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Historical Approaches to Creativity and Innovation

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Abstract
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Chapter 5

Historical Approaches to Creativity and Innovation

Simon Ville

Introduction

Historians have been interested in innovation *per se* but especially for its contribution to economic growth. This contribution has been widely interpreted through new processes and products but also new ways of organising economic and business activity. Historians have had less to say, however, about creativity than innovation. Interest has largely focussed upon the end result of creativity, that is, innovation. This is in large part because of the greater interest in the economic and social consequences of innovation than its origins. In addition, creativity is not easily substantiated through historical evidence since it is not so obviously outcome-based, or as easily documented, as innovation. Nor has much been written about the reverse causality, that is, of innovation upon subsequent creativity. However, increased interest in recent years on the role of human capital in economic progress and the development of knowledge sectors has motivated closer historical consideration of the creative origins of innovation.

In this chapter, I will analyse historical approaches to creativity and innovation. Initially, this will take the form of a broad international comparative perspective and then, more specifically, I will address recent Australian historical experience. This will include a focussed look at sources of new technology in the interwar period. In the final section of the paper, I will address briefly the policy implications arising from the historical survey.

Creativity, Innovation and the Economic Development of Nations

Historians have laid emphasis on technological innovation as both a shorthand to describe different phases of economic development and as a causal factor in transitions between different epochs. One of the key drivers of a nation's nature and pace of economic development is innovation, particularly through the development of cost-reducing processes, the introduction of new products and services, and the development of new ways or organising the activities of firms.

The British 'industrial revolution' from the late eighteenth century was closely associated with the beginnings of a shift from a cottage system of outworkers using hand tools in cotton manufacture to the deployment of machine tools located in centralised factories (Hudson 2004). Thus, innovation was associated with both questions of spatial location and production technology. In addition, innovation was seen as the key to the explanation for this new industrial age: steam provided the wherewithal to power new machinery and, in turn, the railway system and steam shipping that created national and international markets for the products of the new manufacturing era. The chain effect of the new technology of steam rolled through the middle decades of the nineteenth century—steam's use in railways and shipping motivated new advances in iron, steel, and engineering and with it a major stimulus to the European economies (Ville 1990).

The late nineteenth century has been labelled a second industrial revolution—major advances in new, more scientifically-based industries, and in different countries, were driving a new expansionary phase: German chemicals, electricity, and automobiles should particularly be noted (Pierenkemper and Tilly 2004). American firms carried these advances through into the twentieth century, particularly by extending German technology into organisational and marketing innovations. Automobiles were now mass produced on assembly lines, sold through specialist dealers offering hire purchase, all of this achieved under new governance structures associated with multidivisional organisations (Chandler 1966).

Moving into the second half of the twentieth century, the types and location of innovation shifted once more and with it economic and industrial hegemony. From the 1950s Japanese firms began to challenge those in Europe and North America particularly through holistic innovation in manufacturing systems, known as lean production, new approaches to labour management, and the development of imaginative forms of inter-firm transacting especially just-in-time contracting (Fruin 1992).

The diffusion and transfer of technology

Besides playing a role in the economic development of individual nations, innovation provides us with a closer understanding of the interaction between the economic rise and decline of nations. "Technological leapfrogging" is the ability of emerging economies to invest in the latest phase of innovations unencumbered by the sunk costs and interdependent requirements of older technologies. This process is made the more compelling where a command structure, normally that of government, provides the leadership for a poor, undeveloped economy to invest in innovation catch up as was the experience of late nineteenth-century Russia (Gerschenkron 1962). It also requires an effective method of technology transfer. Historians have had much to say about the receptacles and obstacles to technology transfer. David Jeremy, for example, identified the key role of skilled British migrant textile workers in the successful introduction and adaption of the cotton industry in nineteenth-century United States (Jeremy 1981).

