008). These have achieved dominance because of the enhanced economic performance of the US since 1995 and have served to obliterate features of previously successful innovation systems producing superior economic performance in, for example, Germany and Japan in the not so distant past (see, e.g. Dertouzos et al, 1989).

In our view, discussions of the design of national innovation policy should be set in to the context of a case study (found, for example, in Nelson, 1993, and Edquist and Hommen, 2008). The case that we have chosen is Australia, where we can clearly discern a steady shift in perspective of innovation policymakers away from the standard market failure approach towards an NIS approach, recognising the complex, evolutionary character of the economic system. Australia is also attractive as a case because of the availability of numerous reports and academic papers on the nation's extensive experimentation with industry, science, technology and innovation policies from the 1980s (eg Pappas et al, 1990; Dodgson, 1989; Productivity Commission, 1995) to a major recent review of Australia's NIS (Venturous Australia, 2008) and the release of the Federal Government's new innovation policy (Powering Ideas, 2009). Using a broad analytical framework that incorporates both market and system coordination issues, we discuss the shifting policy design path in Australia. We examine the way that the key coordinating institutions in the Australian innovation system have evolved up to the present and we offer a novel semantic analysis of contributions to the innovation policy debate from the perspective of the actors in the system.

We respond to calls for further research into the rich and organic development of NIS over time (e.g. Dodgson et al 2008), building on our still limited

knowledge of the dynamic properties of NIS in terms of their stability and evolutionary potential (Balzat and Hanusch, 2004). We also respond to Edquist's (2005) entreaty for greater integration between conceptual and empirical studies. We argue that the evidence we provide for Australia suggests that any consideration of 'failure' must go beyond the special case of 'market failure' and consider the extent of 'system failure.' We also explain how this distinction is useful in policy-making.

2. Market failure and complex-evolutionary perspectives

Before turning our attention to the innovation policy problem it will be helpful to spell out what the idea of market failure involves and how complexity analysis adds to our understanding of the policy agenda. The central ideas of the market failure doctrine are rounded in the theory of a perfect competition and the fundamental welfare theorems that link this idea to the optimum allocation of resources in an economy. Market failure means that price signals are distorted and resources misallocated relatively to the *optimum optimorum* and the main types of distortion relate to the exercise of monopoly or monopsonistic power, the absence of future markets so that the signaling system is incomplete, asymmetric information so that the true situation cannot be assessed in terms of market signals, and externalities of which information spillovers are the principle exemplars. The problem that now arises is that these "failures" are an intrinsic consequence of the process of innovation itself and could only be eliminated if innovation ceased. Thus the model of perfect competition in a stationary state, a world in which innovation, or indeed any change of human knowing is absent, can serve only as a distorting mirror in which to reflect the innovation policy problem.

The limits of stationary analysis were well understood by Schumpeter, and indeed Knight, Marshall and Hayek, who all held a view of an innovation driven economy as competitive but not perfectly competitive- Knight's concept of the economy as a "self-exciting system" being particularly apt. Instead they correctly understood that a knowledge driven economy cannot be stationary and that competition is therefore a process of disequilibrium dynamics not a state of equilibrium affairs. The far from equilibrium nature of the competitive processes is essentially evolutionary, in that innovations produce economic variations and the market system adapts the allocation of resources to the possibilities that are implicit in the innovation. Innovation depends on change in knowledge and the economic responses to it generate further changes in knowledge so that the system is essentially autocatalytic. That is to say innovation and enterprise create the opportunities for further

innovation and enterprise, each advance leads to further questioning and conjecturing of other possible innovations, without apparent end: that is the lesson of modern capitalism and the particular way that it has instituted the growth of economically useful knowledge.

In this process the profit mechanism plays a central role, for contra to perfect competition in which profit is absent because enterprise is absent, but profits are not necessarily an indication of distorted markets but rather are the corollary of differential economic performance: they have the characteristic of transient rents, transient in the sense in which the water in a stream is transient but ever present. Thus profits, enterprise and economic development are ineluctably connected, it is the process that sustains the useful application of knowledge without which standards of life do not increase: it could not be further removed from the mirror in which market failure has its image. This is not to say for one moment that the framing institutions of the market are unimportant or that, for example, barriers to entry and business formation may be harmful to innovation. Important they are but their importance is not to be found in departures from perfect competition.

This characterisation leads us naturally to the idea of an economy as a competitive open system in which the advantage to be assigned to markets is not their capacity to optimize resource allocation but rather their capacity to stimulate innovation and adapt to the possibilities immanent in innovation. As with any system it is composed of parts connected within boundaries so that it is in effect a system of connected systems in which a chief organising principle is the division of labour and the chief operational consequence the idea of emergent development. The innovation subsystem is deeply intertwined with the market subsystem, and both are shaped by national regulations, institutions and cultures. This is not in question but what matters are the specifics of the intertwining. We find it helpful to think of a national innovation system being more or less productive at the identification and solution of innovation problems. Each innovation problem is more than an invention problem because it requires invention to be commercialised, it requires attention to many different kinds of knowing in its solution, including knowledge of product and factor markets, and it therefore draws on the skills and capabilities of many different individuals employed in different organisational contexts. Problem solving is necessarily a distributed process and has two important aspects. The first is its autocatalytic nature, the solution of problems simply serves to create the conditions for the identification of further problems, and the results are emergent. By this we mean that solutions cannot be causally related to antecedents by the observer, who will solve a problem, how it will be solved, who will use the solution and

how they will use it are essentially unpredictable. The lesson of history is that essence of innovation is surprise, the essence of surprise is Knightian uncertainty, and in this the course of innovation is akin to the growth of fundamental science. As we point out below this gives innovation an experimental dimension, the dimension of business experiments in which many failures accompany the ultimate successes but who and how cannot be foretold.

We shall demonstrate below how these ideas translate into an innovation policy agenda but here it will suffice to draw the connection between parts and components characteristic of any system. There is a natural policy agenda to enquire if a nation has access to all the knowledge that is required to solve particular innovation problems, which means does it have access to the relevant knowledgeable individuals. This is true not only in fundamental science, technology and engineering but, equally importantly in access to the translational knowledge that is invariably needed to demonstrate validity of concept and turn concept into market reality. Knowledgeable individuals as the parts do not of course make a system that depends on the parts being connected for a purpose. The incentives and barriers to connectivity thus form the second strand of the complex systems approach to innovation. How open are firms, universities, research organizations and other knowledge intermediaries to connectivity is thus a crucial issue. As organizations reflecting a division of labour in the production and use of knowledge their internal incentive structures and operational procedures may inhibit connectivity by supporting conflicts of interest so that openness is not to be presumed but itself is an emergent property of a well functioning national system. It may well be that the individuals that can facilitate the process of problem solving are in different organizations, in different economic sectors, even in different countries. That is the magnitude of the policy agenda, how to keep the parts open to the possibility of connection. We now turn to the national differences in the specific ways innovation problems are confronted and connections constructed.

3. Variety in analysis but uniformity in policy prescription

A number of literatures emphasize how diverse national characteristics influence innovation performance. Comparative analyses of ‘stock market’ and ‘welfare’ capitalism (Dore 2000) and ‘liberal market’ and ‘coordinated market’ economies (Hall and Soskice 2001), for example, explore differences in varieties of capitalism and their dynamics (Berger and Dore 1996). Others argue how the social and political contexts that influence the creation of and

rationale for institutions (Boyer 1996) emphasize the continued importance of national influences.

Hall and Soskice acknowledge the centrality of NIS in their discussion. They argue that liberal and coordinated market economies have very different capacities for innovation. So, for example, innovation in liberal market economies is secured via institutions supporting basic research, technological entrepreneurship, competition around technical standards, venture capital industries, and effective technology transfer between science and business, including the movement of scientists and engineers within fluid labour markets. Hall and Soskice argue that these characteristics are especially supportive of radical innovation manifest in the innovative designs and rapid product developments, based on research, found in fast-moving and complex technology sectors, such as biotechnology, telecommunications and defence.

