Public Policy Framework for the New Zealand Innovation System

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Executive Summary

This report seeks to develop a broad conceptual and empirical framework against which innovation policy issues in New Zealand can be assessed and evaluated.

The report addresses five broad questions:

- What does economic theory and applied economic analysis tell us about the importance of innovation to economic growth, and its place on the ‘agenda of government’? Here the answer is that we have solid grounds for believing that innovation shapes output and productivity growth, and for assigning high importance to policies towards innovation and technological change. However economic theory tells us little about how innovation happens. For that we need to look to the more recent research field of ‘innovation studies’.

- What does recent research on innovation tell us about the real nature and characteristics of innovation across industries? The report surveys some of the robust results from relevant research. These are: Innovation is pervasive across industries (that is, not confined to so-called “high-tech” activities), it is collaborative and therefore somewhat collective in character, it is cumulative over time, highly risky, and subject to occasional large, discontinuous shifts that disrupt industries and entire economies. Knowledge is an increasingly important input, and many “low tech” industries rest on the use of complex scientific knowledge bases. Most importantly innovation is systemic in character: innovation capabilities and performance are shaped by systems of industrial structures, institutional frameworks, regulatory structures, educational and capability development systems, and knowledge infrastructures. Against this background, innovation policy requires a system-wide policy approach focusing on the creation and use of knowledge, and on business development.

- What are the main functional processes of an innovation system? The report argues that successful innovation systems are characterized by institutional arrangements (which may differ significantly across countries) that take care of five broad problems:
  - identification of innovation opportunities
• the creation of technological capabilities,
• business finance and development,
• risk and uncertainty management,
• infrastructure provision.
These system functions are argued to be a potential focus for innovation-oriented growth policies.

• What are the main characteristics of the New Zealand system and its innovation challenges? The report approaches this question by looking at economies of the “New Zealand type”. Like other small open economies (the Nordic countries, the Netherlands, Australia, Canada), New Zealand rests largely on a low tech industrial structure which offers important innovation and growth opportunities. A key argument here is that although such economies as Finland and Sweden possess high tech industries, they have developed on (and continue to rest on) major low and medium tech activities which are shared by New Zealand. These low tech industries are not stagnant or declining – they are characterized by innovation and growth, and offer long term development potential. Such industries offer firstly locational advantages that are difficult to compete away, and secondly linkage potential into other growing activities. They form the basis of major cluster specialisations.

• Against this background, what are the primary challenges faced by the Growth and Innovation Framework in New Zealand? The argument of the report focuses on the need to engage with low tech sectors, and the need to address the problems of infrastructural provision and management that face innovation across such sectors. The report offers comments on some key elements of the Growth and Innovation Framework, especially skills and talents, international connections, innovation and engaging with sectors. The report agrees that these are central to innovation and growth performance, and offers comments on how they should be approached. It adds, however, the topic of infrastructures, which is argued to be a central issue for small economies in particular.

Engaging with innovation as a policy issue, especially in a systems context, raises major informational and analytical challenges. Some small economies – notably the Netherlands and Finland – have sought to build organization and research
programmes that address these challenges. This report makes only one specific recommendation: that New Zealand should, in some form, establish an agency that addresses in a comprehensive and integrated way the problem of enhancing policy knowledge and learning about the innovation system that shapes New Zealand's economic and growth performance.
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1. Introduction

1.1. Innovation as a Policy Challenge

Innovation has become an important arena of policymaking in OECD countries in recent years, with policymakers now seeing it as central to achieving a wide range of economic and social objectives. There are three broad reasons for this. First, innovation generates qualitative improvements in products and processes, and through this it produces output and productivity growth. Second, real incomes and economic welfare are affected the ways innovation shapes levels of technology. Third, innovation is central to establishing and maintaining competitive trade positions that both accompany and enable domestic growth strategies. Because of these wide effects, innovation is central in the longer run not only to economic performance, but also to the financial position of the government.

However innovation poses big challenges for policymakers, in terms of how it happens, how it has real effects, and how it should be supported and encouraged. These challenges largely flow from some special characteristics of innovation: it is in many senses a collective phenomenon, it rests on
capabilities that require sustained investment and are cumulative over time, it requires complex knowledge infrastructures, and its processes and outcomes are often highly uncertain.

This report seeks to identify some of the central policy challenges in an innovation-oriented growth strategy, and possible responses to them, in the specific context of New Zealand. The following sections first discuss the role of innovation in economic theories of growth, and the empirical evidence concerning innovation and growth. The argument here is that theory and evidence both suggest that innovation deserves a very high place on the agenda of government. However current economic theories lack a good account of what innovation, and innovation capabilities, actually look like in the modern economy. This leads to a discussion of what modern innovation research tells us about the characteristics of innovation; it argues the need to take a ‘systemic’ approach to the sources and processes of innovation. Many systems approaches to innovation suggest we should focus on specific national economic characteristics, especially when it comes to designing and implementing policy. So the report then turns to the characteristics and industrial structure of New Zealand, widening the discussion by focusing on innovation in economies of what we might call the ‘New Zealand type’: that is, small, open, advanced economies. The focus here is on the nature of innovation and knowledge bases in the so-called ‘low technology industries’ on which the New Zealand economy is based. Finally, against the background of this analysis, the report turns to a discussion of the ‘Growth and Innovation Framework’, seeking to identify some of the core policy issues for the Framework.

1.2. Innovation, Technological Change and Growth

A key initial question is whether or not innovation deserves a high ranking on the ‘agenda of government’. The answer to this depends on the centrality of innovation to economic growth, and the size of its impacts. In exploring this, the following section looks at theories of economic growth, and at the applied economics of innovation, R&D and growth. It is worth noting that arguments
about the importance of innovation to growth are not just a matter of formal economic theory.

There are four significant bodies of work that establish the innovation-growth link. The first is a body of work in economic history that asks why it was that Northwestern Europe and then the USA and Japan were able to escape from poverty into self-sustained growth. The broad answer to the question is that institutional changes (especially establishment and legal protection of property rights) created an economic environment with incentives to innovation which installed productivity-growth regimes; this work is associated with such writers as Fernand Braudel and Immanuel Wallerstein, and more recently with Kenneth Pomeranz (2000), David Landes (1998), and Ernest Jones (2003). The second is the history of industrialization, where a very wide body of work maps the links between innovation and growth; for a recent overview, see Bruland and Mowery (2004). The third is the history of technology, where historians have turned away from simply mapping the evolution of technologies to analyzing the links between innovation and economic dynamics; Mokyr (2002 and 2006) are major contributions to this. Finally, there is the economics of growth, discussed in the following section.

1.3. Technology and the Economics of Growth

Economists famously differ over many things, so it is worth noting that growth is a surprising area of unanimity. All theories of economic growth are in agreement: growth rests ultimately on technological change. However there are strong theoretical divergences between the various theories of growth. There are four main approaches:

- the neo-classical approach, and growth accounting
- evolutionary models and the legacy of Joseph Schumpeter
- ‘technology-gap’ models of growth
- ‘new growth theory’

In the first and oldest of these approaches, the sources of technological change are seen as external (or ‘exogenous’) to the economy. In the last three, technology and innovation are seen as something produced within the
For this reason modern theory is often referred to, in a general way, as ‘endogenous growth theory’. How do these theories approach innovation and technological change?

**Neo-classical growth analysis.** The Classical economic thinking of the nineteenth century focused on three major problems, namely the ways in which economies allocated resources, the distribution of income, and the processes of economic growth. Economists such as Smith, Ricardo and Marx all considered the growth process to be a central scientific problem, and all saw what Marx called "the conscious application of science" as a key characteristic of economic growth. Within modern neo-classical economics, however, the focus has been primarily on resource allocation and efficiency, and on the equilibrium properties of economic systems. Within neo-classical economics, the theory of growth has not really focused on the factors which shape economic dynamics and which determine growth rates and performance, but rather on the question of whether equilibrium concepts are relevant to growing economies. In this context, technical change was seen as being interesting for its effects on the equilibrium properties of the system, and for the income distribution, but the role of technological change as a driving force of growth was downplayed. However the neoclassical school produced one major result which has had a powerful impact in shaping ideas about the links between technical change and economic growth. In the late 1950s a number of economists, the most visible being Robert Solow, attempted to isolate the relative contributions of capital investment and technical change to the growth of productivity (output per worker) in the United States. Solow showed that the long-run growth of the US economy could not be ascribed to growth in labour or capital inputs, but was primarily influenced by a "residual factor", which Solow labeled "technical change" (Solow 1957, Abramowitz 1971). This startling result led to a wide debate on the measurement of factors contributing to economic growth, as well as to a large research programme on "growth accounting", which attempted to quantify such factors as increasing labour skills, better capital goods, the role of technical change in shaping long-term growth patterns. One of the basic outcomes of this long programme of research has been that although technical change is no longer seen in quite
the same dramatic terms as in Solow's original paper, it is now consistently recognised as one of the basic forces underpinning economic growth. But as noted above, a problem with the approach has been that it sees technical change as resulting from processes outside the economic system, rather than theorising it as an aspect of activity inside the economy itself.