Related to leapfrogging and technology transfer is the need to distinguish between originators and users of new technology. Originating firms and nations are the first to absorb its economic benefits and have the trading opportunity to sell the innovation to others. However, recipient users, including late developing nations, avoid the costs of developing the technology and may gain more in terms of spanning developmental gaps from its widespread deployment. Thus, based on a "social savings" calculation, some later developing European nations, such as Spain, appear to have gained more from their railway system than its technological originator, Britain (Ville 1990, 167)

History confirms that the choice and duration of an innovation is often not optimal. Part of the explanation for this lies with human cognitive limits. It is also a function of the interconnections between technological systems as the leapfrogging hypothesis indicates. History provides us with the opportunity to operationalise the concept of path dependency, wherein an initially favourable innovation may continue to operate beyond what is economically optimal. The example is often given of the QWERTY keyboard, designed to minimise key clashes on typewriters but still widely adopted for computer age keyboards (David 2000).

So far, our description of the sweep of history is suggestive of the role of so-called critical, heroic or “macro-inventions”, which deals with an essentially new technology, or a cluster of, that constitutes a radical break with the past and has the ability to usher in a phase of renewed economic progress (Mokyr 1990). Where they also generated large positive externalities as a “general purpose technology” (Lipsey et al. 1998), their impact was substantial and wide-ranging, affecting both the pace of economic growth and the sources of leadership. Examples of this are thought to include steam power in the mid nineteenth century, electricity from the end of that century, automobiles in the first half of the twentieth century, and information technology in the second half. Long run economic fluctuations, known as Kondratiev cycles, have been associated with macro-inventions, rising with the diffusion of each new breakthrough and tailing back thereafter. However, within each major historical phase of macro-invention lies many individual micro-inventions, which incrementally improve the original concept and often bring the technology to a “tipping point” whereat major economic breakthroughs are reached. To achieve sustained economic progress, Mokyr argues, an economy, or particular industry, must generate both macro and micro inventions. Thus, steam shipping finally dominated the major oceanic routes by the 1880s, after decades of incremental improvements to engine efficiency, with major implications for the efficiency of international trade and the emergence of the first phase of globalisation (O'Rourke & Williamson 1999).

The institutional sources of creativity

A modified view of innovation mutes the centrality of the macro-invention and its spreading effects achieved through externalities. Instead, “innovation is perceived as a broad process, pervasively embedded in many industries” (Bruland 2004, 146). Its embracing nature is not the reverberation from a macro-invention but rather "a general social propensity to innovate" as Bruland (2004, 146) noted of eighteenth-century Britain. This perspective provides us with a powerful link between creativity and innovation as general processes. North's (1993, 16) idea of "mental models" describes society-wide belief systems that help individuals understand and interact with their environment. Mental models evolve gradually over time, their constancy enabling us to make some generalisations about populations over longish periods of time. Thus, some nations may have been more "creative" than others at particular periods of history. If the industrial revolution was the creative awakening for Britain, then the Renaissance might have been the same for Italy, and the so-called "Golden Age" of the seventeenth century for the Netherlands. While we tend to associate these particular phases of Italian and Dutch history with the creative visual arts, they were also times of significant practical innovations, note the construction of the Dutch system of canals and the innovative output of the Italian dockyards.

The institutional sources of the creative spur behind the principal phases of innovation highlighted above have not gone unrecorded. Creativity has variously been associated with major cultural and intellectual movements, types of educational institutions, the capabilities of firms themselves, and the facilitating role of government. The so-called Age of Reason and the "Enlightenment" of seventeenth-century and eighteenth-century England, which were associated with a spirit of rational and critical enquiry into real world phenomena, has been widely viewed as an essential prerequisite to the subsequent "industrial revolution". This was seen as fostering an environment of individual observation, inventiveness, and the generation of "useful knowledge" as a public good (Mokyr 2002), epitomised by Watt's realisation of the practical implications of the expansiveness of steam in a boiling kettle.