Coordinated market economies, in contrast, exhibit few of these features and their characteristics, such as close inter-firm collaboration and customer/supplier links, and high labour retention, suggest a predilection towards incremental improvements to products and production processes. “In short, the institutional frameworks of liberal market economies provide companies with better capacities for radical innovation, while those of coordinated market economies provide superior capacities for incremental innovation” (Hall and Soskice 2001:47).

The empirical validity of Hall and Soskice’s distinction between systems conducive to radical and incremental innovation has been called into question, with calls for greater account of sectoral differences within nations (see e.g. Akkermans et al, 2009). But there is little argument about the differential capacity of nations to innovate (Edquist and Hommen, 2008), and there are broad national differences in the influences on policy formulation (see e.g. Ergas, 1989).

Hart (2009: 648) suggests that perhaps the most pervasive observation in the NIS literature is that national differences in innovation processes tend to endure over long periods of time; noting Nelson’s (1993:509) comment that “institutional continuity is striking”. He attributes this to the path dependence, or lock-in, that limits or prevents change. This is caused by the problems of transferring specific and engrained skills and knowledge, routines that limit experimentation and learning, and the way “interactions among co-evolved institutions tend to dampen or constrain change in any one institution, while simultaneous change across several institutions is hard to achieve”. He argues: “Path dependence at the individual, organizational, and institutional

levels is further reinforced by the expectations of partners in economic exchanges and by political and social power structures (Hart, 2009:648).

Despite the amount of analysis emphasizing continuing national differences in the economic, social and political contexts that influence innovation policy, the justifications for, and prescriptions of, actual policies tend to be rather uniform. This is clearly seen in many OECD international assessments. Thus the OECD concluded in its 2006 Economic Survey of Australia that: "Given that the industry structure explains much of the relatively low R&D intensity, that framework conditions appear favourable and that Australia is a strong user of ICT, innovation is not considered in a separate chapter in the remainder of this Survey." (OECD, 2006:58). In its Economic Survey of Australia for 2008, the word innovation appears only 3 times and neither innovation policy nor performance is discussed as a policy priority (although education policy is). The clear message is that Australia does not need special attention in its innovation policies as it has been complying with what the OECD considers to be ('liberal market') orthodoxy.

The OECD's prescriptions emphasize the importance of removing hindrances to the free entry and exit of businesses, including cheapening business formation, reducing bureaucratic and legislative constraints on bankruptcy and exit, and freeing up the labour market to ensure ease of hiring and firing labour in nascent innovative enterprises. These prescriptions go hand in hand with an emphasis on the importance of subsidizing capital markets, insofar as there is perceived to be a market failure in the provision of risk capital for small innovative businesses. This should be bolstered by the free flow of risk capital between deregulated and equity- focussed capital markets to promote acquisition opportunities and stock market exit routes for emergent innovative businesses. Incentives to ensure that university and public sector research moves closer to market also feature strongly in this prescription.

Box (2009) summarizes this view by undertaking a 'stock take', of the OECD perspective. It suggests that 'framework' conditions are most important: macroeconomic stability, openness to trade, deep financial systems, competitive markets, labour market flexibility and low taxes. She argues there is little evidence or rationale for R&D incentives, or support for entrepreneurship and small and medium-sized firms. She contends that supporting management training "appears" beneficial, but "little is known" about the relationship between government procurement and innovation and that this requires further study. While human capital is identified as a vital input to innovation: "More evidence-based policy is required in the education system, particularly so that the system better adapts to change and evolving social needs"p6. Furthermore, she claims that: "[i]ndustry-science links are a

key facet of innovation and are driven mainly by the matching of university orientations to business needs."p5.

This view is based on the presumption that the United States innovation system is World best practice and that the key factors driving that system should be mimicked in other OECD countries. In Europe, in particular, the view that the replication of a stylized US innovation system, characterized above, lies at the heart of many policy recommendations. A recent analysis conducted for the European Commission of the implications of US innovation performance for EU policy, for example, concluded that "It is widely acknowledged that innovation and entrepreneurship are at the heart of competitiveness of the US economy and that knowledge transfer from research and the dynamic venture capital industry play an important role in fuelling company creation and growth. It is for these reasons that … the European Commission focused on the recent US experiences in these fields." (ProInnoEurope, 2007).

The view of the US as an archetypical liberal market economy thriving on a deregulated stock market with little government intervention has not gone unchallenged. The criticism of the importance of entrepreneurship as a central factor per se, in contrasting the US with other economies, is that it appears that it is not the birth and death rates of firms that distinguishes the US from other economies as much as the rate at which firms expand once they are established (Bartlesman et al, 2004; OECD, 2003).

In this context and, in particular, in relation to high-risk high technology innovating firms, the role of public procurement in the United States has been of considerable significance. Placement, through contracts, of support for small business R&D is on the same scale as the total formal venture capital market provision for such activities (Connell, 2006). Moreover, the bulk of the productivity and output growth miracle of the United States in the period since 1995 and in other immediate preceding periods was not dependent only on the productivity impact of innovating firms newly entered into the high technology centre of the economy. It was primarily due to the transformation of productivity in incumbent firms that dominated the industries at the beginning and end of the period analysed. Key to this transformation was the diffusion of new technologies through end users. It has been the development of new business models, and the transformation of dominant firms based on them, in the service sector which has been of key importance in raising productivity growth, bearing in mind that the service sectors in both the US and in other industrial economies including Australia account for the bulk of economic activity and, in the US case, the bulk of the acceleration in productivity growth since 1995 (Hughes and Grinevich, 2007).

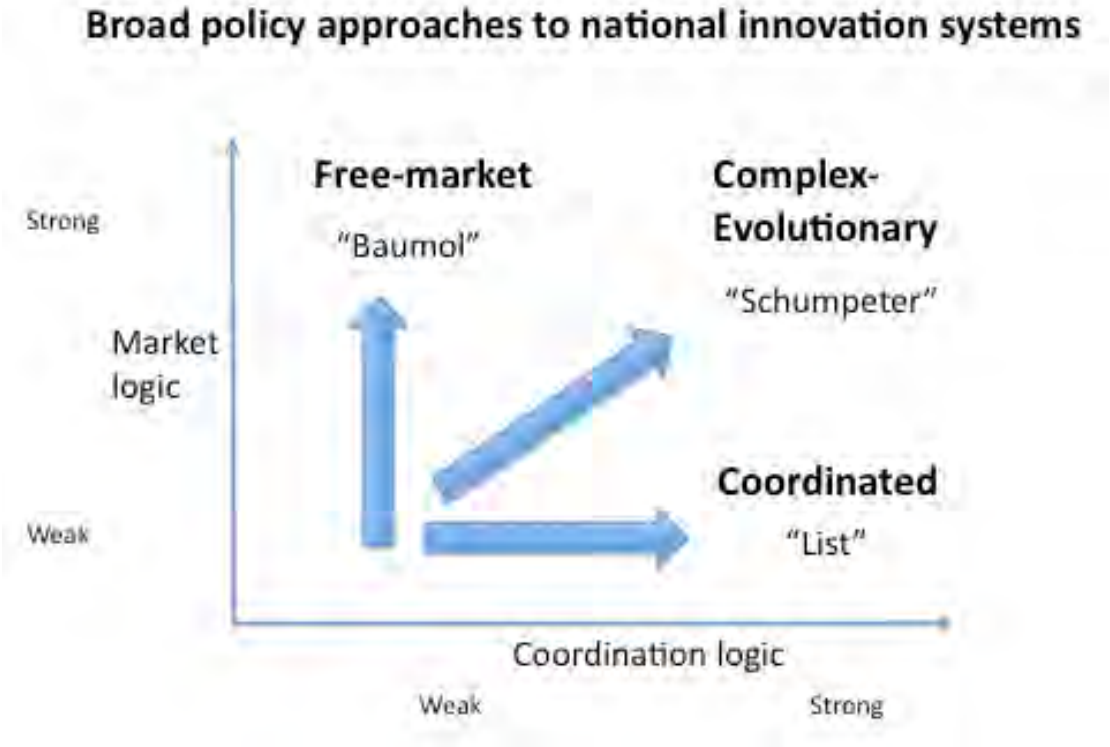
It is remarkable that, despite these empirical findings, the standard view of the US innovation system has persisted. Indeed, it has come to completely dominate innovation policy analysis throughout the OECD economies. The result has been an eclipse of models focusing on notions of state intervention and coordination and the performance potential of different varieties of capitalism. It is a striking paradox that the economy held to be the model of private sector liberal market capitalism was both the source of and has been hit most severely by the collapse of its deregulated financial sector in the worldwide financial market crisis of 2008-09. In the fallout of that crisis there has been a renewed interest in the development of more inclusive, coordinated and regulated forms of capitalism and, also, new perspectives on economic policy. It is clear, however, that governments require guidance in modifying their approaches to policy, in particular, in the field of innovation that is so fundamental to the process of economic development.