**Joseph Schumpeter and evolutionary models of growth.** The influence of the Harvard economist Joseph Schumpeter (1883-1950) has increased steadily since his death. In a series of powerfully argued books, Schumpeter argued that competition in capitalist economies is not simply about prices, it is also a technological matter: firms compete not by producing the same products cheaper, but by producing new products with new performance characteristics and new technical capabilities (Schumpeter 1912, 1939, 1947). The search for new technologies is thus an integral part of competitive economies, and the development of new technologies is a continuous process. This leads in turn to what Schumpeter called "creative destruction", the removal of old technologies to make way for the new. This view of capitalist dynamics is based on Schumpeter's well-known rejection of competition in terms of "a rigid pattern of invariant conditions, methods of production and forms of industrial organisation". Rejecting the idea that price competition is particularly important, by contrast, Schumpeter insisted that

... in capitalist reality as distinguished from its text book picture, it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organisation ... competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and outputs of existing firms but at their foundations and their very lives (Schumpeter, 1987, p.84)

Creative destruction is at the heart of the growth process, because new technologies led to increased investment, and resulted in the use of technologies with better performance and higher productivity. But there remains a big question about what this kind of competition really entails. In his book *Business Cycles*, Schumpeter argued that growth occurred in discontinuous bursts, with "clusters" of innovations leading to investment
booms and thus to cycles of growth: for him growth was not an equilibrium process, but rather a process involving major structural change. From this perspective, growth rested on ‘carrier’ technologies – key technologies in any particular economic epoch (such as steam power, electricity, vehicles, ICT etc). These technologies are radical breakthroughs that provide the bases of new industries, and that replace existing industries. The major statements of this position in recent years are Freeman and Louca’s *As Time Goes By: From the Industrial Revolutions to the Information Society*, and Carlotta Perez’s *Technological Revolutions and Financial Capital*. They argue that new critical technologies – in particular ICT and biotech – drive economic growth, and therefore should be at the heart of innovation and growth policies. These ideas have had strong policy resonance, and have been influential in the OECD, and in the major industrial countries. Despite the policy success of these positions, however, it should be said that those who support this approach have yet to demonstrate that these ‘carrier’ technologies can in fact account for the growth record of the advanced economies, and particularly the smaller advanced economies which have not rested their growth records on such technologies. (It will be argued below that many of the small advanced economies are based on long-standing low tech sectors and that the new technologies do not in fact replace existing industries). A different form of Schumpeterian approach has been developed in recent years. This is a major research programme in so-called "evolutionary economics", which explores industrial dynamics in terms of variety creation (through innovation), and selection (mainly via markets) as a way of theorizing endogenous change in the economy. The founding text of this work is Nelson and Winter 1982, which sees the economic process as one of continuous internally-generated change, a continuous disequilibrium in which technological competition is constantly generating small-scale (and occasionally large-scale) innovations. In this framework, with process change increasing productivity and product change shifting the quality of product attributes, innovation depends on a wide range of inputs many of which may emanate from the public sector. This latter form of evolutionary economics has not however been transformed into a general theory of growth. But an important point about it is that it looks at variety creation across the whole of the economy, and not just in critical sectors (such
as steam power, or ICT). The implications of this approach are by no means
the same as the Freeman-Perez version of Schumpeterian growth described
above: there is no presumption that relevant innovation is concentrated in
particular sectors, or that it needs to be radical in character.

Technology-gap models of growth. A key empirical feature of economic
growth, referred to above, is the existence of significant differences among the
growth rates of economies, both nationally and regionally. This has led to a
wide body of theory and applied research which seeks to explore the roots of
these differences; such theory is of considerable importance for small
economies. The key idea is that we can distinguish between countries which
are at the scientific/technological "frontier", and those who behind the leaders;
they have a technological gap between themselves and the leaders. The
follower economies of course have the opportunity to "catch up" with leaders
by importing and diffusing the advanced technologies of the leader
economies. From this perspective, rates of growth of output must inevitably
differ. In leader economies, the growth of output is dependent on the rate at
which the scientific/technological frontier moves; in small or follower
economies it is determined by the speed with which such economies are able
to adapt and use the technologies of the leaders. This in turn depends on
research activities (among other factors): it has been shown that rates of
growth in follower economies are strongly dependent on the rate at which
such economies invest in scientific and technological activity (Fagerberg,
1987; Fagerberg and Godinho, 2004). These models therefore not only bring
 technological change directly into the theory of growth, they do so in ways
which are potentially of great policy importance for small economies which
import most of their technological requirements. It has been shown that these
types of model are important in explaining inter-country growth differences
across the OECD (Dowrick 2001). Catch-up models are however open to the
same criticism as growth theory more generally – they say little or nothing
about how the technological acquisition, on which catch-up is based, actually
works. However political scientists, such as Wade and Weiss, have shown
that institution-building and government policies have been central aspects of
catch-up in the modern era, especially in South East Asia. Linsu Kim has
shown that processes of imitation and learning can lead to creative innovation strategies, and has developed this into a comprehensive model of catch-up growth; his work focuses especially on South Korea. For Europe, economic historians such as Bruland (1999) have shown in detail the pattern of technology acquisition, and how smaller economies organized technology acquisition, in the 19th century. She showed three important results for the Nordic economies: first, that these economies acquired technologies across a wide range of sectors in the 19th century, second, that these technologies were acquired from external sources (that is, internationally), and third, the acquisition process was strongly supported, encouraged and to some extent financed by governments. So there is considerable evidence concerning how catch-up worked in a number of poor economies that have since become leading economies of the modern world.

The "New Growth Theory". In recent years a new body of theory has emerged, usually known as the "new neo-classical growth theory" (Verspagen 2004). In these models, the basic process used to explain economic growth is the phenomenon of increasing returns to scale, which follow from the externality aspects of technological change. In essence, the non-rival aspects of knowledge make sustained growth possible. Several of the most important approaches within this field involve modelling a specific "research sector" of the economy, which produces both specific new inputs, plus general scientific and technical knowledge. In these models, growth results partly from increases in the productivity of tools and equipment (intermediate inputs) resulting from technological change, and partly from "spillovers" of knowledge from one area to another. It is the spillovers that generate increasing returns, basically because production functions are not independent, and the knowledge input can enter into many or all firm-level production functions. This is actually a very longstanding idea in economics – the notion that knowledge is non-rival and non-excludable, costlessly transferable etc.: in other words a pure public good. If this kind of view of knowledge is built into a growth model, a key difference then emerges between this type of model and neo-classical growth theory. This is that the growth rate can be permanently raised by activities which increase the flow and use of collective knowledge in
the system. The policy implications of this are not simply a call for public subsidies of R&D, but are also related to actions which facilitate the private and collective production of knowledge (through industry associations, for example, or collaboration agreements, public-private R&D institutions).

Empirical aspects of economic growth differences: the statistical evidence
To what extent are the various theories supported by empirical evidence on growth? Economists have devoted increasing effort to empirical analysis of the sources and effects of the invention, innovation and diffusion of new technologies. This is not the place for even a brief overview of this body of research. However in understanding the economic importance of technological change to the growth process, some well-established empirical results are relevant and worth referring to. These are as follows:

(i) 'Technical change’ is the most important contributory factor in economic growth. In this context, technical change refers to causes of economic growth other than increased inputs of capital and labour. It can therefore include new techniques, organisational change, better education and knowledge and so on: all of the components of technological change broadly defined. In a challenging study in the mid-1950s (see above), Solow showed, in an analysis of the long-run sources of US economic growth, that technical change accounted for almost 90% of the growth of output in the US between 1909 and 1949; increased use of capital and labour played a relatively insignificant role. This led to a substantial body of work from a variety of perspectives, both in the US and internationally, to check the validity of Solow's work. Although some studies have argued for a lower contribution by technical change to growth, all have confirmed that it is indeed the most important contributory factor in shaping the rate of growth of output, particularly in the post-war period.

(ii) Innovative activity, as measured by Research and Development (R&D) and by patenting, is closely associated with the level of output and income at country level. There are of course significant differences in
the level of income per capita among the countries of the world. These differences are strongly correlated with inventive and innovative activity, as measured by R&D per capita and the extent to which a country patents new inventions. That is to say, countries with higher levels of inventive and innovative activity also tend to have higher levels of GNP per capita (Fagerberg 1987, 2005).

(iii) Social rates of return to R&D are consistently higher than private rates of return (Griliches, 1992; Griffith 2000). This suggests that inter-sectoral spillover effects of R&D are as important, or more important, than direct effect of such investment. Bernstein and Nadiri (1991) showed that social returns are higher than private returns across a set of industries, with the highest margins being (as would be expected) in those industries that provided capital or intermediate inputs.

(iv) R&D is strongly associated with productivity growth at firm level. One of the main ways in which companies and countries seek new technologies is through R&D, and this has led many economists to explore links between the level of expenditure on R&D and the rate of productivity growth, especially at company level. A consistent result of such work has been that there are indeed positive and significant correlations between productivity at firm and industry level, and the amount of R&D which firms and industries perform (see Griliches 1987 for the pioneering studies on this, and Nadiri 1993 who surveys a large literature shows that gross firm-level rates of return tend to be between 20-30% across a wide set of industries).

(v) Shares in world trade, at industry level, are correlated with innovative activity. Within technology intensive industries, the degree of innovative activity (again measured by R&D and patenting) is the most important determinant of export performance by the industries of particular countries. That is, within any particular industry, countries with higher levels of innovative activity have higher shares of world trade. (For an
empirical analysis within the context of a theoretical model of international competitiveness, see J. Fagerberg, 1989).

(vi) Private R&D correlates with growth rates. Angus Maddison, in work for the OECD that follows up his many studies of economic growth, shows that R&D is strongly correlated to growth mainly via private business R&D (Maddison 2003, Guellec and van Pottelsberghe de la Potterie 2001).

(vii) There are strong returns to public R&D. In a major cross-country study carried out in the OECD, Guellec and van Pottelsberghe de la Potterie (2001) show that public R&D has positive but limited direct effects on productivity, but has important effects via stimulating business R&D, via contract research.

1.4. Limitations of Growth Theory and Econometric Analyses

The approaches sketched above give us solid theoretical and empirical grounds for seeing innovation and technological change as central to economic growth. But at the same time they can be accused of an important general weakness, which is that they explore correlations or other statistic relationships (such as significant coefficients on independent variables in a regression equation) without ever investigating why these statistical relations exist, or what shapes them. In effect, they treat technological change as a deus ex machina: something that causes change, but is not itself explained. None of the theories gives any place to an analysis of what causes technological change, of what shapes its processes (a point made cogently in Dosi 1988).

Both economic theory and empirical analyses tell us that innovation is important, but they do not help us to understand how it happens, and what promotes or inhibits it. None of the theories address either (a) the specific industrial structures on which growth is based (and which differ across countries) or (b) the complex ways in which knowledge is actually created and
diffused (and which shape innovation capability), or (c) the specific mechanisms through which technological catch-up has been organized. The basic problem is that economic modeling strategies usually require a drastic simplification of the process being modeled. In neo-classical and new growth theory the economy is usually seen in effect as a one or two sector economy, with one output, and no detailed understanding of innovation at all. Although ‘catch-up’ is an extremely important historical process, catch-up models in economics are also over-aggregated, typically with very little account of what social or institutional factors actually enable economies to access, adapt and deploy foreign technologies (as noted above, this criticism does not apply to the work of political scientists and economic historians). The general point here is that neither the mainstream models, nor the quantitative analyses based on them, offer a good descriptive point of departure for understanding the complexities of how innovation actually works and relates to growth.