An emphasis upon more formal scientific and technical training in educational institutions provided a breeding ground for creativity and experimentation in German industry in the late nineteenth century (Arora, Landau and Rosenberg 1999). American firms of the early twentieth century such as General Electric and Westinghouse developed in-house research laboratories capable of developing a series of related technical advances in engineering and chemicals (Chandler 1990). Likewise Japanese firms contained notable research capabilities, but also drew upon government organisations and incentives to pursue innovation in fields such as steel and computing (Anchordoguy 1988).

Behavioural patterns and social processes help to provide an understanding of how ideas are shaped. Attitudes to individualism and uncertainty undoubtedly impact on the desire to experiment. Individualism expressed as a willingness to think and act differently from the mainstream will engender new ideas and approaches. A literature exists that associates de-familisation, the breakdown of large extended kinship ties, with the fostering of individualistic enterprise cultures, which includes a desire to innovate (Macfarlane 1978; 1987). Inventiveness requires a degree of risk-taking given the likelihood of failure; it additionally represents a desire to mitigate sources of uncertainty through the introduction of needed innovations. White (1992) and Ville (1998) have both argued for the importance of risk and uncertainty as an organising principle in the history of Australia. A desire to mitigate environmental uncertainties helped to shape business decisions and structures, and related to this is the fact that much creative thinking and innovative activity was designed to reduce uncertainty.

Social capital and trust-based networks

Sociologists, economists and, more recently, historians have begun to analyse the role of trust-based networks in sharing ideas and the flow of information relevant to innovation across organisational divides and geographic boundaries. At the core of this approach is the concept of social capital, which analyses the degree of interaction among individuals and between organisations who trust one another. Such information networks help to determine the extent, nature and direction of the flow of ideas although this is not always optimal since networks can have exclusive as well as inclusive implications (Maskell 2000; Ogilvie 2003). Geographic contiguity among related industries can foster trust and generate reciprocating cycles of creativity and innovation as firms provide an innovation response to a perceived need which in turn motivates new creative opportunities; such is the Silicon Valley story (Lécuyer 2006).

While social capital can help to bridge institutional and cultural divides, the concept of "communities of practice" explains how practitioners in the same field or industry can develop a mutually supportive social environment for the flourishing of new ideas (Wenger 1998). The rise of scientific and engineering societies in the eighteenth and nineteenth centuries brought together in a meeting place the demand for and supply of knowledge in the form of inventors and researchers, on the one hand, and firms that would adopt the emergent "useful knowledge" on the other. Many such societies codified their knowledge in published proceedings; for example, from 1860 the *Transactions of the Institute of Naval Architects* in Britain (Missing reference – not required – is a general comment on this journal) published the latest developments in the rapidly advancing field of shipbuilding technology. This interaction of inventor and user created reciprocal loops between creativity and innovation, as the former reacted to insights gleaned from the perspectives and needs of the latter.

The accumulation of large stocks of social capital in Britain by the eighteenth century has been viewed as an important prerequisite for subsequent rapid economic growth (Szereter 2000). British migrants are believed to have transported their social capital tradition with them to the United States and other settler nations including Australia (Greene 2001). Such a view is consistent with Laird's recent thesis that successful entrepreneurs in nineteenth-century United States owed much to their social capital connections (Laird 2006). Godley's study of Jewish immigrant entrepreneurship in New York and London, 1880-1914 (Godley, 2001 – Missing reference from Reference list – IS in references), illustrates the role of trust-based networks carried across geographic boundaries to the process of creativity and innovation. Moreover, from a comparative perspective, it confirms the significance of particular national and cultural environments as Jewish migrants in the United States behaved more entrepreneurially than their otherwise identical counterparts in the United Kingdom. His work forms part of a longer and broader historiography focussing on the cultural determinants of economic development, which includes Weiner's (1981) classic study of the development of an anti-business culture in Britain from the late nineteenth century

Our examples of the economic impact of displaced groups are replicated through history, and their significance for creativity and innovation are heightened when they bring with them complementary stocks of human capital. Indeed, migrants have often been highly talented bringing with them knowledge and creativity across many areas of the economy and the arts. In such cases, it is often governmental intolerance of diversity and heterodoxy that has driven out creative sectors of society to the detriment of the domestic economy. Mokyr (2005) has used this insight to trace increased toleration of heterodox ideas by European governments in the three centuries after 1450. Analysing 1185 scientists, he estimates a decline in mobility levels, despite improved transport facilities, as European states, competing for economic advancement, embraced their heterodox creative thinkers.