4. A framework for policy analysis

To illustrate the different policy approaches to national innovation systems we offer a highly stylized framework in Figure 1. This identifies the relative strength or weakness of free market-based and coordination logic in innovation policy trajectories. Categorizations in the social sciences always do some violence to the nuances of the perspectives and views of those contained within them, which may also prioritize different issues. They nonetheless provide useful heuristics for thinking broadly about differences in approaches to issues, and considering the dynamics and tensions between them. The location of particular nations within such a framework is inevitably inexact as many will display multiple and occasionally contradictory characteristics. Candidates for placement on the free market-dominated trajectory, for example, would include the USA, but its government's involvement in defence expenditure and support for early stage innovation in small firms displays characteristics of a coordinated approach. Candidates for location in the coordinated trajectory include the Scandinavian and developing Asian economies, although these, of course, possess very different levels of economic and equitable development, with varying capacities for significant radical innovation. No nation can be allocated to the intermediate 'complex-evolutionary' trajectory, because it has not yet been adopted as the central framework for policy development in any country. However, there is little doubt that, at the pragmatic level of policy formulation, account has sometimes been taken of what we can identify as evolutionary and complex system realities prevailing in a particular country. For example, Nill and

Kemp (2009) report that the Netherlands has recently been experimenting with innovation policies that are based upon a complex-evolutionary perspective. Most countries, however, have been rather *ad hoc* in accounting for complex-evolutionary factors in designing their innovation policies. But it is, nonetheless, important to acknowledge this available policy trajectory because, as we have seen, numerous governmental and academic analyses point to the potential significance of the complex-evolutionary approach (eg Lundvall, 2007), and it offers the opportunity to engage with both free-market and coordination perspectives.

Figure 1.



The free-market view is perhaps best expressed and encapsulated in the work of Baumol (2002) and Baumol et al. (2007). In the terminology of Baumol et al., the liberal market economy is identified as Entrepreneurial Capitalism in which small innovative firms play a significant role. The promotion of free market structures are viewed as central to innovative performance with little or no role for government apart from the creation of processes to ensure that capital market failures are addressed and large firms are kept on their competitive toes by maximum openness of international markets and entry and exit of radically innovative small firms. (Baumol et al., 2007).

Baumol et al emphasize that the Entrepreneurial Capitalist economy consists of an appropriate balance of organizations capable of providing both radical and incremental innovation. This particular balance is viewed as having been achieved in the case of the United States since 1995, which is the example, par excellence, if not the sole example, of Entrepreneurial Capitalism. In Baumol (2002) the analysis emphasizes the importance of oligopolistic rivalry and routine innovation activities in the typical large business-dominated technical and manufacturing sectors of the economy. In Baumol et al (2007) the emphasis switches much more to the importance of radical innovation and entrepreneurship as the means by which economies, otherwise driven to stagnation by relying on incremental innovation alone, must seek to rejuvenate themselves.

A contrasting view, which encompasses notions of the 'developmental state' and 'social market', emphasizes the key co-ordinating role of government in facilitating technological competitiveness, social inclusion and equity. This perspective has many proponents (see, e.g. Johnston, 1982; Wade, 2004) but is, perhaps, best expressed in the work of Friedrich List. Our interpretation of List is based on his reading by Freeman (1992), who points to several fundamental reasons for his support for national innovation policies. These include the importance of: intellectual capital; interactions between tangible and intangible investments that are manifested in new investments embodying the latest technologies and the learning that occurs through using them; imported foreign technology, investment and skilled migrants; skills, especially in scientists, engineers and designers; manufacturing sectors, including the way they stimulate agriculture and services; taking a long-term view in developing and applying economic policy; and an active interventionist economic policy to promote long-term development (Freeman, 1992:62-3). Freeman argues List's approach had a profound influence on Germany's economic policies and approaches to technology. "Its first and most important consequence was the early development of an education and training system capable of putting the acquisition and dissemination of world technology on a regular and systematic basis" (Freeman, 1992:63).

The third approach is the complex-evolutionary one which we can associate with the seminal writings of Joseph Schumpeter in the early 20th Century and with neo-Schumpeterians, such as Richard Nelson, who have extended Schumpeter's analysis in important ways.

Schumpeter argued that to have innovation, there must be entrepreneurial behaviour and that such behaviour lies at the very foundation of the process of economic evolution. Such behaviour involves decisions that, necessarily, must be made in states of radical uncertainty. So we cannot use neoclassical

economic theory to understand innovation. Entrepreneurs bring together new combinations of technologies, devise new organisational rules and develop new human skills to generate novel products. Such behaviour is driven by aspirations to make profits and accumulate wealth. But, operating in uncertainty, these actions must be based on mere beliefs concerning the future, both with regard to future market conditions and the internal effectiveness of the organisational/technological combinations that have been devised. Those engaged in entrepreneurial activity, whether in a small firm or in a functional role in a large firm, are famously over-optimistic in forming such beliefs and only a minority of projects succeed.

With such uncertainty, it is not possible to know until after the event which entrepreneurial scheme – or policy - turned out to be the most efficient and/or produced the most desirable product. This will depend upon what market conditions and internal configurations that actually emerge. Some will succeed as much by accident as design. Although many entrepreneurial initiatives fail, many also succeed because there is a vast diversity of market niches that become available as a complex economic system evolves. But we do not necessarily see the extent of failure in the competitive selection process that operates because we mostly observe the projects that survive. This gives us the illusion that what we see are the optimal outcomes of rational decision-making. But the reality is that these survivors are the outcome of a vast experiment in which the failures play a crucial role. Without entrepreneurial individuals and groups risking failure, there would be no economic evolution.

Schumpeter also told us that cultural and institutional rules are very important since they affect the beliefs that are adopted and determine the extent to which they can be acted upon in economically useful ways.

Neo-Schumpeterians have developed these ideas drawing upon the biological and physical sciences. Beginning with Nelson and Winter (1982), the evolutionary economic approach argues that competitive selection will occur in the presence of variety in ideas and options for the future, and this will lead to the emergence of dominant processes, products and organisational forms. However, this can only occur if new variety is generated and this depends upon new ideas and skills being available to entrepreneurial firms of all sizes and ages. Unlike evolutionary biology, variety is not generated randomly but results from entrepreneurship. As Schumpeter stressed, entrepreneurship involves new combinations and re-combinations and, although new technologies may be used, key innovations are often organisational in nature. Thus, writers such as Foster (1997) and Witt (1997) have argued that the generation of variety involves a process of ‘self-organisation’ and that this

process and the competitive selection process necessarily overlap while incremental innovation and learning from experience are taking place. Acceptance of this, necessarily, means that we are dealing with the evolution of a complex system (Foster 2005), with multiple contributions and connections.

A key contribution that explains how complex-evolutionary innovation policy might work is Metcalfe (1994), further elaborated in Metcalfe (1995, 2003). As a further indication, Nill and Kemp (2009) articulate how a complex-evolutionary environmentally sustainable policy can be implemented. It is clear the adoption of a complex-evolutionary approach also means we must recognize that there are major problems facing any attempts by governments to implement detailed coordination strategies. The biggest challenge for policy-makers from an institutional perspective is how to re-design both policies and the mechanisms for delivering them that account for the uncertain and unpredictable nature of innovation and structural change.