Evolutionary economies offers a far more disaggregated and nuanced picture of economic processes, but has not yet extended into a good growth theory. This is partly because while the theory rests on the creation of variety and diversity, and is therefore descriptively more complex than mainstream theorizing, it has not yet succeeded in incorporating representations of innovation that grasp the full complexity of the processes involved. In some cases, such as those of the neo-Schumpeterian approaches above, evolutionary theories involve very oversimplified innovation models.

The fact that models are simplified is a necessity of any modeling strategy, and does not of course mean that models are not useful. But models often abstract away from precisely the points of difficulty or complexity that confront policymakers. This is particularly the case with innovation, and to identify the real policy issues we therefore need to go beyond the modeling representations of innovation, into the more detailed empirical studies of innovation that have burgeoned in recent years. What can these studies tell us that is relevant to current policy challenges?
2. Characteristics of Innovation, and Policy Implications

2.1. What Does Innovation Really Look Like?

It is certainly possible to go beyond the schematic representations of technology within theories of economic growth, and to say more about the causes and shaping of innovation. Over the past twenty years or so a major transnational research effort has created a new field, “Innovation Studies”. Innovation Studies explores the origins, rate, characteristics, and effects of technological and organisational change, and the business processes through which innovation underpins economic growth. The most comprehensive overview of the field is Jan Fagerberg, David Mowery and Richard Nelson (eds), *The Oxford Handbook of Innovation* (Fagerberg et al 2004).

Technology can be thought of broadly as the knowledge and learning necessary for new products and processes. Innovation is the commercialisation of product and process novelty. Innovation Studies therefore focuses on the structure and operations of learning, including science and R&D as well as diverse non-R&D learning processes, and on the array of corporate activities involved in bringing innovations to the market.

What have we learned from Innovation Studies? This section attempts to sum up some of the results that have been achieved via this research effort, seeking not only to crystallize the analytical results, but also to identify some of the policy dilemmas or challenges that they present. So what follows consists of a discussion of results, and a discussion of policy implications. A later section will attempt to assess these policy issues in terms of the fundamental rationales that are offered for policy intervention in market economies.

In summing up innovation research, there are at least nine core results that are ‘robust’ in the sense that they are strongly confirmed by widely applicable data and empirical research across countries and industries. These results are as follows:
Innovation processes are non-linear. Perhaps the most important result of modern innovation research is rejection of the so-called ‘linear model’ of innovation – namely the idea that innovation is essentially based on processes of scientific or technological discovery, and that the innovation process consists of translating research results into new products. In this approach, innovation depends on science or R&D as its originating moment, and then sequentially develops discoveries into engineering concepts and then into product development. Although such processes do actually occur, in fact very few industries innovate like this. A different (and equally simplified) view of innovation would be that firms seek to develop new product concepts in response to conjectures about market dynamics. They try to build such products on the basis of their existing technological capabilities. If they run into irresolvable problems in the development process, then they may turn to R&D for a solution: but R&D is expensive uncertain in outcome, and is a last resort. In this conception R&D plays a very different role – it is a problem solving activity undertaken in the course of ongoing innovation projects, rather than an initiating moment of discovery. The policy consequences of this shift of approach are very far-reaching, because large parts of public policy for innovation – across most OECD economies – consist of support for R&D combined with some kind of commercialisation measures. How, to what extent, and with what effectiveness the ‘knowledge infrastructures’ of universities and research agencies operate as problem-solving resources remains a key policy challenge.

Innovation outcomes rest on investment patterns that create specialised knowledge and capabilities in enterprises. Within the mainstream of economics, the operation of firms is in general not seen as problematic. Firms make optimal decisions (concerning both what to produce and how to produce) in the face of more or less well defined decision environments, and the capabilities that are needed for this are usually neither in question nor in focus.

Innovation, however, rests on quite specific and differentiated areas of competence and capability that must be constructed by firms. Firms must
create the resources that they use to innovate, and this is costly, time-
consuming and risky. Building innovation capability requires investment in
tangible and intangible assets, the latter including a wide range of skills and
knowledges that make up the intellectual capital of the enterprise. The
process through which this happens is complex and highly problematic. There
are difficult issues concerning strategic decision-making, where managers
face a constant tension between the demands of current production and the
requirements of current profitability, on the one hand, and the need to create
assets for the future on the other. The difficulty here is partly that the
commitment of resources reduces current profitability (in the context of
competing claims for these resources), and partly that the innovation process
is unpredictable and uncontrollable, and outcomes are often radically
uncertain. At the same time, there is no general path towards innovative
success, and this introduces considerable diversity and variety in approaches
to innovation, even among enterprises in similar lines of business, let alone
across industries and sectors. From the perspective of enterprises, the
implication is that innovation rests on the ability of managements to engage in
knowledge creation and asset building in experimental circumstances where
no methodological guidelines exist. (Lazonick 2004 gives a good overview of
these company-level issues). From a policy perspective, the problem is the
factors that shape or inhibit the abilities of companies to engage in such
investment. These factors range from patterns of corporate governance
(where structures of ownership and control can affect corporate decision
making), to the ability of firms to cope with risk, to factors affecting time
horizons of investment. Policy issues in governance, taxation, accounting
standards and the labour market arise here.

Innovation is pervasive. Innovation is not something that happens only in a
relatively small group of high-technology industries, nor something that is
driven by a small set of industries or technologies. The new innovation data,
particularly from the EU, show clearly that innovation in the sense of
development and sales of new products is distributed right across the system
in all advanced countries. Industries that are regarded as ‘traditional’ or
mature or ‘low-tech’ often generate substantial amounts of sales from
technologically new products and processes. Likewise, the service sector is also strongly innovative, across almost all of its component activities, and this is particularly important since the service sector is the largest sector in all advanced economies (see European Commission, 2004, p.238-9). Low and medium tech sectors are not in any absolute decline in OECD countries, and in terms of shares (either of manufacturing output or GDP) remain very large and persistent. The issue arising out of this for policy is one of focus: where should innovation policy efforts be directed? Virtually all OECD countries in effect focus innovation policy support on the technologies underpinning high-tech sectors, either via direct support for such fields as ICT, biotechnology and nanotechnology, or via subsidies to R&D. Seeing that about half of all business R&D in OECD countries is performed in high tech sectors (sectors that typically account for less than 3 percent of GDP), R&D tax credits are in effect a subsidy to high tech sectors. However if innovation is pervasive across sectors, then it may be necessary to reassess the focus of policy in terms of the ability of low tech sectors to innovate and grow, and the specific mechanisms through which that happens.

*Innovation capabilities are cumulative.* Innovation capabilities build up over time, by building on past developments. So competitiveness has a historical dimension, with learning over time contributing to the accumulation of knowledge and of specialized skill bases. Cumulative development can affect companies but also sectors and countries, and it can also be linked to the fact that many technologies take very long times to develop. On the one hand cumulativeness can offer powerful competitive advantages, with accumulated knowledge comprising both an entry barrier and a specialised expertise that is difficult for competitors to replicate. Such cumulative developments are one factor that underlies patterns of technological specialisation at national level that seem to persist over long periods, and that serve to differentiate the advanced economies (Archibugi and Pianta 1992 give the most recent detailed overview of this).

But cumulativeness can also have detrimental effects. In particular it can underlie “lock-in”, namely the inability to move away from technologies that
are in some sense less adequate than alternatives. Firms are often locked in
to particular technologies, and therefore face serious problems in adapting to
new technologies if and when technologies do actually shift. Lock-in implies a
strong commitment to the existing technology, and reluctance or pure inability
to move. This is one reason why disruptive technological changes tend to lead
to significant changes in the population of firms producing a particular product
(so the shift from film to digital photography has led to entry of firms like Sony
and Panasonic, and exit of firms like Polaroid and to a large extent Kodak).

Why does lock-in occur around particular technological trajectories, and what
are the implications for policymakers? One of the primary reasons for the
existence of cumulativeness and “lock-in” is the fact that technologies do not
consist of individual technical artifacts. They are better conceptualized as
systems – as interlocking patterns of technique and modes of use. On the
purely technical level, most technologies are complex products and
processes, consisting of more of less detailed systems of interconnecting
components and devices. But technologies are also systemically connected
with the social world: with patterns of training, with infrastructures, with forms
of production organization, and with modes of technology use. These
systemic aspects of technology mean that it can be very difficult to change
particular technologies (such as polluting production methods or, on a large
scale, hydrocarbon-based energy systems) independently of changes in the
system as a whole. But system changes are considerably more difficult to
initiate and sustain than changes in individual techniques. So an important
problem, both for analysis and policy, is to distinguish carefully between cases
where technological change is relatively unproblematic, and cases in which
systemic factors generate major obstacles to change.

The policy issues here point in two countervailing directions. On the one hand,
there is the need to think about the public role in sustaining existing
competitive advantages over the long run: how, for example, should education
or infrastructure policies be shaped to support existing areas of
specialisation? Beyond this, there is the problem of policy support to
overcome lock-in during periods of transition. Then the challenge is to
understand in more detail that character of obstacles to transition where specialisation has created lock-in, and the implications for policy foundations, policy design and implementation measures.

*Innovation relies on collaboration and interactive learning.* Enterprises very rarely innovate without technological cooperation or collaboration. Knowledge creation happens through an interactive process with other enterprises, organisations, and the science and technology infrastructure and so on. Empirical research in a number of countries under the auspices of the OECD has shown that innovating enterprises are invariably collaborating enterprises, that collaboration persists over long periods, and that the publicly-supported infrastructure (such as universities and research institutes) are important collaboration partners. This is strong empirical confirmation of the idea that innovation should be seen as a collective phenomenon (see Howells, 2000, for an overview of research on this topic, and OECD 2001 for a range of cross-country studies of innovation). The policy issue is first, whether or not specific measures for collaboration are necessary, and if so what the design principles should be, and second, whether individual company support mechanisms are appropriate at all in the presence of collaboration.