Governments can go beyond benign tolerance to a more active encouragement of creativity, particularly through mitigating many of the potential sources of market failure. Khan and Sokoloff (2004) have shown how the design of smart patent law in nineteenth-century United States made it easier for less wealthy and well-connected individuals to become inventors than was the case in Europe. Well-defined property rights, the enforcement of patent law, and the ability to raise finance through the collateral of a patent were all key features of the American patent system. The effect therefore was to foster creative activity more broadly throughout society.

Therefore, understanding the role played by particular institutions, such as social networks, government policy, and educational and research organisations, and the form of accepted behaviour (norms) between them and among individuals provides the institutional framework in which innovation has occurred. This "innovation systems" approach has been widely conceptualised and analysed in the contemporary innovation literature but has received little attention from historians (Nelson ~~and~~

~~Winter~~ 1993; Edquist and McKelvey 2000). History, nonetheless, provides the setting for analysing the evolution of distinctive innovation systems, that is, a combination of elements of continuity – key patterns – moderated by historical experience and change. Such patterns or layers, by setting some distinctive ground rules, have helped to give shape and coherence to a multi-layered national framework for innovation at the beginning of the twenty-first century.

Innovation in Resource-Based Economies: the Australian Experience

Domestic innovation and its creative spur has been focussed on resource-based industries throughout Australian history because of their key role in the economy, both as a share of output, but particularly their dominance of exports. The share of resources production (agricultural, pastoral and mining) in GDP fluctuated around 25-35 per cent from the mid nineteenth century until the 1920s, thereafter declining gradually to around 15 per cent by the 1980s (Hea~~a~~lliwell 1984, 88). The share of resources in exports fluctuated around 40 to 70 per cent (Pinkstone 1992). Staple theory, which emphasises the stimuli accorded economic modernisation through staple commodity exports, has been widely analysed and discussed in Australian historiography (Pomfret 1981; Fogarty 1985). The advisability of development centred on resource industries has been debated for at least half a century. It has been argued that resource-based development is destined to fail since the "windfall" associated with resource abundance has brought in its wake cognitive, societal, policy, and economic constraints on development. In the 1990s Sachs and Warner (1995) formalised this perspective into the "resource curse" hypothesis. Recent work has provided something of a counterbalance by indicating that the curse is not inevitable and by investigating what resource-based economies can do to mitigate it (Ross 1999; de Ferranti et al. 2002).

Nations such as Australia, New Zealand, Norway and Sweden testify to the possibilities for successful resource-based development. One element of the debate is whether resource-based development represents a focus on industries with a low technological capability. As a consequence, this may have contributed to a loss of relative international ranking of GDP per capita over the twentieth century as Australia and similar nations missed out on high growth industries stimulated by rapid technical progress such as automobiles, aviation, complex chemicals, and information technology. Such a view is also consistent with a broader academic and popular debate as to whether manufacturing industries should be the principal foundations of any modern economy. As such, the following research questions might be addressed. Are we correct to view primary industries as a low innovation sector? Does resource-based development restrain a nation from participating in the rapid change and sequential phases of new technology of the manufacturing and services sectors? Has this form of development created a heavy reliance upon imported technology at the expense of a domestic innovation system? We will address each of these questions in turn.

Innovation in the primary industries

Resource-based industries are highly dependent upon the nature and vicissitudes of climate, geology, and geography, each of which are highly spatially contingent, often requiring a different response across nations or even sub-national regions. Technology provides a means of moderating, these influences.