An attraction of the complex-evolutionary policy approach is that markets play a key role: they are the medium in which competitive selection occurs and it is necessary for policymakers to facilitate their creation and effective operation as and when they are needed. However, markets in the complex-evolutionary approach pose some difficulties not addressed in neoclassical conceptions of markets. These markets do not fail but many organizations that use them do and, given time, such markets will tend to produce successful but monopolistic entities. Policymakers tend not to think of markets in this way after decades of advice from neoclassical economists and, of course, the notion that an innovation policy initiative must result in the support of failed entrepreneurial projects, or even organizations, as a necessary part of nurturing the successful, poses difficulties for Treasury officials and politicians the world over.

5. The case of Australia

From the mid-1990s to the mid-2000s, the period of the Coalition Government of Prime Minister John Howard, Australian innovation policy was dominated by the logic of free markets. Since the election of a Labor government in 2007, policy has increasingly been informed by coordination and complex-evolutionary approaches, although, as we shall see, free market thinking remains the predominant guide to actual policy interventions at the present time. An important contributor to the policy discussion was a major review into Australia's National Innovation System, chaired by Dr Terry

Cutler (hereafter the Cutler Review), announced by Senator Kim Carr, the Minister for Innovation, Industry, Science and Research, in early 2008. This extensive and intensive process provides an opportunity to assess the dynamics between the diverse approaches in our framework and their potential for further integration, which when added to the specific circumstances described below, make Australia a particularly interesting case study.

5.1. *Background: A successful economy, but continuing productivity and innovation problems*

The Australian economy had, in the decades preceding the world financial crisis of 2008-9, a strong record of productivity growth and growth in living standards which accelerated from the 1980s through to the 1990s. (OECD, 2007:203) The Australian economy has also weathered the world recessionary storm relatively well with negative growth in GDP in only one of the 8 quarters prior to mid-2009. Over the 1990-2004 period as a whole, Australia had higher real growth in per capita real household expenditure than the UK, USA, Canada, Germany and Japan.

The labour productivity growth that underpinned this, however, decelerated from the mid-nineties onwards falling from 7th to the OECD average (OECD, 2007:205), with continued growth in real per capita incomes and expenditure increasingly sustained by significant raw material-linked terms of trade effects rather than underlying productivity growth (Rowthorn 2007). As Venturous Australia (2008:ix) notes: “Sometime around 2002 Australian productivity went from growing substantially faster to growing substantially slower than the OECD average”.

It is also notable that the overall pattern of productivity growth in Australia has been concentrated in relatively few sectors. Hughes and Grinevich (2007) provide an overview of the structural composition of Australian output since 1980 and a disaggregated analysis of trends in labour productivity growth. They show there is considerable instability in the ranking of sectors by labour productivity growth, so that the overall economy performance is driven by different sectors at different times. There are therefore important structural factors that affect the way in which the underlying impact of the NIS is manifested in differences in sectoral productivity performance. Hughes and Grinevich also show that within the overall structure of activity in the Australian economy high productivity growth period since 1992, the services sectors are dominant, both in real gross value added and in terms of hours worked. Their analysis suggests that the forces that have driven productivity

growth in the services sectors have been central to the overall acceleration of labour productivity growth. The transformation of productivity in the services sectors is intimately linked to the development and application of information technologies, which in turn require the effective development of a wide range of complementary investments in management and other organisational and often intangible assets (Hughes and Scott-Morton, 2006).

Australia's innovation performance has been mixed, with some significant achievements, considering the relatively small size of the economy, and some continuing deficiencies. It is clear, however, that innovation is critical to the success of all elements of the Australian economy, including those that are significantly resource-based. As Australia's foremost economic historian, Geoffrey Blainey, has observed, Australia's powerful mining industries today would have been insignificant without a long series of innovations, especially in mining and metallurgical methods, transport, and marketing, and the wool industry, which for more than a century produced about half of Australia's export revenue, would have been of little importance without a long series of major and minor innovations (Blainey, 2006).

The historical importance of innovation in the resources sector in Australia is also captured by the Australian chapter in Nelson's 1993 collection on the NIS, which concentrates extensively on resource industries (Gregory, 1993). Gregory observed that:

"The distinctive characteristics of the Australian national innovation system are a low level of science and technology expenditure, a high level of government involvement in financing and undertaking research, a low level of private sector research and development and exceptionally high dependence on foreign technology" p324

Many of these characteristics remain apposite, although the Howard government of 1996-2007 did see declining government commitments to research (OECD, 2007:69). Based on research for the Cutler Review, the Government's statement, *Powering Ideas* (2009), for example, points out that Commonwealth spending on science and innovation fell 22 per cent as a share of GDP since 1993-94. It also points out that business R&D spending declined in the late 1990s, only 15 per cent of innovation-active businesses spend money on R&D, less than 3% of Australian R&D is financed from abroad, compared to 17 per cent in the UK and 8% in the EU, and only 7000 businesses registered for R&D tax incentives.

Nonetheless, there are positive recent developments revealed in OECD data. Gross Expenditure on R&D spending in Australia was A$21 billion in the

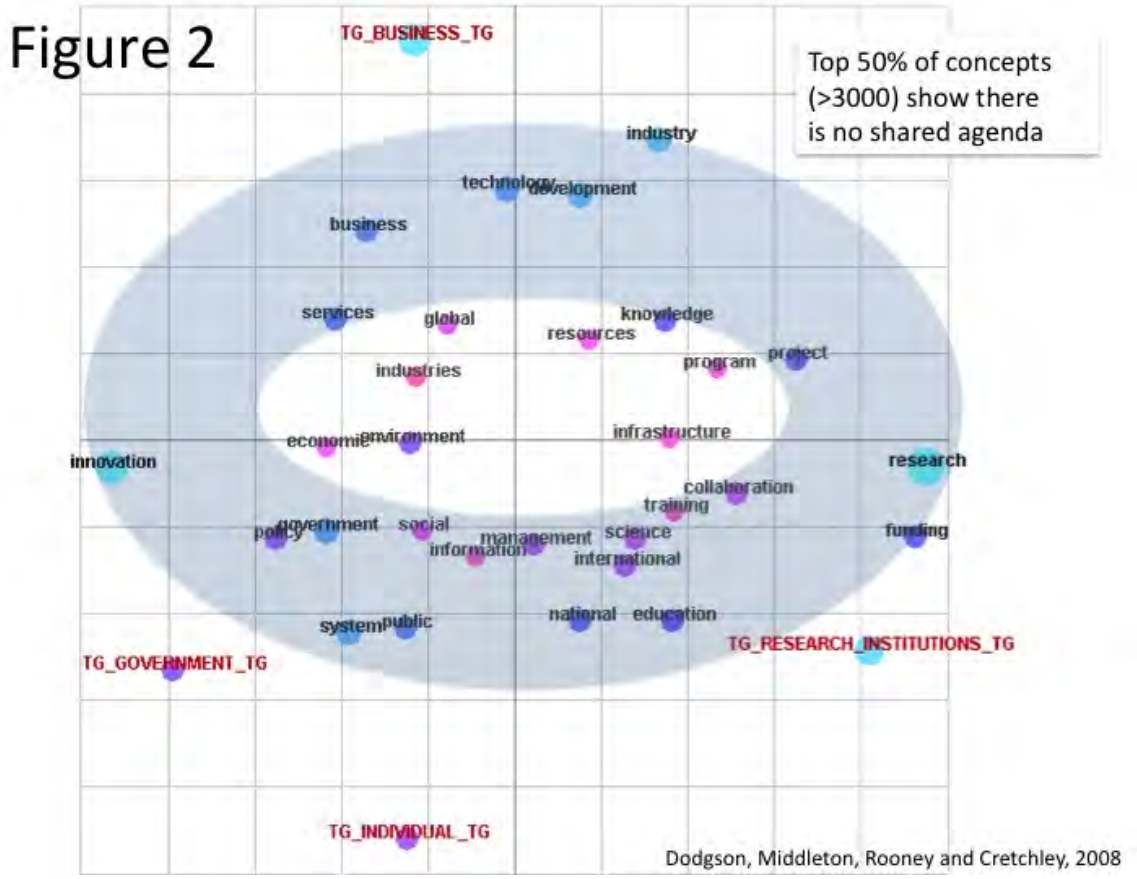
year 2006-2007, exceeding 2 per cent of GDP for the first time in history. Businesses performed the largest amount of R&D in Australia in 2006-2007, worth A$12 billion. Business R&D expenditure has increased substantially since the 1980s but, at 1.15% of GDP, remains lower than the OECD average of 1.56%. Universities spend $5.4 billion on R&D, with the majority provided by the government, and only 6% of university research funded by business. One major trend in Australian R&D expenditure is the decline in basic research as a percentage of total expenditure, reducing from 12.1 per cent in 1992 to 10.2 per cent in 2000-01 and 8.4 per cent in 2006-07 (OECD, 2009).