*Innovation is highly uncertain.* Innovation involves both serious risk and serious uncertainty, both in technological and in economic terms. Risk here refers to the fact that potential outcomes of an innovation may be known but show very large variability in results. Uncertainty means that we do not even know what the potential outcomes might be – it is simply not possible to know what is on the technological or economic agenda. It has very rarely been possible to predict the path of innovation, even in general terms, and this is a big problem for both companies and governments. Enterprises very often make major forecasting mistakes, even when they are very well informed, and managed by highly competent and knowledgeable people – they are rarely able to predict the economic outcomes for new products and processes. This leads to major problems for enterprises in assessing investment decisions involving innovation activity (Rosenberg, 1996). The policy issues here relate to the long-standing and well-recognised role of government is reducing,
shifting or diversifying risk. A basic policy issue is that risk diversification requires portfolios of projects, and small firms or even entire small economies may not be capable of this; in practice governments then step in to ameliorate risk.

Clusters are important, and reflect national and regional patterns of industrial and technological specialisation. Geographic clustering appears central to competitive advantage, a result that has emerged from a wide variety of studies. 'Horizontal' clusters – meaning groups of enterprises in the same line of business – are widely found, and seem to be associated with better economic performance of enterprises in the clusters. Vertical clusters, meaning sustained relationships between enterprises in different activities, can be identified using input-output techniques, and reflect country specialisations that often differ widely. There is some evidence that cross-border clusters may be becoming more important. These patterns of specialisation are cumulative, built up over long periods, and appear to be hard to change. (OECD, 1999). Clustering appears to be closely linked to the general issue of cumulativeness, and raises similar policy issues: there is a subtle balance to be made between support for existing areas of cumulated advantage, and capacities to adapt to technological dynamics that may affect the cluster.

There is strong science-technology interaction in innovation. The science system is important for innovation, and there is a strong interaction between technology and science. Many inventions draw on science – for examples, analyses of patents show that there have been dramatic increases in citations from patents to scientific research, and that a very high proportion of the papers cited are produced within public sector scientific research organisations. Other studies have shown strong but indirect interactions, through which industries both affect the process of scientific research and use its results; many traditional industries, from this perspective, draw intensively on scientific results in industry-level knowledge bases. So-called “low tech” industries are not low knowledge industries. Although science does not provide the raw material for innovation in any simple way, it remains a key
element of industry knowledge bases across the economy, including in low tech industries, and therefore a key element of innovation capability (Martin and Nightingale, 2000). The general policy problem here concerns how the science-technology infrastructure should be composed, funded, governed and managed, and how it should be linked to business-sector users. At the present time, the dominant method of thinking about this link, in OECD countries, is around the concept of commercialisation: infrastructural institutions are encouraged to commercialise R&D results through patenting, licensing and spin-off companies. This approach contains a notable flaw, which is that very little innovation takes the form of commercialisation of R&D results. In some cases the commercialisation model of innovation is appropriate. But often science institutions take the form of problem-solving collaborators within ongoing innovation projects; policy support for such activity implies science policy approaches that are very different from the commercialisation model.

_Innovation is systemic._ One of the most persistent themes in modern innovation studies is the idea that innovation by enterprises cannot be understood purely in terms of independent decision-making at the level of the enterprise. Apart from collaboration, discussed above, there are broader factors shaping the behaviour of enterprises: the social and cultural context, the institutional and organisational framework, regulatory systems, infrastructures, and the processes which create and distribute scientific knowledge, and so on. Taken together these factors make up a system, and system conditions can have a decisive impact on the extent to which enterprises can make innovation decisions, and on the modes of innovation which are undertaken. These characteristics suggest important differences between economies, and between the ways in which innovation occurs across economies, that persist over time (Edquist, 1997). The systems issue is an important one for policymaking in small economies, and is therefore treated specifically in the following sections.
2.2. ‘Systems’ Approaches to Innovation

‘Systems’ approaches to innovation are founded on one of the most persistent themes in modern innovation studies, namely the idea that innovation by firms cannot be understood purely in terms of independent decision-making at the level of the firm. Rather, innovation involves complex interactions between a firm and its environment, with the environment being seen on two different levels. On one level there are interactions between firms - between a firm and its network of customers and suppliers, particularly where this involves sustained interaction between users and producers of technology. Here the argument is that inter-firm linkages are far more than arms-length market relationships - rather, they often involve sustained quasi-cooperative relationships which shape learning and technology creation. The second level is wider, involving broader factors shaping the behaviour of firms: the social and perhaps cultural context, the institutional and organizational framework, infrastructures, and the processes which create and distribute scientific knowledge, and so on. These environmental conditions are often seen as specific to regional or national contexts, but they are also dynamic: their forms of operation change with political conditions, changing technological opportunities, economic integration processes and so on. The basic argument of systems theories is that system conditions have a decisive impact on the extent to which firms can make innovation decisions, and on the modes of innovation which are undertaken.

System approaches take a variety of forms, and the literature on them has become very large. However they usually take as their starting point a definition by Lundvall:

... a system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new and economically useful, knowledge ... a national system encompasses elements and relationships, either located within or rooted inside the borders of a national state (Lundvall, 1992, p.2.)
According to Lundvall a distinction can be made between a narrow and a broad definition of an innovation system respectively:

The narrow definition would include organisations and institutions involved in searching and exploring - such as R&D departments, technological institutes and universities. The broad definition ... includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring - the production system, the marketing system and the system of finance present themselves as subsystems in which learning takes place (Lundvall 1992, p.12)

Systems theories involve a very strong hypothesis, which is that diversity in macroeconomic performance can be traced to underlying system differences across the above elements. What factors suggest that a focus on national systems and national policy levels might be relevant? Studies of innovation systems tend to focus the fact that there are significant differences across national economies in a range of areas relating to innovation and learning. With considerable variations of emphasis, studies tend to focus on the following elements:

*Industrial structures and technological specialisations*

The world economy essentially divides into two groups of countries, rich and poor, with little convergence between them; but inside the rich group there has been convergence in real income levels, productivity levels and so on. However even where economies are converging in terms of macroeconomic indicators, it should be noted that this is occurring on the basis of differences in industrial activities and technological capabilities which can be marked and persistent between the national economies involved.

The technological differences relate to persistent technological specialization. Macroeconomic convergence appears to involve, at least for many countries, the construction and maintenance of quite specialized technological capabilities, and this is reflected in patterns of R&D expenditure, patenting,
scientific publication and so on. Moreover the firms in which such capabilities reside appear to develop competences and capabilities within specific national contexts, even when the firms are multinational in terms of production and operations (Archibugi and Pianta 1992; Patel and Pavitt, 1994a and 1994b). These considerations incidentally suggest that neither ‘globalization’ (however defined) nor economic integration are replacing the national entity as an economic space; rather they are supplementing it. Patel and Pavitt have shown that even major multinationals rely strongly on their local and national contexts for their technologies (Patel and Pavitt 1991)

Institutional structures

Economic behaviour rests on institutional foundations, in the sense of legally or customarily established ‘rules of the game’ which evolve because of the advantages they offer in reducing uncertainty. Different modes of institutional set-up lead to differences in economic behaviour and outcomes. Some of the most important institutional differences relevant for innovation concern major and persistent variation in systems of governance: both narrowly in the sense of formal regulatory systems of corporate governance, and more broadly in the sense of rules of the game for corporate behaviour. Corporate governance is concerned with the institutions that influence the ways in which business corporations allocate resources and returns. Corporate governance is important for business enterprises because it both enables and proscribes strategic decisions concerning the types of investments they should make and to whom the returns on these investments should be distributed. Corporate governance is also important for national economies, because of the central role of corporations in the allocation of resources and returns on national and international levels. Around the world many different national systems of corporate governance prevail, but both regional economic integration and globalisation are creating pressures toward convergence to an "ideal" corporate governance system. So the relation between corporate governance and economic performance is therefore one of the key ways in which institutional structures affect system performance. But other key institutional areas include the operation of labour-management relations, cultures of
entrepreneurship, and legal frameworks of corporate law. Within this general
arena of institutions should probably be included such wide phenomena as
public attitudes to the role of the state (where there are very strong inter-
country differences which powerfully affect innovation behaviour).

Administrative and regulatory systems

It is well established that public policy systems affect innovation outcomes, but
there are important cross-country differences in organisational structures and
policy cultures. The differences include, firstly the specific arrangements and
powers of ministries and agencies responsible for innovation. But there are
strong national differences in such areas as accounting standards, and
regulatory frameworks affecting health and safety, or environmental change. It
is often argued that product regulation inhibits innovation (or, conversely, that
is in some simply way promotes it). But in fact regulatory arrangements often
have the effect of modifying existing innovation paths, and this leads to
differences across national systems.

Education and R&D systems

Human resources are a key element of innovation systems (a point which will
be discussed in more detail below. The OECD (2001b) has shown that there
has been a substantial secular rise in the qualified labour force, that formal
skills are increasingly important, and that there is stronger mobility of highly
skilled labour. This has directed attention to schooling and university systems
as components of the innovation system. The important point here is that
there remain major inter-country differences that set national innovation
systems apart from one another. It is important to remember that
organisations such as universities can differ sharply in terms of financing,
scientific research organisation, governance, teaching priorities and
capabilities, and so on. So recognizing the increased importance of education
in innovation involves complex decisions about the nature and organisation of
education systems that remain highly idiosyncratic at national levels.
There seem to be two broad roles for infrastructures in shaping technological change in innovation systems. On the one hand, such technologies often involve significant accompanying infrastructures. Automobiles, consumer electric technologies, information and communications technologies, aeronautics and so on all rely on extremely substantial infrastructure investments – highways, electricity distribution networks, cable networks etc. The provision and economics of these infrastructures appear to have powerful effects both in initiating and driving the rise to dominance of new radical technologies. On the other hand, turning to knowledge infrastructures, the major technological innovations that have shaped the modern world mostly originated or developed in public sector infrastructural organisations (Faulkner and Senker, 1995). Radar, telecommunications, microelectronics, nuclear power, biotechnology, advanced aircraft, space-based communications, new materials, the internet - in these core technologies of the modern industrial economy many or most of the important developmental decisions were made, in one way or another, in government or public infrastructural agencies. Of course the decisions came from a variety of organisations - the military, research councils, civil ministries, universities - and the key choices and decisions were not necessarily made in any rational or consistent way. However none of the qualifications that we might make about the role of the public sector should obscure the extraordinary importance of public-sector decision-making at key stages in the evolution of these technologies. It might be argued that radical breakthroughs which have occurred in industrial R&D labs are by contrast noticeable by their rarity, although they may be of great economic importance. Given the prevalence of such infrastructural inputs to modern technology, it seems unlikely that the infrastructural role is merely accidental, and it is therefore worth asking whether there is anything essential (or indeed systematic) about infrastructures and large-scale innovations. If we look at the histories of specific technologies, especially those generally regarded as having a major economic or technological impact, it is surprising how often the fundamentals of the technology are developed in government labs, publicly-owned companies, universities, military R&D programmes, etc.
It is often hard to understand how radical technologies in particular emerge or become established unless we take into account the roles of supporting infrastructures.

