A preliminary innovation evaluation system for economic development agencies
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This article examines the nature of the innovation process and its role in economic development. Evidence suggests that Australia is not only losing ground internationally in the pursuit of technology-based exports, but also in terms of its underlying innovative capacity. Innovation is essential to long-term industrial export growth, and economic development policies need to reflect the nature and the scope of the innovation process. It is proposed that one way to improve Australia’s performance is to manage the risks associated with innovation assistance by placing greater emphasis on early innovation evaluation. A Preliminary Innovation Evaluation System is described that is designed to enable economic development agencies and others to identify promising ideas at an early stage in the innovation process.

Economic development is a means to an end, rather than an end in itself. Its importance in Australia can be measured in terms of new jobs, a broadly-based higher standard of living, improved product choice, advances in health care, conservation of natural resources, reduction in pollution and practices harmful to the environment, as well as improvements in a variety of other needs. In short, economic development draws its value and justification from the potential to solve societal problems and to improve the quality of life.

The goals of economic development can be viewed from incremental and radical perspectives. The incremental view of economic development tends to be narrow in geopolitical scope and short term in perspective with a heavy emphasis on current job creation or preservation. For example, economic development activities that rely on poaching firms from other regions may create local jobs, but in the broader scheme of things, there is no net gain in employment for the country.

The radical view of economic development tends to be broader in scope and longer in duration and is more likely to contribute to long-term economic growth and vitality. These include innovative economic development activities designed to stimulate new technologies, new products, and new services. Collectively, they produce the kind of industrial performance that drives real increases in employment and other social benefits.

Radical economic development, however, also means taking greater risks. The purpose of this article is to argue the need for radical economic development and to describe a system for early evaluation that is designed to enable economic development agencies and others to minimise the risks. The first section benchmarks Australia’s competitive industrial performance and innovative capacity compared with other nations. In the second section, the multi-disciplinary process of innovation is described. In the third section, the nature of innovation risk is examined together with the importance of identifying it early. In the last section, a Preliminary Innovation Evaluation System is introduced that is designed to enable economic development agencies and
others to identify and manage innovation risk.

Benchmarking Australia’s Performance

How does Australia compare with other nations? Table 1 reflects Australia’s ranking in the United Nations Industrial Development Organisation’s Competitive Industrial Performance Index in 1998 and 1985, together with the ranking for each of the four indicators from which the index is constructed (UNIDO, 2003).

### Table 1: Australia's Competitive Industrial Performance

<table>
<thead>
<tr>
<th></th>
<th>Rank 1998</th>
<th>Rank 1985</th>
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</thead>
<tbody>
<tr>
<td>Competitive Industrial Performance Index</td>
<td>29th</td>
<td>23rd</td>
</tr>
<tr>
<td>Manufacturing Value Added (MVA)</td>
<td>23rd</td>
<td>15th</td>
</tr>
<tr>
<td>Manufactured Exports (ME)</td>
<td>30th</td>
<td>27th</td>
</tr>
<tr>
<td>Technological Structure of MVA</td>
<td>24th</td>
<td>27th</td>
</tr>
<tr>
<td>Technological Structure of ME</td>
<td>47th</td>
<td>44th</td>
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</table>


UNIDO’s Competitive Industrial Performance Index focuses upon countries’ competitive ability to produce and export manufactured goods. The top ten countries in the 1998 Competitive Industrial Performance Index are Singapore, Switzerland, Ireland, Japan, Germany, the USA, Sweden, Finland, Belgium and the United Kingdom. Australia ranks 29th, falling six places from 23rd position in 1985, and behind countries such as Slovenia, Hungary, Portugal, the Philippines, the Czech Republic, Mexico, Malaysia, Norway, Israel and Spain. The index is constructed from four underlying indicators of performance. By deconstructing the index, it is possible to shed further light on Australia’s relative performance.

Australia ranked 23rd in 1998 for manufacturing value added per capita, falling eight places from 15th position in 1985. While Australia improved the dollar value of manufacturing value added per capita from 1985 to 1998, it did not do so at the same rate as a number of other countries thus under-performing in the relative rankings.

Australia ranked 30th in 1998 for manufactured exports per capita, falling three places from 27th position in 1985. This ranking reflects the component of manufacturing value added that is exposed to international competition. Australia did increase the dollar value of manufactured exports per capita, but it did not match the increases in many other countries.

Australia ranked 24th in 1998 for the technological structure of manufacturing value added, rising three places from 27th position in 1985. The higher a country ranks on this indicator, the more technologically complex is its industrial structure. It reflects the agonisingly slow structural shift in Australia from lower technology to higher technology activities.