The challenges confronting Australia in promoting innovation are immense. As a relatively small country they include the sheer scale and complexity of investment in the development of new innovation capabilities in the USA, Europe and Asia. Spending, as it does, less than 2% of the OECD's total R&D expenditure, Australia will always remain at the periphery of global developments in innovation. The challenges for Australia are exacerbated by: a lack of clarity and tensions between education, science and industry policy; the unclear roles of the State governments in a Federal system; and structural impediments to innovation, such as a predominance of small firms in the industrial structure and a high reliance on overseas multinational companies in high-tech sectors (which explain the low levels of business expenditure on R&D) (Cutler, 2006).

5.2. *Analysis of policy discourse: The extent and nature of the continuing problem.*

A content analysis using Leximancer software was made of 606 of the public submissions to the Cutler Review (see Appendix A for a description of the analytical tool and its use). The analysis was undertaken to identify the main themes, concepts and ideas identified in the submissions. In a sense this develops a 'user-driven' analysis of the NIS, as described by the people who are sufficiently motivated to write a submission on how to improve it. The major findings of this analysis showed a large number of diverse issues were discussed in the submissions, revealing a rich and densely populated collection of concerns, and indicating a highly complex innovation ecology involving many components. There was a consensus about the high value of innovation and its contribution of economic and social life, and recognition of the central importance in Australia of the connections between research, industry and innovation. In this sense, discussion of NIS provided a common focus for dialogue amongst diverse contributors. There was, however, little common purpose between the various agents and institutions – separated in the analysis into submissions from business, research, government and

individuals - in Australia's NIS or mutual understanding of how it is configured and how connections within it are enabled. The findings reveal that, although the importance of Australia's NIS is widely appreciated and contains a large number of different elements, it is a disconnected system where there are few bridges between its major players. This is seen in Figure 2, which displays concepts mentioned in submissions over 3000 times. The language used by contributors from business, government and research institutions is profoundly different. They are dispersed in the representative map; had there been agreement, they would have been co-located centrally. The constituents of Australia's national innovation system do not agree about its most important core elements. This finding is confirmed by OECD evidence that places Australia lowest amongst its members on capacities for collaboration between firms and between firms and higher education, and second lowest on collaboration between firms and government (OECD, 2007:77).



This analysis supports policy prescriptions that encourage building the institutional framework and organizational capabilities to better connect Australia's national innovation system. In particular, it supports policies that can contribute to filling the gaps in the centre of the system. Collaboration is seen as a key concept, but largely within the purview of research institutes rather than in the business community. The submissions reveal that very few

important institutions connect the various elements of the system, with only the Commonwealth Science and Industrial Research Organisation (CSIRO) and the Australian Research Council registering significance, but without substantial scale and connectivity. The Cooperative Research Centres (CRC) program (discussed along with the CSIRO below) was similarly perceived not to be of core significance. The submissions are, however, clear in their support for policies to improve the human capital aspects of the system, such education, training, management and knowledge.

This evidence provides policy makers and managers with substantial challenges when considering innovation policy and practice and places particular importance on the need to respond quickly and well to new approaches to systems of innovation that might encourage better use of limited resources. It poses particular questions for policies towards those institutions, including the CSIRO and CRCs, whose role includes being key brokers of connections in the system.

5.3. *Institutional evolution: from coordination to the free market*

The historical development of the public sectorCSIRO, and the more recent evolution of the CRCs program, illustrates one of the major patterns of institutional evolution within Australia's NIS.

Now over 80 years old, the CSIRO employs over 6500 staff across 55 sites and accounts for 10 per cent of publicly funded R&D and 6 per cent of total R&D expenditures in Australia (Upstill and Spurling, 2007: 114). Formally established in 1926, research in the CSIRO's early decades focused primarily on primary industries, especially agriculture. During the 1950s and 1960s, CSIRO's expertise in radio astronomy and wool science, in particular, contributed to its growing international reputation for scientific excellence. It received increasing funding from government in a climate of optimism in Australia about the potential for science to deliver economic growth. By the 1970s, CSIRO was a large and diverse organisation with 37 research divisions functioning largely autonomously in its research agenda. The Organisation dominated the Australian scientific landscape as the country's largest public research agency. The oil shock in the 1970s, along with growing environmental concerns and increased economic competition, as trade liberalisation took effect, raised significant new challenges for the CSIRO. It was no longer clear to policy-makers that "scientists left to themselves would deliver the benefits that industries and national economies needed" (Upstill and Spurling, 2007: 115). The continuing tension in such institutions between the need to deliver immediate and long-term outcomes became increasingly

clear. In addition, a watershed came for CSIRO itself in the mid-1970s when R&D funding in universities reached equivalence with CSIRO's funding, ending its dominance of the Australian NIS.

This turning point marked the beginning of a period of substantial change involving many reviews and revisions of CSIRO's goals, governance and structure. A 1977 Inquiry recommended a new focus away from basic research and towards end-user driven research. The Organisation was restructured with Divisions in related sectors grouped into Institutes. A CSIRO Board was created in 1985, responsible for overall strategy, governance and performance and reporting to the Federal Minister for Science. In 1988 a target was set for the CSIRO to attain 30 per cent of its total income from external earnings with no reduction in its appropriations from the government. The target was introduced in response to perceptions about the low levels of capability within the Organisation for external collaboration and technology transfer. As well as increasing the focus on shorter-term problem-solving projects commissioned by private firms, the intention was to 'gain a better knowledge of industries' needs, and to foster mutual respect and confidence' (Jones 1986 cited in Upstill and Spurling, 2007:122). The intention was that the Organisation's increased collaboration with industry would 'back up' and 'further stimulate' corporate R&D efforts. The introduction of the external earnings target had significant impact on the incentives driving the Organisation's interaction with end users.

In 1996, an internal reorganization to re-focus research activities saw the Institute-based structure replaced with matrix structure of research divisions combined with industry, economic or 'national benefit' sectors. A hybrid management structure based on divisions and several large cross-organisational national Flagship projects was introduced in 2001. In 2009 the Flagship structure defines the research focus of the Organisation, with large-scale multidisciplinary teams, comprising partners from industry and international research agencies, focusing on issues such as water, energy and climate.

All these changes reflect changing perspectives by government departments, individual Ministers, industry bodies and the CSIRO itself on its appropriate structural role in the Australian NIS. The broad shifts over the last two decades have been towards more applied research, increased external funding and enhanced commercial outcomes. Evidence of the transformation is seen in the way that although the 30 per cent external funding requirement was abolished in 2003, CSIRO's external revenues have exceeded the threshold since the early 1990s, with the major share from collaborative and contract research. This involves numerous partnering activities such as joint ventures,

collaborations with international research agencies, relationships with large companies and interactions with over 1,000 small-and-medium sized enterprises. Co-investment, consulting and research services generated $296m for the Organisation in 2006 out of a total income of $947m.