2.3. The National Innovation System As A Policy Concept

In a time of globalisation, it may appear strange to argue that any kind of national approach to innovation or any other domain of policy is relevant. It is sometimes argued that globalization is rendering the state (at whatever level) obsolete, and that the integration of product and capital markets removes the possibility of effective policy interventions by government. However it is important to note that many of the structural elements of the system described above are either predominantly or wholly national in character: they are built up largely by the use of national resources in national contexts. They are subject to national decision-making, even where there may be increasing transnational elements. For example, how much a country spends on R&D, what kind of education system it constructs and operates, how much it spends on education, how it builds and finances its knowledge infrastructures, how it supports its areas of specialisation, are matters for that country alone. Certainly financing such assets faces budget constraints, and in the area of institutions there is an increasing zone of transnational bargaining and regulation (for example with respect to agreements like TRIPS, TRIMS or GATS). These considerations suggest that, at least with respect to the core elements of the innovation system, there is no reason to believe that government is any less important in setting the context and framework for economic behaviour than it ever was (see Hirst and Thompson, 1996, for a discussion of this). The real problem is how to think about what desirable performance of the system looks like, and why and how governments should act towards it.

2.4. Functionality In Innovation Systems

Much of the literature on systems theories focuses essentially on differences of structure – transnational variation across the aspects described above. But from an innovation point of view, what really matters is functionality: that is, what do the components of the innovation system actually do, and how do
they operate? Innovation processes have various functions that need to be fulfilled – they must be initiated (usually by some perception of an opportunity), they must be financed, they must deploy capabilities that in turn have been created and maintained etc. Any evaluation of how systems function should therefore rest in part on an account of what do they do in terms of innovation functions. Here we discuss five functions:

- identification of opportunities
- creation and distribution of knowledge and capabilities
- supporting and financing business development and production capacities
- managing risk and uncertainty
- impacts of infrastructures

Identification of opportunities

In much of economic theory, the problem of recognizing an innovation opportunity is in effect assumed away: the assumption is that the market mechanism leads to the taking up of all profitable opportunities. It is important to remember that this idea rests on assumptions of full and complete knowledge, of costless and instantaneous access to knowledge, and of global rationality on the part of firms. In practice matters are much more complex than this. Often it is very unclear what an innovation opportunity actually is: opportunities rarely seem to present themselves in transparent ways. Especially with technologies that disrupt existing technological knowledge, an innovation opportunity often represents a complex interplay between governments (who may be procuring or regulating an innovation), businesses, financial systems, and research infrastructures. It is often the case that a consensus needs to be constructed, and so the emergence of ‘opportunities’ is not an automatic process, but something which a national innovation system may perform well or badly. Many examples might be thought of here: the idea that mobile telephony was a technological opportunity emerged in
Scandinavia as an interplay between state-owned telecom labs, electronics firms, telecom service providers, standards agencies, regional authorities, etc, and only developed slowly over many years. The opportunity for mechanical harvesting of grapes in Australia developed in an interaction between CSIRO, American machinery producers, universities, and major incumbent vineyard owners. Because of this collective and non-obvious character, potential opportunities seem to require discussion forums, which may occur via business associations, informal networks, large firms, government agencies etc. In small economies, there may be a need for some more systematic approach to identifying, analysing and discussing potential innovations.

*Creation and distribution of knowledge and capabilities*

Systems must create knowledge and skills for innovation, and they must distribute them, through mobility, education, or other transmission mechanisms. Much of public policy focuses on the creation of knowledge via R&D, but a focus on R&D-based knowledge creation leaves aside two broad issues: capabilities with respect to non-R&D inputs to innovation, and the distribution of knowledge. Different systems may have different ‘distributional powers’ as Foray and David put it, and this also is a function of specific national environments.

The ability to innovate rests on capabilities that extend well beyond R&D, and that may be distributed across quite different organisations. Innovation requires commercialisation, so there are business skills in particular – these will be discussed separately. But it also rest on specific innovation inputs, such as design skills, the analysis and assessment of markets, engineering capabilities, software skills etc. Many of these inputs depend on the capabilities of the education system. In an innovation systems context it is important to remember that what matters about the education system is not its efficiency in terms of costs, or its ability to attract foreign students or external revenue, but the specific skill and capability outputs that it produces. The creation of complex scientific and technological knowledge bases, and the processes of personal and organisational interactions on which they rest,
along with specific vocational and labour skills, are a major function of the system. There are many different ways of organizing and structuring the capabilities of a system, and there is rarely any general coordinating mechanism involved. Capabilities of a national system usually emerge as a property of unplanned interactions between the science system, the military, research labs and institutes, industrial companies, etc. But policymakers need to be able to understand how a particular system is functioning, and this suggests the need for some kind of framework against which relevant capabilities can be logged, monitored, and assessed.

Supporting and financing businesses and production capacities

Innovating is much more than learning or creating knowledge. It always involves a range of activities related to business that have little to do with technological capabilities – this includes business planning, investment programming, strategic marketing, and human resource policies. In turning innovations into economic outcomes the crucial ‘middle term’ is business development, and this involves a range of assets and abilities that are not necessarily related directly to innovation. These include the ability to finance capital investment programs, the ability to create efficient production systems on an adequate scale, the ability to recruit and coordinate appropriately skilled labour forces, the ability to construct and use marketing channels, and the ability to create and deploy logistics systems. These skills and capabilities can be thought of as assets that are complementary to innovation capabilities. Whether or not a growing firm can succeed in both innovating and creating complementary assets is very much open to question: David Teece has argued it is the absence of such complementary assets that explains why many innovating firms (especially lead innovators of radical technologies) often fail (Teece 1992). It is possible to innovate and to produce technologically leading products without being able to create the business capacities to appropriate the benefits of the innovation. The Australian wine sector is a good example of this: it has created leading products that are largely owned by foreign multinationals as a result of failure to build the complementary assets that would underpin global business presences by
domestic firms. These capabilities, which are central to actually getting innovations into production, are heavily shaped by system characteristics that are external to the firm: the governance system, the financial system, the education and training system etc. There is clearly a strong difference between smaller economies on this dimension of system functioning: some are extremely good at creating firms, while others have performed poorly.

Management of risk and uncertainty

Risk (in the sense of the probability of certain outcomes) and genuine uncertainty (in the sense that we do now know what the possible outcomes might be) are defining features of innovation. After all, innovation by definition is novelty, and we do not know what the nature and impacts of novelty might be. The identification and management of risk is therefore a key function of any innovation system, and systems differ sharply in how well they approach and manage risk. It is usually the case that successful systems have multiple methods of risk and uncertainty management. The basic problem is that profit-seeking companies, especially if they have relatively short time horizons for investment, are rarely likely to invest in longer-term of high risk project. Historically, high risk projects have been managed by such means as government subsidies (e.g. for biotech development), military procurement systems (e.g. for semiconductor development and computing, or for the GPS system), income-contingent loans (e.g. the launch-aid system for Airbus), or through research institute funding (for the world-wide web), or through the independent labs of state-owned companies (for mobile telephony). These functions of risk and uncertainty management are central to innovation, but are rarely openly acknowledged or addressed. An economic system that cannot bear or diversity risk, or meet the challenges of uncertainty, is likely to fail to innovate.

Creation and management of infrastructures

Much innovation is infrastructure-dependent: it relies either on the creation (usually by the public sector) of physical infrastructures, or on knowledge
infrastructures as support mechanisms. Infrastructures pose special problems for public policy, and particularly public finance, for three reasons: they tend to be very large in scale, they tend to be systemic in character, and they tend to be very long-lived. So they often entail enormous financing burdens, they must be constructed in an integrated rather than an ad hoc way, and their long lifetimes mean that normal investment appraisal techniques are usually unsuited to evaluating their costs and benefits. Historically speaking, these characteristics explain why states have typically played major roles in decisions to establish and to operate infrastructures. However operating an infrastructural organization is a different matter to establishing one, and much of modern economic reform has involved either privatisation or deregulation of infrastructure operations, or attempts to change the incentive structures and financing of such organizations (the latter has been especially important with universities and research institutes). However these changes have often been proposed and carried through without any detailed analysis of the specific characteristics and functions of infrastructures, or study of their effects. This is particularly so when it comes to knowledge infrastructures. In the past, knowledge infrastructures have tended to be created in haphazard and uncoordinated ways. But knowledge infrastructures perform increasingly important functions with respect to innovation – they create knowledge, they store and maintain knowledge, they create new enterprises, they support innovation-related problem solving, etc. So infrastructures are increasingly central to innovation performance, and increasingly are objectives of policy systems.

2.5. Policy Rationales and Foundations

What are the implications of the ideas described above for the rationale and scope of public policy? The approach developed above suggests that innovation rests on structures of institutions and organizations, and that performance depends on how the structures function operationally. This suggests an approach to policy that rests on assessments of evaluations how specific organizations or structures contribute to system functionality. This
offers a perspective that at some points links with the usual ‘market failure’ approaches to policy, but also goes beyond it.