The natural environment that primary industries have faced in Australia has few parallels in other regions of the world, necessitating domestic solutions to many production problems. Drought, poor soil quality and pestilence emphasised the vulnerability of farming to output vicissitudes that have been marked even for such a highly unpredictable sector. Early innovations in the farming sector, therefore, focused on overcoming development obstacles and mitigating cyclical instability. These included the jump stump plough, drought and disease tolerant wheats, fertilisers, merino sheep breeding, dams, artesian wells, wire fencing and nets (Raby 1996). Moreover, regional differences in the environment have been marked, farming processes and products varying, for example, between temperate coastal areas, inland arid locations, and sub-tropical regions. In mining, Australia by the late nineteenth century began to play a key international role as one of the major extractors of mineral deposits and one of the principal sources of technical change. In contrast to the proliferation of small scale operations in Australian farming, mining soon became concentrated in the hands of the leading corporate players who had the resources and motivation to drive innovation. BHP, in particular, has used its technological know-how as a competitive advantage in becoming a resource-seeking multinational, for example in the operation of coal mines in New Mexico, a large copper mine in Chile, and a diamond mine in Canada.

Participation in new manufacturing innovation

While Australia has not been a key figure in most of the new high-tech industries of the twentieth century, she has shared in many of the benefits they have brought to producers and consumers. Australians, for example, have been heavy users of air transport and information technology products for both work and leisure. This has particularly included the primary industries—aviation, for example, has facilitated crop spraying, ore prospecting, and more generally facilitated communication with remote mining and pastoral settlements. More recently, information technology has improved operational efficiency such as through optimal crop watering and the development of electronic auction sales. Australians, in general, have been amongst the largest users, per capita, of information technology products. As such, they have shared in its benefits which, particularly over the last decade, have favoured users more than producers due to enormous improvements in efficiency and substantial reductions in price. In particular, information technology has facilitated major productivity improvements in the wholesale and retail trades, construction, and finance (Gordon 2000).

Australia has participated in high tech industries where tradeability has been limited by the physical cost of importing or the specific needs of the local market, or where government policy has provided subsidies, tariffs or other forms of support to foster a local industry. A classic example has been the automobile industry where a series of tariff and exchange incentives facilitated the first entirely Australian-built vehicle in 1948 (Conlon & Perkins 2001, 115-16).

Vertical integration and product diversification by major Australian resource companies have provided opportunities to embrace manufacturing innovation. Capabilities initially established in resource industries were often extended forward into processing and, ultimately, final good production. CSR and BHP are both notable examples of this. CSR’s early success in the nineteenth century rested on being the first company to install technologically-advanced sugar refining plants on a scale that dramatically lowered costs. By the 1930s, its research laboratories, supported by foreign licences, visits to overseas plants, and international joint ventures, led the firm to new downstream products, particularly in the alcohol and chemicals industries. After World War Two, related diversification into building materials became the company's focus including the production of vinyl flooring (1949), insulation and hardboard (1959), particle board (1960), and pre-mixed concrete (1965) (Hutchinson 2001, 109-10). Technical efficiency became the company's watchword. BHP vertically integrated forwards from mining to become the steel industry leader with major plants in Newcastle (1915) and Port Kembla (1935). Subsequently, it diversified into a range of related downstream products, which included steel alloys, hot water systems, and tools. Significantly, both companies have now leveraged their technical leadership overseas, CSR in the American building materials industry through Rinker, and BHP-Billiton, now separated from its steel-making capability (Bluescope), in many overseas resource industries as noted earlier.

Imported technology or a domestic innovation system?

International technology transfer has been a key part of the innovation process in Australia, particularly outside the resource-based industries. This has occurred through a variety of channels. Many modern manufacturing industries in Australia are dominated by foreign multinationals, who have imported innovations as part of their process of establishment and operation. On other occasions, technology has been transferred as part of a joint venture between a local and a foreign firm. It has been estimated that 83 per cent of the firms responsible for major innovations between 1939 and 1953 had overseas affiliations, while 80 per cent of payments by Australian firms for technical know-how in 1988-9 went to related foreign enterprises (Hocking 1958, 28-9; Bureau of Industry Economics 1993, 122).