CSIRO is the primary research partner in the Australian Co-operative Research Centre (CRC) program, which provides government support for collaboration between industry and research agencies. CSIRO has been the biggest contributor to this program, providing over $1 billion in cash and in-kind contributions and participating in 122 of the 168 CRCs funded to 2008. Direct commercialisation through licensing and start-ups has been another strategy for CSIRO in furthering the application of its research, although income from these sources is relatively small compared to contract income. In 2007, CSIRO had a portfolio of over 2000 patents.

The CRC programme was conceived in 1989 with the first Centres starting in 1991. The Minister for Science and Technology claimed at their launch that: "The cooperative research centres will help Australia to achieve closer linkages between science and the market". As we have seen, this is a continuing problem in Australia. The CRC program has continued with successive governments and had 10 selection rounds by 2008. Centres have a 7-year funding cycle. In 2007-08 there were 58 CRCs operating. In total the government has invested A$3 billion in CRCs, with almost A$9 billion leveraged from participants in cash and in-kind contributions, including approximately A$2.9 billion from the universities, A$2.3 billion from industry and A$1.1 billion from industry (O'Kane 2008).

A 2005 review of the CRC programme identified substantial scientific outputs but found little evidence on widespread adoption of research outcomes, and limited licensing and contract research income (Howard Partners, 2005). While CRCs have generated clear economic benefits (Insight Economics, 2006), these are geared towards larger-scale, longer-term arrangements that are suited to big research users, requiring extensive management. They have also been used inappropriately, for example in an abortive attempt to recreate the Australian space industry (Moody and Dodgson, 2005). Only 570 Australian firms have participated in CRCs.

A review by the Productivity Commission in 2007 argued that the commercial focus of the CRCs led them to engage in collaborative research that would be undertaken without public support, and encouraged a more public good approach to research, a view endorsed by the review of the CRC program in 2008 (O'Kane, 2009). Like the CSIRO, the CRC program faced pressures to move away from its public good objectives.

5.4. *The free market path interrupted? - Policy evolution*

A key event in Australian innovation policy-making occurred in February 2000, with the National Innovation Summit. Convened jointly by the Federal Government and the Business Council of Australia, the peak employers' representative body, the Summit involved a wide-ranging consultative process and a 2-day meeting of some 600 influential representatives from business, research and government. Despite significant input from innovation researchers on the value of innovation systems thinking, the Summit's outcomes were largely shaped by neo-classical economic orthodoxy and a continued science-push, linear approach advocated by the research sector (Marsh and Edwards, 2008, 2009). The emergent policy outcome: *Backing Australia's Ability (BAA),* announced in January 2001, produced substantially more funding for science, but comparatively little for collaboration or the commercialization of research. A second government statement, BAA 2, was produced in 2005, affirming the main directions of BAA and, thus, it was the policy framework that prevailed until 2009.

Marsh and Edwards connect the outcomes of BAA with the neo-classical economic influence on policymakers, especially amongst the key decision-makers in the Innovation Summit process. This led, for example, to a preference for general tax relief rather than focussed or selective support for innovation that was presumed to 'distort' prices; it discouraged attention to the properties of institutions other than markets; and it reflected a belief that market failures pose less long-run risks than government failure. Marsh and Edwards note that efforts were made in the process to bring systems thinking to bear, most notably in a report produced by the advisory Learned Group: *Shaping Australia's Future* (1999). However, they observe that, although some passing reference is made to this work, a strong market failure/ science-push approach was ultimately adopted.

A decade later, the Cutler Review was given the task of identifying gaps and weaknesses in the innovation system and developing proposals to address them. The review had broad terms of reference, a complex structure, and a time-compressed schedule. Under the chairmanship of Dr Cutler a panel of 10 drawn from the academic, business and policy community conducted a wide-ranging review of relevant evidence. They were advised by an international panel of experts on innovation policy drawn from the UK, the USA and from

within Australia.[1] A particular feature of the Review process was the holding of a number of public meetings across Australia and an invitation to submit evidence relevant to the review panel's consideration. A total of around 700 public submissions were made to the Review as a result of this process. The Review Committee's deliberations were influenced by the decision made by the Government early in the review process to cut 'Commercial Ready,' the major policy support mechanism for early stage innovation support (i.e. pre-empting its findings). The Review was also conducted simultaneously with other cognate government reviews into higher education, climate change, the automobile industry, and the textile, clothing and footwear industries. The review process was hampered by a lack of reliable data on innovation in Australia, with only a preponderance of data on R&D and patenting available (the latter of limited relevance, given Australia's industrial structure biased towards non-patenting sectors). The Review Committee reported its findings on 29th August 2008, with 72 recommendations grouped under the following headings: Innovation in business, Strengthening people and skills, Building excellence in national research, Information and market design, Tax and innovation, Market facing programmes, Innovation in government, National priorities for innovation and Governance of the innovation system.

The government's response was released on 12th May, 2009 in conjunction with the Federal Budget, in its statement, *Powering Ideas*. It builds upon Venturous Australia's identification of the importance of both market and systems failure: "The (Review) panel considered evidence of both market failure – where commercial incentives are insufficient to induce socially and economically desirable behaviour; and system failure – where the scope for innovation is limited by policy and institutional shortcomings."p15. Indeed, *Powering Ideas* refers extensively to complex systems thinking. It states, for example, "Our capacity for invention and discovery depends on the strength of our national innovation system… One way to make the system stronger is by strengthening its constituent parts. The other is by strengthening the links between those parts. Australia needs to do both."(Powering Ideas, 2009:1). It argues the market cannot provide all the answers and public policy has a major role to play… "… governments have a responsibility to step in where markets fail. It is their job to plug gaps in the system through which ideas might be lost." p3 And: "With the global recession forcing firms to focus on immediate problems at the expense of long-term investments in new products and processes, the case for government intervention is more compelling now than ever"p.43.

[1] One author of this paper was engaged in this Review as a member of its Panel, the three others were advisers to it. One author was a member of the Learned Group advising the Innovation Summit and attended it as a delegate.

In *Powering Ideas* it is accepted that: "The innovation process is complex and risky. Everything is interconnected… Innovation outcomes can be hard to measure, and many experiments end up telling us only what doesn't work. Innovation policies and programs must be designed with these conditions in mind." It emphasizes the importance of collaboration, which: "stretches our research dollars further, spreads risk, favours serendipity, propagates skills, and builds critical mass. It is increasingly the engine of innovation." P8. And it highlights the importance of skills: "Making innovation work requires a workforce with sophisticated skills of all kinds – including leadership and management skills. It also requires cooperative workplaces in which creativity is encouraged."p17

It is also notable that a broad range of issues are canvassed, including the importance of innovation for environmental sustainability and social inclusion and justice, and there is an appreciation of the wide range of contributors to innovation including museums, galleries, libraries, and other scientific and cultural repositories. It recognizes the importance of the free flow of information and notes the challenges of getting IP laws right, acknowledging that governments around the world have erred on the side of excessive protection. For a reflective view on the policy response to the Review by its Chair, see Cutler (2009).

A content analysis comparison of BAA and Powering Ideas reveals a dramatic change. The narrative in BAA was preoccupied with the role of government and its support for research (see Figure 2). In contrast with BAA, Powering Ideas has a much more systemic narrative, concerned with the connections between innovation and research with industry, businesses and government (see Figure 3). The content analysis tells us about the discourse in the documents, not the actual policy outcomes. Nonetheless, the analysis helps to record the way the discussion about innovation in Australia has changed very considerably in a relatively short time.