Systems approaches, at whatever level, tend to see innovation performance as a result of how sets of institutions and organizations work. Both analytical and policy issues then turn on the nature of the components of the system, the nature of the links between them, and how well those linkages work. The links may take various forms. They may be economic, or they may involve the transmission of knowledge, or they may involve the joint use of infrastructures, and so on: the precise connections cannot be specified in advance, and often need detailed empirical investigation to uncover. But the point is that innovation performance can be seen in large part as a form of co-ordination problem – components of the system must work in a coherent way (that is, all moving in more or less the same direction, with more or less compatible objectives) towards the development and use of the new technology that is the object of the innovation process.

Where institutions, infrastructures or inter-firm connections are well established within a particular technological framework, the coordination needed for innovation may be unproblematic (although even stable technologies can run into novel problems). But where a new technology involves a major disruption, coordination can be very difficult. Some innovations are radical with respect to existing procedures, engineering capabilities or technical knowledge bases – they involve major discontinuities, and ‘shocks’ to the existing technological systems. That is why technological historians such as Thomas Hughes write about such innovations largely in terms of ‘systems, built by system builders’. The coordination problems that arise are relevant at all levels of innovation. Even if innovation is seen in terms of incremental improvements to existing technology then current organisations and regulation systems can readily run into technological or economic problems that require new forms of coordination to solve. But if we see the task of innovation in a more radical way, as shifting the fundamental technological systems on which the current industrial economy is based, then the coordination problems become really critical. A systems approach would
suggest that the identification of co-ordination failures, the design of policy instruments to overcome them, and the development of relevant actors, are likely to be an important rationale for public policy intervention, and important also in deciding its scope and objectives.

The ‘system failures’ sketched above are all essentially problems of co-ordination, and so the claim made here is that market economies are characterised at the technological level by major co-ordination failures. Such failures are often recognised in economics, particularly in Keynesian macroeconomic theory, where sub-full employment equilibria rest on the existence of coordination failures. Such equilibria are situations in which workers would like to work and to consume (at existing wage and price levels), and firms would like to employ and produce, but no mechanism exists to overcome the inability of labour and product markets to coordinate via price signals. At this point, Keynesian arguments for public intervention come into play.

It seems necessary to distinguish these types of coordination problem from the concept of market failures in neo-classical theory. As the name suggest, the market failure approach rests on the idea that existing markets fail to coordinate behavior effectively, but it often goes on to assume that such problems can be resolved by the creation of markets, or by substituting government action for a market. Market creation usually takes two forms. Firstly, market failures can be resolved by the creation of property rights – so problems associated with beneficial and detrimental externalities can be resolved by the assignment of property rights which may then be traded (patenting comes under this category). Secondly, market failures can be resolved by the creation of contingent markets, which take account of varying states of the world (so appropriate futures markets in labour and products could resolve the Keynesian coordination problems noted above).

The argument here is that coordination problems with respect to innovation systems relate primarily to institutional action that precedes the operation of markets, or organizational action that creates a new arena for economic
behavior. There seem to be two types of problem. One is that we might be able to conceptualise a market for some benign outcome, but the real issue is to see how that market could be institutionalized. So issues related to corporate governance, accounting procedures, or risk management devices and so on are issues to do with the shaping of markets or substitution for them, rather than interventions in market operations. A second problem is that it may not be possible, in principle, to create a market at all. That is, the relevant problems are simply not amenable to a market solution, and could only be resolved by some other coordination mechanism. The main alternative is some form of administrative coordination that may be more or less democratic, or more or less hierarchical. Overcoming problems related to knowledge creation, education and training, or lock-in and specialisation, require institution building not market rectification.
3. The New Zealand Context

3.1. The Structure of the New Zealand Economy and its Implications

This section discusses some of the implications of the New Zealand context. The particular focus here is on commonalities between New Zealand and other comparator economies. The point of departure here is the implications of the New Zealand industrial structure: what are the developmental implications associated with innovation in the historically-derived structure of the New Zealand economy? The emphasis here is not on describing the details of the New Zealand situation, but rather on the analytical and policy challenges that emerge.

New Zealand is characterised by an industrial structure with a strong emphasis on agriculture, a small manufacturing sector with a large proportion of output concentrated on low and medium-technology sectors, and a large service sector incorporating a large social and community services element (meaning especially health and education). Both the gross and business (GERD and BERD) R&D intensities are low. There is a technology balance of payments deficit, suggesting significant technology import. Likewise a significant share of gross fixed capital formation is met by imports: so here also there is likely to be a strong level of embodied technology import. Rates of gross fixed capital formation are comparatively low. From a geophysical perspective, New Zealand is distant from its main markets, but has significant natural resources (such as agricultural land, timber and forests, and fish). Its physical make-up is such that it faces communications problems and hence has major physical infrastructure challenges.

It is extremely important to note that these characteristics do not make New Zealand stand out among the small, open, advanced economies of the world. In a general way the characteristics described above are shared with such countries as Finland, Sweden, Norway, Denmark, Iceland, the Netherlands, Canada, and Australia. As others have noted, these are really the important
comparator countries for New Zealand (see Claus and Lee 2003 and Sanderson 2004 who make this point clearly).

The importance of the shared structures and geophysical situations lies in the fact that these comparator countries are not simply advanced economies, but are among the richest in the world. In terms of the underlying productivity measure, output per worker hour, several of them outstrip the United States, and most of them have sustained very high growth rates of output and productivity in recent decades. Most of these countries have not only generated high income levels in terms of GDP per capita, but also maintain major welfare systems related to health, education and social protection. It is worth noting that this prosperity in many cases is relatively recent rather than intrinsic to the situation of the countries. The Nordic area countries in particular were, until comparatively recently, very poor. In the 19th century all of them faced major rural crises, had low levels of income relative to other countries (Norway in the mid-19th century was comparable to Sicily), and had very high rates of out-migration. So, against this background, their development trajectories since the late 19th century have been very spectacular.

How can these development trajectories be understood, and what is the relevance for structures of the New Zealand type? The points that will be emphasized here are:

- the leveraging of resource bases,
- the development of low technology industries, and
- the process of technological upgrading.

Within development economics it is sometimes argued (by Jeffrey Sachs for example) that abundant natural resources are actually an obstacle to development. There is a ‘resource curse’ that keeps developing countries stuck in low value-added and low growth activities. This hypothesis is certainly not confirmed by the experience of the small open economies mentioned
above. Without exception, these countries have rested their development paths on resource-based sectors, and out of them have developed low and medium technology industries that have driven growth within these countries. This has been the case not only historically, but in many instances remains the case today. Even where some countries – such as Sweden, Finland and the Netherlands – have developed significant high tech sectors, these have supplemented the low and medium tech specializations, but have not replaced them. Table 1 sets out some of these specialisations both from historical and contemporary perspectives.

The key point to emphasize here is that these countries have by and large become rich via the leveraging of natural resources and the persistent upgrading of low tech and resource based industries. One of the basic mechanisms in this has been the sustained development of both upstream and downstream linkages from the resource bases, leading to major cluster development. Sweden shifted from iron ore production to iron and steel, to fabricated metal products (most notably cars and trucks), and then to machine tools and electronic systems. Norway moved from marine transport to shipbuilding to marine electronics, developing the world’s first automated navigation systems, and continuing to be a leader in surface and subsea marine applications. Finland went from paper production to chemicals for paper, and then to paper machinery (a major sector in which it is a world leader). Of course four of the countries (Canada, Sweden, the Netherlands and Finland) have succeeded in creating important electronics and telecommunications sectors, and the processes through which this happened deserve attention; however in each of these countries electronics remain a relatively small sector, and prosperity continues to depend on continuously upgraded traditional industries. Moreover it remains the case that the Netherlands and Denmark are heavily agricultural economies, with substantial export earnings from food products (a point which is also true of another allegedly high-tech small economy, namely Israel). It is worth noting that these linkages have underpinned a distinctive approach to economic policy in some of these economies. The Swedish economist Erik Dahmen, for example, developed an influential body of analysis based on the concept of
“development blocks’, that is mutually supportive industries that could be linked in both the input-out senses, and in terms of shared knowledge bases; this work became a key contributor to the development of innovation system concepts (Dahmen 1970). Much later, it also became the basis of the work of Michael Porter on clusters; here it should be noted that Porter has strongly emphasized the importance of cluster development out of existing industries and resources.

Dahmen’s work both reflected and contributed to a specifically Swedish mode of industrial organization. The key point is that in Sweden, and in the Scandinavia economies more generally, the emergence of linkages and development blocks did not just happen: it was organized. In Sweden a specific form of corporate organization and governance emerged that was central to its industrial development. The main specifically Swedish element is the persistence of concentrated ownership and practical control of key industrial enterprises by family spheres or other conglomerate blockholdings. Sweden is characterised by large-scale blockholdings in significant parts of the industrial system by what are in effect active family-based or bank-based closed-end investment companies; the most famous of these is the investment vehicle of the Wallenberg family, Investor AS. There are at least a dozen such family groupings, often playing an active role in enterprise strategy, organization and operations. This is by no means unknown elsewhere, but the scale and impact of this pattern nevertheless remains a distinctive feature of the Swedish system. The ‘investment trust’ ownership structure also has an institutional form outside of the family groups, based on bank-centred investment companies, which own and control very significant parts of the Swedish economy. So closed-end conglomerate holdings dominate large parts of the economy, and form a core element of the governance system. These holdings have rather deep historical roots, and in some cases even the individual holdings stretch back almost a century. So they impart an important degree of continuity to the Swedish system; at the same time, the fate of these holdings is one of the key elements in shaping change at the present time. Such arrangements are not unique to Sweden.
Distinctive, development-oriented governance arrangements can be found across the industries of the Nordic world.

These general points are highly relevant for New Zealand, because it shares the low tech emphases, the resource characteristics, and the widely distributed economic structures of the small economies mentioned. Such an industrial structure is not non-innovative (see Ferranti et al 2002 and Hirsch-Kreisne et al 2005 for arguments on this point). If we look at the distribution of innovation activity (meaning introduction of new products or processes, or expenditure on innovation) in New Zealand, we find the following:

Firstly, innovation activity is widely distributed across all the major sectors, according with the ‘pervasiveness’ characteristic described above. Figure 1 below shows that within manufacturing, innovation is found across all sectors regardless of their formal classifications of technology intensity. That is, in common with other small open economies, New Zealand has innovative low tech sectors.