It might be inferred from such a heavy reliance upon foreign technology that Australia has lacked a domestic or national innovation system, with most local inventiveness being restricted to some specific, largely primary, industries. Freeman defines a national innovation system as: “the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies” (Freeman 1987, 10). Thus, innovativeness includes activities associated with imported technologies. Perhaps most significant is the modification and adaption of foreign technologies to suit local needs, a process requiring significant creative and inventive energy. A sample of firms in the 1970s revealed that 42 per cent of their research budget was spent on modifying foreign technology (Parry & Watson 1979, 107-9).

Gregory identified four distinctive features of the Australian innovation system, each of which has an ongoing historical resonance: low science and technology expenditure, low private R & D, high government financing and participation in research, and high dependence on foreign technology. Consistent with its role in many aspects of the Australian economy, government has served as a major provider of finance and of research organisations. Much of this support has been oriented to the rural sector in recognition of the market failure problems associated with a proliferation of small producers for much of our history. Moreover, it represents a response to unique environmental challenges and the realisation that most of the benefits will be captured locally in commodity markets dominated by Australia

(Gregory 1993, 325-9). The CSIRO and its predecessor CSIR is a major public sector research organisation oriented to the needs of resource industries (Schedvin 1987). Other aspects of a national innovation system that might be emphasised a little more include the role of educational institutions, both vocationally oriented such as Schools of Mines [why was this highlighted?] and agricultural colleges, and more broadly based universities as providers of pure and applied research. Agricultural and pastoral societies are a reminder of the role of social and community movements in innovation. Stock and station agents have provided a key network node connecting farmers with a wider business and research community (Ville, 2000, 153-61). Finally, the contribution of domestic corporations has perhaps been understated in place of global companies. Local firms have played a role in negotiating joint ventures with overseas firms, seeking out other sources of knowledge, and honing their adaptive capabilities.

Research Focus: The Technological Drivers of Structural Change in Interwar Australia[1]

"…in 1914 (Australia) could barely arm its expeditionary forces with rifles, is today able to manufacture locally a sufficient quantity of the most modern and complicated weapons from warships to guns" (*Australian Investment Digest*, April 15, 1940, p. 148).

It has long been assumed that tariff policy drove structural change in the interwar Australian economy from rural industries towards manufacturing by providing price protection for infant or inefficient industries (Benham 1928; Anderson & Garnaut

1987). Investment shifts in favour of manufacturing, however, may have owed more to exogenous changes in process and product technology than to the impact of public policy. Thomas (1988, 271) has argued that "Australia's continued march towards industrialisation was based not on artificial inducements to produce manufactures, but on lower costs, underwritten by increased efficiency and productivity". Manufacturing not only expanded in sise, its technological base and what it produced changed dramatically. Technology, largely imported from abroad, was the catalyst for change by creating new products and reconfiguring cost functions. Its adaptation, industry by industry across the 1920s and 1930s, has been mapped by Mauldon (1938) who shows that there were marked differences in the rate of what he describes as mechanisation between industries and across time.

The key to this pattern of technological change was the emergence of two new general purpose technologies, electricity and the automobile. Their impact was substantial and wide-ranging. Demand for both products increased rapidly from low starting points during the interwar period. These technologies transformed many aspects of both consumption and production. Electricity provided the technological base for a wide range of new and improved consumer durables. Automobiles constituted a major new durable in themselves, which, like the many electrical household products, heralded major and exciting changes in personal lifestyles. On the production side, the flexibility, controllability, divisibility, and speed of electrical power provided many productivity-enhancing opportunities, particularly through the spread of electric motors. Automobile production created the demand directly for many new related industries such as petrol refining, the manufacture and repair of a wide range of vehicle parts, and the construction of roads and parking stations. Motor vehicles increased factor mobility across many industries, especially through improved access to raw materials and better commuting opportunities for workers in labour-intensive manufacturing.