Australia ranked 47th in 1998 for the technological structure of manufactured exports, falling three places from 44th position in 1985. This differs significantly from the technological structure of MVA and reflects Australia’s continued dependence on exports from primary
industry rather than manufacturing industry. It also reflects the slow evolution of Australia's industrial and export structure and further highlights the need to shift both manufacturing value added and exports up the technology scale.

It is clear that Australia’s competitive industrial performance does not compare favourably with a number of other nations. It highlights the need to develop capabilities and increase productivity through innovation. Gans and Stern (2003) measure Australia’s innovative capacity and present new findings about its drivers. The Innovation Index, interpreted literally, is the expected number of international patent applications per million persons given a country's current configuration of national policies and resource commitments. Table 2 reflects the changes in Australia’s Innovation Index from 1980 to 2000 and its ranking compared with other nations.

<table>
<thead>
<tr>
<th>Year</th>
<th>Index</th>
<th>Rank</th>
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<tbody>
<tr>
<td>1980</td>
<td>20.6</td>
<td>16th</td>
</tr>
<tr>
<td>1985</td>
<td>27.5</td>
<td>14th</td>
</tr>
<tr>
<td>1990</td>
<td>29.7</td>
<td>14th</td>
</tr>
<tr>
<td>1995</td>
<td>46.0</td>
<td>14th</td>
</tr>
<tr>
<td>2000</td>
<td>50.9</td>
<td>17th</td>
</tr>
<tr>
<td>2005 (est)</td>
<td>63.9</td>
<td>17th</td>
</tr>
</tbody>
</table>


Australia’s Innovation Index has climbed steadily since 1980. However, the relative ranking compared with other nations has dropped from 14th place in 1985 to 17th place in 2000, and it is expected to remain at 17th place in 2005. Australia has improved its innovative capacity, but it has not done so at the same rate as a number of other countries. It is no surprise that Australia’s ranking for innovative capacity is reflected in its ranking for competitive industrial performance.

Like economic development, innovation can also be viewed from incremental and radical perspectives. Incremental innovation tends to focus upon small improvements that may extend the life cycle of existing products, but it rarely challenges them or opens up significant new market opportunities. In contrast, radical innovation explores new technologies and product opportunities beyond existing product lines and/or market opportunities. Australia's competitive industrial performance may ultimately depend upon radical innovation. Today's products, processes and services need to be radically improved or replaced by new technologies and new product opportunities. Competing successfully over the long run internationally will ultimately depend on achieving technological leadership in niche markets.

Gans and Stern (2003) argue that a nation’s relative performance in producing global innovation is linked to three drivers - the strength of a common innovation infrastructure, the vitality and innovation orientation of regional clusters, and the quality of linkages between the innovation infrastructure and a nation's clusters. They suggest that perhaps most importantly, Australia must expand its efforts to develop an effective pool of trained innovators, including trained scientists and engineers as well as encouraging entrepreneurship and managerial training. Education and training institutions are becoming aware of their role in contributing toward future innovative capacity. However, it is the Commonwealth and state government economic development agencies that are in the most expedient position to create a culture of innovation amongst their own clients.

**Innovation Process**

Innovation is a multi-disciplinary process characterised by a series of steps or stages. It starts with an idea, or initial discovery, that needs to be assessed, developed and tested. Everything, from the smallest incremental improvement to the most
radical technological advance, starts with this embryonic stage.

An innovator must possess, or have access to, a variety of skills and resources. For example, creativity is the essential element at the idea generation stage, technical expertise is significant at the technical research and development stage, and marketing skills are of paramount importance at the market introduction stage. The innovation process is a chain of events that is only as strong as its weakest link.

Large companies are likely to have the technical, financial, and managerial resources essential for the latter stages of the innovation process. However, they tend toward structures that do not encourage the creativity and entrepreneurial spirit that is so essential in the early stages. As a result, they may be cautious and conservative and devote their immense resources to pursuing incremental improvements instead of venturing into the risky world of radical innovation. Independent inventors and innovators, on the other hand, generally have only their creativity and willingness to accept risk as they enter into the innovation process. Unless established companies develop the entrepreneurial spirit upon which innovation feeds, independent inventors and innovators are likely to continue to be the major source of radical new product, process, and service ideas.

Inexperienced innovators often believe that the leap from idea generation to market introduction is only a short distance and they do not recognise how complex, costly, and time consuming the process can be. Complexity increases because the number of variables multiplies with each succeeding stage of the process. Costs accumulate with increased complexity, the level of technological sophistication and the relative difficulty of entering the marketplace. The time required for an initial idea to reach the marketplace can take several years because the innovation process generally follows a consecutive sequence of events and only rarely will some be undertaken concurrently.