These results accord quite closely with those of other innovation surveys in small open economies. For example, in all sectors of the Australian economy at least 30 percent of firms are innovating over any 3-year time period. In Australian manufacturing, the most intensively innovating sectors are machinery and equipment and chemicals, each with about 50% of firms innovating. Nevertheless in such ‘traditional’ industries as food products, textiles and metal products between 30 and 35 percent of firms are innovating: see Australian Bureau of Statistics 2005; see also Eurostat 2004.

What follows from this structure is the suggestion that innovation policy for New Zealand cannot simply be based on high tech sectors, but will have to have an extensive base in the industries that New Zealand actually possesses. Linkages, development blocks or clusters have not, in similar economies, emerged out of some general propensity to cluster growth: rather, they have emerged from locationally specific resources, and have developed in rather logical ways both forward and backward. The result is strong ‘vertical’
clusters. For New Zealand, an important challenge will be to technologically upgrade, and to innovate, in such sectors as food and beverages, textiles and clothing, printing and publishing, timber products etc., but also to develop their upstream and downstream potentials. There are strong advantages to such an approach. Firstly, its viability has already been demonstrated by the other small open economies discussed above. Secondly these are growth industries, in the sense that they are large industries that contain substantial high-growth sub-sectors. They therefore offer important innovation and growth opportunities. The question that follows from this is whether and how the GIF relates to these challenges.

3.2. Assessing the Growth and Innovation Framework

This section turns to the Growth and Innovation Framework. The intention here is not to have a general discussion of the GIF, but rather to assess elements of it against the specific background of the analysis presented above. The main components of the GIF are

- Skills and talents
- International connections
- Innovation
- Engaging with sectors: focusing government resources

Two further elements are added here. The first is the problem of assessing and benchmarking New Zealand’s performance, which is discussed in the following section. The second is the knowledge infrastructure – the complex of organisations and institutions, including universities, research institutes, industry associations etc that creates and distributes knowledge across industries.

3.3. Assessing New Zealand’s Performance: Identifying Opportunities, Constraints and Obstacles

A central challenge in policy design is assessment of New Zealand’s innovation and growth performance with the objective of identifying problems that might be solved with policy interventions. How can this be done in a practical sense? In economic theory, a frequent way of approaching this issue is by comparing actual structure and performance to a model that exhibits
optimal properties. One major problem with this is that it tends to abstract away from the real characteristics of the economy, and of its constraints and potentials. The only real alternative to this is a comparative approach, which looks not for an abstract optimal performance, but at what realistically similar economies are able to do. The discussion above suggests several lines along which this might be done. These are

- Comparative analysis against small open advanced economies
- Comparative analysis against resource based economies
- Comparative analysis of low R&D-intensive sectors and linkages

Appropriate comparator economies and sectors have been suggested above, with one possible modification. The discussion above has focused on successful economies – economies that have managed to transform natural resource bases into advanced industrial and service economies. But there are other examples, in particular of resource-based economies, where successful development has been inhibited or blocked; a relevant example in terms of structure might be Chile. However the general point is the need to focus on structurally similar economies, since such economies exhibit contextual similarities, and similar problems in terms of policy capabilities, financial resource mobilization, infrastructure provision, etc. It makes sense to carry out case studies of industries or specific technologies within the framework of structural similarity, because industry development conditions often differ sharply between small and large economies.

A general conceptual framework for comparative analyses has also been suggested above, in terms of the structures and functions of innovation systems both at national and sectoral levels. These seem to lead to a (non-exclusive) set of questions that might help to provide a consistent and coherent framework for evaluation, including:

- How does the institutional and organisational structure of New Zealand compare, both at national and sectoral levels, and what are the potential implications – for innovation behaviour – of such differences?
- How does functionality compare with respect to key system functions? Bearing in mind that it may be difficult or impossible to replicate either
institutions or functions, what changes or innovations in policy might generate desirable functional effects?

- Under what circumstances do different patterns of linkages or cluster development emerge across structurally similar economies? How are linkages in practice developed, particularly in resource-based sectors? Is it the case, as Gavin Wright has argued, that whether or not linkages emerge is exclusively a matter of government policy (Ross 1999, Wright and Czelusta 2003)? If so, what are the general policy options and methods?

- At sectoral levels, how do New Zealand’s key sectors compare in terms of innovation and growth dynamics to those of comparator economies, in terms of opportunity conditions, underlying knowledge capabilities, business investment conditions, etc.? Can any lessons be drawn about factors shaping (a) the dynamism of particular sectors or (b) the backward and forward linkages?

These types of questions are not simple to answer, and addressing them requires resources, capabilities and inputs that themselves need to be addressed as a precursor to analysis and assessment. These issues are discussed in the final section below.

3.4. GIF: Skills and Talents

One of the common features of countries that have successfully industrialized is the early establishment of educational systems, and their subsequent development. Those who have sought to theorise the links between education and development have usually done so by linking education directly to technology:

> The heart of the whole process of industrialization and economic development is intellectual: it consists in the acquisition and application of a corpus of knowledge concerning technique, that is, ways of doing things (Landes, 1980, p.111, cit Easterlin 1981, p.2)

Recent work on education and skills has tended to make two core claims about technological evolution. The first is that technologies have become considerably more complex, both to develop and to operate. Most production technologies are now multi-technologies, often involving the fusion of quite
different fields – for example, Imai refers to ‘mechatronics’ as a new dominant technology, involving the fusion of mechanical engineering and electronics. The second claim is that, as a result of increasing complexity, technologies are increasingly codified and require specific educational skills to acquire and run. This point has been made very strongly by Abramowitz and David:

Perhaps the single most salient characteristic of recent economic growth has been the secularly rising reliance on codified knowledge as a basis for the organization and conduct of economic activities, including among the latter the purposive extension of the economically relevant knowledge base. While tacit knowledge continues to play critical role…codification has been both the motive force and the favoured form taken by the expansion of the knowledge base. Although this particular trend can be traced far into the past, only within our own century has it progressed to the stage of fundamentally altering the form and structure of economic growth (Abramovitz and David, 1986, p.35)

Abramovitz and David see these codified knowledge bases as being based on formal education and training: ‘Technological change tended to raise the relative marginal productivity of capital formed by investments in the education and training of the labour force at all levels’ (Abramovitz and David, 1986, p.37). They therefore relate the technological performance of the US economy to secular expansion of education, and argue that the two are closely interconnected. The perspectives of Abramowitz and David have been closely followed in recent work on knowledge and education (see Foray 2004, for example), who has showed that human capital formation is closely related to productivity growth.

The main policy issue deriving from this is how the education system relates to domestic human capital development. Governance reforms within higher education have usually been undertaken with efficiency criteria in mind (usually expressed via changes in staff-student ratios), or with shifting the burden of university finance via links with private-sector funders or significant changes in the composition of fee-paying students. It is rare for tertiary education to be discussed in terms of its impacts on domestic capability
creation over the long term, which is the main problem from the point of view of the innovation system. One exception to this is Finland, which now has a target to achieve degree-level education for 70% of the current primary school cohort, as a component of sustained skill upgrading; there are extensive current discussion on the implications of this target for university funding and operations. This kind of ambition is rare but important, and such a shift of perspective is necessary in assessing how education system fits into broader patterns of capability development.

3.5. International Connections

This section comments on only one aspect of internationalization, namely global knowledge creation and flows. This is not a new issue for economies like New Zealand – all of the small open economies discussed in the previous section were characterized by significant inward knowledge flows as part of their industrialization processes (Bruland 2005 is a detailed discussion of how this occurred in the context of the Nordic economies). This occurred, as it still occurs, via acquisition of intermediate and capital goods, via personnel flows, via scientific collaboration, and so on. But such flows may be becoming more complex and more important. It was noted above that a key feature of innovation is collaboration between innovating firms and other firms and organizations. It is increasingly the case that such collaborations cross borders, in the form of cross-border production networks or transnational value chains. Underlying this development is the extension of knowledge bases across borders, and the need to integrate such knowledge bases across technologies that seem increasingly complex. Quite apart from the continuing fact that New Zealand is but a small part of the global knowledge creation effort, and therefore needs to maintain international links, there are good grounds for seeing this international dimension as a more important part of domestic knowledge bases. This implies a specific need for actions that monitor, access and disseminate relevant information and knowledge: this needs to be seen as a more explicit function of the knowledge infrastructure, to be discussed below.
Innovation

A key issue for New Zealand is how to think about the nature of innovation in the New Zealand economy. As argued above, it is often the case that R&D and innovation policies are defined in terms of frontier research areas (such as ICT, biotech and nanotech) However it is also very important to keep the industry dimension in perspective. High tech industries (usually defined as industries with R&D/Sales ratios of more than 4%) make up only a small component of manufacturing, and an even smaller component of GDP. This is true of all OECD economies: there is no OECD economy in which high tech manufactures make up more than 3% of GDP. All OECD economies rest on a combination of large medium-technology and low-technology manufacturing industries (such as food and beverages, or fabricated metal products), and large-scale service activities (of which the largest are education, and health and social services). Innovation surveys carried out in many countries show that these industries contain significant proportions of innovating firms, that they develop new products, and generate significant amounts of sales from new and technologically changed products.

The expanding data and evidence on innovation in these low and medium-technology industries and services suggests that we should take a wide view of innovation and its effects, recognising that growth is generated across many sectors of the economy. Of course we should not deny the existence and importance of radical technological breakthroughs. But it is important to challenge the oversimplified idea that high-tech industries are ‘leading’ sectors, and that growth rests on their technologies in some simple way. Rather we should recognise that innovation and hence growth impulses are pervasive across the economic system, which would explain why many so-called ‘low-tech’ sectors and low-tech economies have been growing rapidly. In other words, growth impulses are dispersed across the system because innovation also is widely dispersed - it is not the case that innovation is confined to a small group of high-tech sectors. Growing sectors innovate in different ways, with a great deal of variety in methods, approaches and results. This diversity among industries is particularly important with respect to
knowledge creation. So the specific engagement with innovation that faces New Zealand is the problem of innovation across the low tech sectors.