In both cases, therefore, these new technologies created a clustering of new industries around them, but also provided productivity improvements in many older and unrelated sectors. Finally, note should also be made of the impact of these technological breakthroughs on the service sector including public transport (trains, trams, buses, and taxis), distribution systems (road vehicle transport), retail (store organisation and presentation), finance (vehicle hire purchase), and leisure (moving pictures), holiday accommodation, and recorded music), which in turn fed back into further demand for manufacturing products.

A recently-constructed database of most new capital issues in this period reveals the acquisition and adaptation of foreign patents by innovative-minded domestic firms to be a central part of this process of industrial transformation. The capital issues information, extracted from the *Australian Investment Digest,* contains evidence of 2176 new issues across the interwar period and, when compared with stock exchange data for increased company capitalisation, it appears to have captured most new issues. The aggregate trend for the number of new capital issues and the amount raised over the interwar period describes a pronounced cycle similar to other measurements of economic fluctuations in Australia. There was a steady rise of capital issues until the onset of the Depression around 1929 when their numbers fell sharply, followed by a recovery from the mid 1930s. The distribution of new issues, either by number or value, across the major economic sectors confirms the conventional wisdom, that resources were being shifted into manufacturing.

The question of investment motivation is aided by information on the reason for the capital issue, which has been coded into some standard explanations. Interestingly, more than half (58 per cent) of the value of new issues in manufacturing was derived from new companies. Twenty-five per cent of new issues were by new companies seeking to purchase the rights to manufacture and/or sell another company's products. This was predominantly about acquiring a patent from the inventor or seeking to replicate domestically the success of a product in a foreign market. This was the largest individual motivator and, in the case of new companies, accounted for almost half of the investment decisions. The subdivisions where this purpose was most significant were transport equipment manufacturing, accounting for 52 per cent of its issues, followed by petroleum and coal product manufacturing and polymer product and rubber product manufacturing (each 50 per cent), then machinery and equipment manufacturing (45 per cent). These were the new technology industries of the period most closely associated with electricity and the automobile. Sixty per cent of issues with this purpose (seeking to purchase the rights to manufacture and/or sell another company's goods or services) were directly related to the technologies of electricity or vehicle production.

The figure of 25 per cent understates the significance of innovation since a further 12 per cent of new issues were merely declared as start up capital for a new company, and a further 18 per cent as expansion or improvement capital for an existing company. A further 20 per cent of all new issues by existing companies did not state a reason, secretiveness doubtless playing a role for some innovating enterprises. Despite the lack of detailed explanation for most existing companies, we expect many purchased new technology through licences and patents and paid for other companies' brands. Thus, an extreme interpretation is that as much as 75 per cent of new capital issues in manufacturing were motivated by a desire to innovate. If innovation is interpreted in the broader sense to include organisational restructuring, the proportion rises above 80 per cent.

The expansion of existing companies was common in more mature industries such as food products, beverage and tobacco products; textiles, leather, clothing and footwear; and primary metal and metal products. Even in these mature industries, however, there were a notable number of new firms. In food products, possessing one of the largest shares of capital issues, more than a quarter of issues were made by new companies seeking to purchase rights to another company's goods or services (16 per cent) or seeking start-up capital (13 per cent).

While this research throws light on the role of innovation in structural change, we have yet to discover the origins of the creative spur behind this outpouring of innovation and adaptation. The opportunities provided by the new general purpose technologies undoubtedly motivated a response in Australia as in many other nations. However, the wide range of innovation across industries and firms old and new is suggestive of a broader propensity to innovate, which goes beyond mere imitation of overseas innovation. Australia went through a structural shift from primary to secondary industries that contrasted with the old to new manufacturing industry shift in many other smaller advanced nations in Europe that were importing American and

British technology. If Australia's experience was quite different and more marked than most nations, historical landmarks may play a role particularly the significance of Federation, World War One, and the broadening of trade routes and migration patterns in creating an Australia that was more independent and confident of its position in the world and was developing a much wider range of international ties and associations. Put another way, it may well prove to be the case that rapid institutional changes in early twentieth-century Australia lay behind a notably innovative phase of economic development. Comparisons with New Zealand, a resource-based economy that experienced more muted institutional change but also less sectoral diversification, may be instructive.