Figures 3 and 4

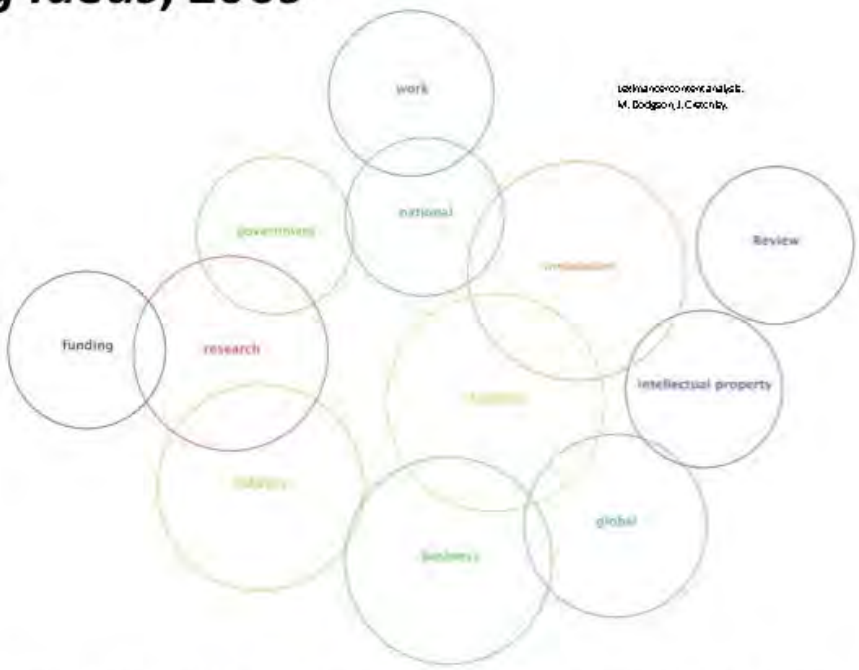
Backing Australia's Ability, 2001

Theme	*Connectivity*
Government	100%
provision	93%
research	84%
innovation	56%
R&D	28%
reforms	19%
encourage	09%
education	07%
ideas	04%
future	02%

The narrative is concerned primarily with the role of Government, and how it supports research and innovation

Powering Ideas, 2009

Theme	*Connectivity*
research	100%
innovation	100%
Australia	78%
industry	62%
government	61%
businesses	57%
national	36%
global	26%
work	21%
IP	07%



The narrative is broader ranging than BAA, describing the connectivity of innovation and research in Australia with industry, businesses and government

The increased concern for innovation policy has brought immediate changes. The headline feature of *Powering Ideas* was an announced 25 per cent increase, to $8.5 billion, in the Commonwealth science and innovation budget between 2008-9 and 2009-10. It also stated a number of ambitions, including increasing the proportion of businesses innovating by 25 per cent, lifting the number doing R&D, and doubling the level of collaboration between Australian businesses, universities, and publicly-funded research agencies over the next decade. Amongst the most important initiatives were changes from a system of R&D support through tax concessions to one of tax credits. New initiatives were announced in science and research funding and the 'enabling technologies' of biotechnology and nanotechnology. A commitment was made to move towards the full cost funding of research council grants in universities (presently only around 40 per cent of research costs are met). A Commonwealth Commercialisation Institute was announced, but the role it will play was vague.

Powering Ideas represents a significant commitment to improving Australia's capacity for innovation, a remarkable outcome considering these new investments were committed to during the height of the concern about the impact of the global financial crisis.

Although Australian innovation policy is now infused with complex-evolutionary thinking, its core justification and decisions about the balance of investments remain based upon market failure perspectives. There are statements in *Venturous Australia* that show a reliance on market failure arguments essentially the same as those set out by an economically orthodox Australian Productivity Commission review of the role of public sector support for expenditure on science and R&D which preceded it (Productivity Commission, 2007).

In seeking to justify public intervention the market failure approach adopted in *Venturous Australia* is quite explicit:

'A fundamental challenge is to identify reasons why state intervention will improve on the outcomes generated by individuals and firms operating freely and interacting through markets' p37 And:

'Beyond the role of government in subsidizing private sector R&D and responding to failures in the venture capital market, the case for further forms of subsidy or intervention is problematic' p.40.

The Review notes that there is an alternative perspective based on developing firm capabilities but does not endorse it or consider what policies it might lead to. There is a striking switch in the Review from a grounded systemic description and interpretation of productivity innovation and growth in Australia to statements such as "…governments can support innovative businesses by reducing impediments and providing incentives to address specific market failures."p.6, and business innovation is supported by government policies that "minimize barriers and maximise opportunities for the commercialisation of new ideas and new technologies"p.9.

Powering Ideas is keen to note its compliance with OECD recommendations (p43), stating the Australian Government: "helps create the conditions for innovation by managing the economy responsibly, regulating effectively, and making specific investments in education, research and infrastructure – not least transport and communications infrastructure. It maintains a pro-business operating environment, with the emphasis on open competition and the free flow of products, people and ideas, both domestically and internationally. These foundation conditions are as important to a country's innovation performance as specific innovation policies and programs". Here *Powering Ideas* references the OECD stock take of innovation policy (Box, 2009).

A number of simple explanations can be offered for the occasionally contradictory and confusing logic within both *Venturous Australia* and *Powering Ideas*. These include the last-minute drafting of particular sections by individuals with differing points of view in what were rushed and pressurized circumstances. They may well reflect a concern to placate different audiences: an attempt, for example, to balance new thinking about innovation with the orthodoxy expected by the Australian Treasury if additional public expenditure is demanded. Nonetheless, whatever their cause or purpose, the continuing 'bottom line' predominance of the market failure logic has significant policy consequences. This is made explicit in the statement: "Innovation takes many forms, but it still relies heavily on formal research and development" *(Powering Ideas* p.31).

Powering Ideas notes a quarter of the Commonwealth's innovation spending goes towards programs that encourage business investment in innovation, including R&D tax incentives (p.18). This equates to $2.1 billion. It also notes that R&D tax concessions in 2009-10 are expected to be $1.4 billion. Two-thirds of the Government's support for business innovation is therefore devoted to R&D. Given the extent of the problems of systemic connectivity revealed during the Review, the question should be raised about the relative balance of this commitment to single firm support.

6. Discussion and Conclusions

From a NIS perspective, arguments in support of an innovation policy based on market failures appear as only one element of an effective policy. The core of the innovation systems approach to policy is more challengingly to understand the way in which systems are inhibited or emerge and function on the basis of their various elements and connections that exist within particular national contexts. The dynamism of economies depends upon the adaptability of innovation systems. Innovation policy has to be designed to cope with the evolving nature of the economy, with its complexities, new challenges and ever-changing problems. This requires the inclusion of an explicit complex-evolutionary approach to understanding and influencing the innovation system. Governments that have a greater appreciation of the complex-evolutionary nature of innovation can make their innovation systems more adaptable and effective than is the case when only free-market perspectives are used. Complex-evolutionary approaches help better address the crucial question: what should our NIS look like?

The complex-evolutionary approach shares with the free-market approach a stress on the importance of markets. But it rejects the market failure perspective dominating much innovation policy, seeing all markets as useful, but necessarily incomplete, arrangements that are heavily influenced by a range of social, political and legal institutions. Markets are emergent instruments that facilitate new kinds of products and services and, although they can arise spontaneously, they often require the support of government to develop and then work effectively. Government can play a crucial coordinating and facilitating role by enabling the necessary network connections within the complex systems of production that deliver new products and services. In other words, government has to be actively engaged in the broader system of which the 'market' is only part and it is not market failure that is the concern but system failure. In the complex-evolutionary approach, government does not just leave things to the 'free market' yet it does not 'pick winners' either. From its pre-eminent position it plays the role of connector by its support of national institutions and infrastructure, and through its programmes encouraging organizational skills and capabilities. It views entrepreneurship and associated innovation as an experiment and accepts that to win successes, failures must be accepted. It recognizes that the system it is dealing with is complex-evolutionary and, therefore, does not attempt to implement simplistic, one-size-fits-all, policies but works in many different settings in close consultation with industry players and stakeholders.

A further implication of a complex-evolutionary systems view of innovation is that market failures (spillovers, asymmetries of knowing, public and collaborative good phenomena) are endemic. They are an essential feature of any market system in which the uneven distribution of knowledge and the impossibility of hedging against risk through perfect futures markets are given as irremovable consequences of innovation activity. It is impossible to predict in advance what combinations of knowledge and resources are required to solve particular problems. In short the more the economy is innovation driven the more it will be characterized by supposed "market failures". Failure is a central feature of innovative economies, shaping market entry and exit in its most profound form.