Low tech sectors have a specific characteristic in terms of knowledge creation, which is that they draw heavily on knowledge created outside the industry. They do not innovate on the basis of internal R&D, but rather on the basis of a flow of knowledge from external sources. Such knowledge can flow in a number of ways: via contract R&D, via joint ventures, via labour mobility, via consulting, via informal know-how trading, and above all via the purchase of capital and intermediate inputs. Many of these background flows of knowledge emanate from the publicly-supported knowledge infrastructure, and it is this that connects public policy with the need to focus on the sectoral structure of innovation.

Engaging with sectors: focusing government resources

In recent years the basic thrust of both micro- and macro-economic policy in OECD economies has been towards equal treatment of industries: that is, policy neutrality across the various sectors of the economy. This has been a cornerstone of economic reform, since it involves the rejection of sector-specific industrial policies based on subsidies. In the EU, this policy is in fact built into the EU Treaty – it is legally impossible to subsidise sectors.

When it comes to innovation, however, this policy approach, though justifiable and necessary in many ways, is far more problematic than it appears at first sight. Many areas of public policy relate to innovation – education, R&D, basic science support, procurement, financial provision, and so on. The fundamental problem is that apparently neutral policies in practice frequently support specific industries. R&D tax credits, for example, which are in place in about half of all OECD economies, in fact function as a subsidy to large R&D performing firms – most of the world’s R&D tax concessions go to about 500 firms in four industries (vehicles, ICT, pharmaceuticals and engineering). In the same way, basic science support can in fact be industry focused – the major priority areas of basic science at the present time include molecular...
biology and biotechnology, each of which support the global pharmaceutical industry. So a more nuanced approach to industry effects of policy is necessary.

For New Zealand, as for the other small advanced economies, these issues are exacerbated by size and by specialization. Whether they like it or not, small economies are specialised economies, and so many of the apparently sector-neutral policies favoured within the OECD are often of doubtful relevance.

3.6. Infrastructures: A Key Policy Issue

The argument above has been that an innovation policy for New Zealand should have a core focus on the innovation capabilities and growth prospects of low tech sectors. These sectors appear innovate in a specific way, via the flow of knowledge from innovation infrastructures, meaning universities, research institutes, government labs, standards-setting agencies, regulatory frameworks etc. (Hirsch-Kreinsen et al 2005). The capabilities of knowledge infrastructures, and their links with industries and sectors, appear to be important in shaping overall innovation performance. There are many outstanding policy issues around the knowledge infrastructure, including the level of funding, the composition of infrastructural activity, the internal organisation and management of infrastructure, and policy integration across government agencies. Here we focus on a specific issue for New Zealand, namely the knowledge foci and tasks of infrastructures.

Within many countries there has been a strong recent development in terms of the governance of knowledge infrastructures. This takes the form of an increasing emphasis on ‘commercialisation”, meaning the transformation of research results into new products and processes.

This emphasis has a number of problematic elements for infrastructure performance. Perhaps the most important difficulty is that it misrepresents both the nature of the innovative process, and the role of research within it. It was noted above (in Section 2.1) that innovation is “non-linear” in the sense
that it does not consist simply of the translation of R&D results, or some other process of technical discovery, into products. Rather, firms usually seek to develop new product concepts that involve new qualities and performance characteristics, and to develop these on the basis of their existing technological capabilities (in engineering, design etc). However they often encounter more or less serious problems in innovation development that require research inputs. At such points they usually need to draw on knowledge bases that are wider than those they either possess or can develop. At such points knowledges emerging from knowledge infrastructures become critical to innovation performance.

These general consideration suggest that the appropriate role of the knowledge infrastructure is not to commercialise products but to create, import, maintain, and distribute the background knowledges that form the underlying 'logos' (as Richard Nelson has called it) of particular industries. This is not a simple task. The underlying knowledge bases of agriculture, fishing, aquaculture, food production, timber products, etc., are (in advanced economies) deep, complex and science-based. Even quite basic food production requires complex instrumentation (for monitoring bacterial contamination for example), ICT and telecommunications systems, and processing technologies resting on knowledges in microbiology, or even molecular biology.

In this perspective the challenge for New Zealand policymakers is how to identify the relevant knowledge bases, how to locate them organizationally in ways that maintain openness and dynamism, and how to facilitate inter-institutional collaboration. In the first place this is an informational and evaluative problem, an approach to which is discussed in the following section.
4. A Public Policy Framework: Conclusions and Recommendations

This report has emphasised the need to conceptualise, design and implement policies for innovation on the basis of an understanding of the real characteristics of innovation processes across sectors. We have good analytical and empirical grounds for believing that innovation drives output and productivity growth. However neither economic theory nor econometric analyses tell us anything relevant about how innovation happens and might be promoted. So this report has devoted attention to exploring what we know, in terms of robust results, about innovation and economic development, especially in small open advanced economies like New Zealand.

Looking at the characteristics of innovation immediately confronts us with problems that seem intractable in terms of the economic theories which are normally used to assess public policy initiatives. Innovation is sectorally pervasive, historically cumulative, highly risky and uncertain, collaborative and therefore collective in character, and subject to discontinuous shifts. It rests strongly on inter-sectoral knowledge flows. From the point of view of the economy as a whole it is characterized by complexity and diversity, making it more or less impossible to construct economy-wide policy measures that affect all sectors equally.

Above all, innovation is systemic in character. It is an outcome of a complex system of institutions, industrial structures, educational capabilities, knowledge infrastructures and regulatory frameworks. These shape the incentives of firms to innovate, and their capabilities in doing so. The functioning of the innovation system affects which industries can innovate, and the abilities of firms to create capabilities, to manage risks, and to access and deploy knowledge. The pervasiveness of innovation means, among other things, that small open economies can – and in fact usually do – innovate and grow on the basis of long-standing mature industries that are often regarded as ‘low tech’ in character.
The argument here has been that innovation systems can be described and analysed not only in terms of structure, but in terms of functionality: in terms of how well they system performs the functions that complex, collective innovation processes require. Policymakers need to evaluate and assess functionality in order to shape, design and implement policy instruments and measures.

Assessment and evaluation is not a simple task, and this leads to the only policy recommendation of this report.

A serious understanding of the functioning of an innovation system requires a complex process of data gathering and analysis, information gathering and assessment, analysis, debate and dissemination of ideas. With the possible exceptions of Finland (in the shape of the Science and Technology Policy Council) and the Netherlands (in the shape of the Innovation directorate of the Ministry of Economic Affairs) there are no small economies that really perform this function adequately.

What is required is a small, effectively-organised and focused agency that systematically gathers, assesses and processes the information that is relevant to policy debate and development. This might include but not be exhausted by the following core elements:

- Collaboration with Statistics New Zealand on collection of, access to and analysis of innovation data, including specific industry studies relation to collaborative links and inter-sectoral flows of knowledge
- Continuing case studies of sectors and industries in New Zealand in terms of (a) identification of knowledge base components and dynamics, (b) industrial organization, (c) skills requirements and labor supply, (d) performance relative to sectors in comparator economies
• Analyses of sectoral and national trends in comparator economies; dialogue with policymakers and business communities in those economies
• Analyses of global industry dynamics relevant to New Zealand, including demand changes, socio-economic trends, and globalization trends.
• Organization of strategy forums that integrate business, policy and scientific communities in New Zealand around the challenge of identifying potential

Implicit in this is the view that information and knowledge are crucial resources both for policy and business, and that investment in knowledge related to innovation is likely to be a critical input to future-oriented innovation policies.
### Table 1: Historical Industries and Contemporary Specialisations

<table>
<thead>
<tr>
<th>Country</th>
<th>Historical growth industries</th>
<th>Some contemporary specialisations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>Fishing, Timber products, Marine transport, Non-ferrous metals, Hydro power</td>
<td>Fishing, Aquaculture, Marine biotechnology, Timber products, Oil, Marine transport, Marine electronics (navigation and subsea technologies including sonar and imaging), Non-ferrous metals and aluminum</td>
</tr>
<tr>
<td>Sweden</td>
<td>Timber products, Iron ore, Iron and steel, Marine transport</td>
<td>Timber products including advanced building materials and flooring, Engineering products, Vehicles, Telecommunications, Aerospace (military and civilian), Ships and boats</td>
</tr>
<tr>
<td>Finland</td>
<td>Timber products, Machinery, Transport equipment (especially ships), Chemicals</td>
<td>Newsprint and high-quality paper, Machinery (especially for paper industry), Chemicals (especially for paper industry), Telecommunications equipment, Ships and boats</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Agriculture, Trade and Finance, Machinery</td>
<td>Agriculture (including extension into new products, e.g. fresh flowers), Agricultural trading and commodity exchanges, Aquaculture (including feedstocks and technology), Electronics, Finance and Insurance</td>
</tr>
<tr>
<td>Denmark</td>
<td>Agriculture, Timber products, Shipping</td>
<td>High-value agriculture, Domestic and Office Furniture, Architecture and interior design, Agricultural equipment, Transport and ports, Electronics, Pharmaceuticals</td>
</tr>
</tbody>
</table>
Table 2: Innovation Activity in New Zealand: Proportion Of Innovating Companies

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry and Fishing</td>
<td>1476</td>
<td>32</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
<td>57</td>
<td>37</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>3522</td>
<td>56</td>
</tr>
<tr>
<td>Electricity, Gas and Water Supply</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>Construction</td>
<td>1209</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6276</td>
<td>44</td>
</tr>
<tr>
<td><strong>Services Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>1767</td>
<td>46</td>
</tr>
<tr>
<td>Transport and Storage</td>
<td>885</td>
<td>38</td>
</tr>
<tr>
<td>Communication Services</td>
<td>87</td>
<td>41</td>
</tr>
<tr>
<td>Finance and Insurance</td>
<td>282</td>
<td>54</td>
</tr>
<tr>
<td>Business Services</td>
<td>2181</td>
<td>42</td>
</tr>
<tr>
<td>Motion picture, Radio and Television Services</td>
<td>84</td>
<td>61</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5286</td>
<td>42</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>11562</td>
<td>44</td>
</tr>
</tbody>
</table>

Source: Statistics New Zealand, Innovation in New Zealand, 2003
Figures

Figure 1: Innovation in New Zealand Manufacturing Sectors

Source: Statistics New Zealand, Innovation in New Zealand, 2003
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