Implications for Policy

What policy implications, if any, may be drawn from our historical survey of creativity and innovation?

Innovation has come in many forms (product, process, organisational) and is clearly a major driver of phases of transformational economic change and changing industrial leadership among nations. The questions that arise from this statement are pertinent for future policy. In particular, how do nations make the most of the flow-on benefits from phases of innovation—making the right choices among technological alternatives, maximising the positive externalities, and optimising its duration.

A range of considerations may influence the choice of technologies at any one time, should the focus be on a nation's areas of comparative advantage or embrace the opportunities for diversification presented by innovation. Australia's approach has manifested various options—strong continued emphasis upon comparative advantages in resource-based industries, but diversification into manufacturing in the interwar period by adaptation of foreign technologies.

History confirms that general purpose technologies have a powerful transformational role although the principal beneficiaries are not always obvious—continental European gains from the railways and Australian gains from electricity and the automobile. In most of the high growth innovative industries of the twentieth century Australia has been an adapter and user of technologies developed overseas. As we have seen with ICT over the last fifteen years, there are many benefits from being a user nation. What is critical, however, is the ability to envisage the potential role and application of foreign-derived technologies, the facilitation of its transfer and adaptation, and the establishment of incentives for its domestic pervasion.

Finally, optimal duration is about acknowledging that macro innovations are followed by many years of incremental micro inventions that transform the efficiency and impact of the original innovation. The ability to gain leadership at the incremental stages can have wide-ranging implications, note for example the success of Japanese computer companies following initial leadership by American firms. However, duration is also about regime change—why do problems of path dependency emerge and how does regime change occur among nations and industries? While there has been an historical focus on explaining the rise of British, American and Japanese manufacturing, equally valuable would be to understand more about the leaders' fall from grace.

Australia presents particular innovation challenges—as a small nation with a comparative advantage in resource-based industries. We suggested earlier that institutional structure is more important than industrial location for a nation. Nor is smallness necessarily a barrier to innovative activity. If innovation leadership remains a possibility, there are two approaches worth pursuing in light of recent historical trends. In the second half of the twentieth century, Australia's population and domestic market grew rapidly. Yet, in many cases, scale economies accelerated more rapidly, meaning the opportunity to compete in many major industries diminished (Forster 1970). However, the raft of changes associated with globalisation and deregulation has enabled smaller economies to compete with increasing effectiveness at the sub-industry level as international specialisation within global industries expands. There is growing evidence to suggest that while manufacturing's share of Australian GDP has been contracting recently, that output is increasingly efficient, competitive and innovative (Anderson 2001, Table 13.4).

A much more recent development is the growing global concern for more efficient management of our natural resources for fear of the consequences of depletion and pollution. This throws the emphasis back upon innovation in resource-based industries and the opportunity for nations like Australia to leverage their expertise here. Recent developments in geosequestration technology is an example of this. History teaches us that resource-based economies can be highly successful and innovative and that it is the broader question of institutional framework that determines performance not the sectoral emphasis of production. As Blainey (2006, 11) noted in a recent survey of the history of Australian innovation, "The history of agriculture in the last 150 years is the history of innovation."

If many nations have experienced periods of creative awakening, what can governments do to foster a creative society and economy and to translate a sense of creativity into Mokyr's "useful knowledge" (Mokyr, 2002). Valuing creativity and heterodox thinking is a message that emanates clearly from the historical literature. Investment in human capital may be one response but the solution is also about the learning system itself and how we learn. Tolerating unorthodoxy, pure undirected research, and accepting that many areas of creative thinking and research will not produce any tangible outcome are part of the story. So too is fostering a strong sense of trust, cooperation and sharing as reflected in the concept of social capital. The treatment of science as a public good and the interaction of scientific researchers and practitioners in eighteenth-century Britain provides lessons for the twenty-first-century policy makers grappling with the significance of open source technologies and community-style websites as receptacles for shared learning.

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