An understanding of why systems failure occurs assists policy-making. Complex systems fail due to inherent 'lock-in' problems. A feature of innovation systems which is well-recognised at the level of a firm is that the system dependent nature of innovation activity leads to the emergence of a dominant set of technologies and associated physical human and social capital infrastructure associated with those technologies. These heavy sunk costs and prior commitments – and institutional 'lock-in' - may make it difficult to respond to changing elements in the underlying innovation ecology. Nor can it be presumed that the prevailing distribution of private resources to innovate (based on past successful innovation) will correlate at all closely with emergent innovation opportunities (future successful innovation). Here is it worth noting Edquist and Hommen's (2008:481) finding that the historically superior performance of fast growth countries with respect to innovation policy coordination was at least partly due to the greater freedom of manoeuvre afforded by the lack of strong vested interests in policies aimed at maintaining an existing sectoral composition of production.

In these circumstances innovation policy must in practice identify and address key factors that limit the ability of actors in the system to respond effectively, using a variety of public policy justifications and interventions. Some of these may be conceived of as being within the conventional market failure approach. Thus, through the use of competition policy and ensuring efficient access to resources for potential new players to exploit new opportunities, governments may encourage the emergence of new and alternative system configurations based, for instance, on new technologies. Policies based on market-failure justifications, such as R&D tax incentives, however, may be particularly weak at achieving this and require supplementation with direct innovation-targeted programmes, as discussed by Nill and Kemp (2009). A particular example of innovation policy intervention in these circumstances could be the structured use of public procurement to encourage early-stage experimentation in new technologies by new potential players. This de-risks,

through the placing of public sector R&D contracts, early stage experiments in new areas. In effect, the innovation policy stance would be to use public procurement through R&D contracts as a form of high-risk venture capital. *Powering Ideas* notes the importance of government as a customer to encourage innovation, but remains vague on specific policies equivalent to, for example, to the USA's SBIR Program.

For a decade, until 2007, Australian innovation policy was largely driven by the free market perspective. In that period, Australia witnessed a distinct slowdown in productivity accompanied by slippage down the relevant OECD league tables relating to innovation performance. This is in sharp contrast to the 1990s where productivity growth was high, benefiting from the more enlightened innovation policies in the 1980s. However, there were undoubted flaws in the old system too and there is no going back to the over-arching, co-ordinated interventionist approach to industry and innovation policy that prevailed at that time. Modern innovation policy has to recognise, explicitly, that market mechanisms can be used effectively, not as the basis for an ideological mantra, but as devices that permit flexibility, selection and change in a complex-evolutionary economic system. Markets are not a substitute for innovation policy intervention; they are an essential complement. The challenge that this integration poses will become very evident in the shift to a low carbon economy that will be necessary in the coming decade. It is difficult to see how this can be done effectively unless a complex-evolutionary approach is adopted to frame policies to promote sustainable innovations. This will have to involve new perspectives in government on what the nature of intervention should be in a NIS. The evidence we have reported on Australia suggests that this process has already begun, but we have yet to see a radical departure from the traditional policy mix.

Systems failure also occurs through institutional failure where changing patterns of behaviour, and the associated rules and norms affecting inter-agent transactions, do not adapt to broad technological changes in the underlying innovation ecology. By addressing the specifics of the role and context of institutions in Australia's NIS, more nuanced and appropriate policies can be considered. For example, the Australian government has announced a massive, $43 billion, broadband investment: the National Broadband Network, which provides significant potential opportunities for enhancing the NIS. It is important to recognize that there are a number of institutional failures in the emergence of new markets based on ICT. This arises, for example, in the impact of ICT in the provision of health and home care in societies with an increasing proportion of older people. Major institutional changes may be required to develop the maximum impact of ICT on innovation in the delivery of such services (Bergek, et. al., 2008). Thus, for

example, the encouragement of private sector provision in these areas may often be linked to the terms on which individuals, through state-supported benefit systems, may access such services. This requires not only the imaginative use of public and private sector health insurance funding, but also social changes in the acceptance of the delivery of health and home care in new institutional environments. The emergence of efficient systems of innovation and delivery in this area thus involves more than addressing activities conceived of as consisting of only markets and individual firms. It requires very specific domain knowledge on the part of policy-makers.

The dynamics and evolution of particular institutions is also best understood in systemic terms. The CSIRO, for example, has a position in Australia's NIS as a large, diversified and well-regarded research organisation, both scientifically and with the public, with demonstrated organisational flexibility to adapt to changing external demands, and deploy multi-disciplinary research capability. It is well positioned as a national institution to address pressing national problems. This capacity has been maintained despite a strong market dominated logic in Government, and declining public expenditure on science and innovation in Australia since the mid-1980s. This is a testament to CSIRO's leadership and adaptability. Its future challenges include cementing and expanding its role as the central player in Australia's NIS. This will entail extension of knowledge and capability in the uptake, use and adaptation of new scientific discoveries and technologies in emerging areas such as services. It should reflect contemporary understanding of the importance of the 'demand pull of business engagement with customers and markets' (Kennedy, 2007), and will require CSIRO's cross-disciplinary initiatives to incorporate knowledge and methodologies from the social sciences, with future resourcing requirements.

This more demand-led approach accords with complex-evolutionary systems that question the equating of innovation systems entirely with science and technology systems or with R&D (Lundvall, 2007; Metcalfe and Ramlogan, 2008). Innovation is an economic act that may rely not on new technology but on new perceptions of market opportunity. There are wide variations in innovation conditions related to the particularities of the knowledge, technologies and markets in play, and the agents, institutions and their interrelations that preclude ubiquitous science-driven models. This implies a complex-evolutionary approach to innovation policy development and formation. It needs to be rooted in a granular approach to the idiosyncrasies of different innovation systems within and between nations. The level at which innovation policy is to be applied needs to be carefully defined in national, regional, sectoral or technological terms. Policy itself in these circumstances should be seen itself as an evolutionary process in which policy

experimentation and the analysis of its impacts in specific contexts is used to further refine the range of innovation policy instruments (Mytelka and Smith, 2002). This requires significant policy evaluation and assessment competence, and recognition that the challenge of innovation policy is continual and changing: there is no absolute ‘solution’.

Nowhere is the need for fresh innovation policy thinking more apparent than the need to better comprehend the innovation process in services sectors. Despite being the major components of contemporary economies, there remains a paucity of policy research on the connections between research and services and the symbiotic relationships between innovation in services and other sectors. Market failure models that elevate R&D spending as a policy aim contribute little to service sectors that undertake little R&D but enact important organisational and workplace innovations (Royal Society, 2009).

Although the Australian policy trajectory is clearly towards deeper engagement with complex-evolutionary approaches, this has yet to be engrained in the decision-making behaviour of policy-makers in the way that neo-classical economic, market failure has become. Further movement down this trajectory would improve the likelihood of policies to address the serious problems of the current lack of collaboration amongst Australian firms. It would elevate the need to support innovation in services and in promoting innovative capabilities in organizations and workplaces. These are policy concerns in all nations, and the Australian experience holds lessons for many countries around the world. The challenge is to provide policy-makers with the clear policy justifications and prescriptions to deal with systems failure as is currently presented by market failure analysis.

Appendix A

The analysis was undertaken using Leximancer, a software tool used to find meaning from text-based documents. The software automatically identifies key themes, concepts and ideas by data mining large amounts of text, and visually represents information in ‘concept maps’ showing the main relationships. These relationships can be examined in more detail by exploring major connections. The data mining occurs automatically. Although the data mining process is automated, interpretation is required and it relies on the ‘craft skills’ of its users, fully engaged with the texts and the strengths and limitations of the tool. The analysis was undertaken by Mark Dodgson, Stuart Middleton, David Rooney and Julia Cretchley, the first two named had deep engagement with the texts analysed and the context of their submission, Rooney has extensive experience with use of Leximancer for academic analysis; Cretchley is Leximancer technical consultant. In the analysis there is no ‘seeding’ of particular concepts; they appear only because of their high incidence in the texts.

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