A high mortality rate for new ideas emerges as subsequent analysis reveals why many of the ideas are not feasible. A classic problem is the discovery that a new product will be too expensive to produce relative to competitive products. There may be inherent production problems that cannot be solved, or perhaps it will not appeal to enough buyers to enable economies of scale in production or distribution. Consequently, it is important to be able to determine the commercial potential of new ideas as early as possible because it is the least costly stage in which to identify and eliminate potential failures.

**Minimising Innovation Risk**

Innovation is a risky business. The risk is greatest in the early stages (Udell, 2002), and it is compounded by the degree of radical novelty (Booze, Allen and Hamilton, 1982). Estimates of the odds of successful market entry vary from 1 in 20 (Webb, 2002) to 1 in 8000 (Kotler and Armstrong, 2002) in the United States. Even after market entry, risk is still a significant factor with estimates of new product failure rates in the United States varying from 20 percent (Crawford, 1987) to 45 percent (Davis, 2000).

Those who are most risk averse, however, ultimately take the greatest risks. Innovators and economic development agencies alike generally assume that sticking close to incremental improvements is the safest course of action. Even the short-term wisdom of this approach is challenged by the new product failure literature that cites incrementalism – the failure to innovate – as one of the major causes of new product failure (AC Nielson, 2001). Economic development agencies that only support low-risk projects are most likely to achieve very little. Pursuing a strategy of familiarity, such as searching out business relocations or providing assistance for established products from known companies, is more likely to result in a product life cycle that has already run its course and is about to be superseded by a
genuine innovation from elsewhere. This is not a recommendation for taking wild risks, but it does suggest that every economic development decision necessarily involves a degree of risk.

Most economic development programs seem to start at the wrong end of the innovation process. Infrastructure improvements and financial incentives can be important, if not essential, to an overall economic development strategy. However, they do not generally provide enough stimulus to encourage radical innovation. Independent inventors and innovators need meaningful evaluation assistance more than funding. The overwhelming majority of new ideas lack commercial merit, therefore indiscriminately investing time, money and effort in them is inefficient and costly. Innovation is not a democracy in which all ideas are created equal. It is a meritocracy in which those ideas with genuine commercial merit should receive assistance.

Creating a positive environment in which ideas can flourish may be as important, if not more so, in the early stages of innovation as traditional economic development incentives. Keeping in mind the interdisciplinary nature of innovation, it is not surprising that many innovators fall short of the competencies needed to complete the process. For example, there appears to be an inverse relationship between technical and marketing sophistication (Brown, 1988). Thus, a strong argument can be made for incentives designed to compensate for innovators’ shortcomings and needs. Technical assistance programs for innovators that are long on creativity but short on technical sophistication can pay significant dividends. Similarly, exposure to management and marketing principles may contribute toward stimulating innovation amongst technical specialists.

Most innovations are a reflection of an individual’s experience and education. However, this does not mean that their experience and education is sufficient to successfully chart a course through the entire innovation process. The vast majority of inventors, and many early stage innovators, have little, if any, experience related to the innovation process. Consequently, even potentially significant innovations fail because of mistakes that more experienced individuals would have avoided. While experience does not necessarily make perfect, assistance that compensates for inexperience may improve the odds.

Accepting the relatively high risk nature of early stage inventors and innovators does not mean that economic development agencies are forced to live with high levels of risk. It means managing the risks associated with new ideas and inventions by employing a structured methodology designed to separate the wheat from the chaff. This is not an attempt to pick winners, it is adopting procedures designed to filter out likely failures. Typically, there are too many unknowns that are crucial to success to be able to predict success with a significant degree of accuracy. However, since many shortcomings and risk factors are readily identifiable at the idea stage, predicting failure can be a more reliable endeavour.

The vast majority of new product decision models are either designed for internal corporate use, or require information that normally does not exist or is too costly to obtain in the early stages. Moreover, little attention appears to have been paid to the development of innovation evaluation models for economic development agencies to use in determining likely candidates for assistance. The result may be that too many innovators emerge from having found an idea, skip evaluation and feasibility analysis, and move directly into technical research and development. In other words, the day of reckoning for low potential projects is postponed until the cost of abandonment is much higher, highlighting the need for a structured methodology for the early evaluation of ideas.

Preliminary Innovation Evaluation System
The Preliminary Innovation Evaluation System (PIES) is precisely what its title
implies — a system for the preliminary evaluation of new product and service ideas. It is intended to provide an efficient and inexpensive decision-theory based evaluation system designed to stimulate technological innovation. It is a tool for encouraging meritorious technology, instilling insight into the innovation process, and assisting innovators to plan for the succeeding stages of development. Its overriding purpose is to make it possible to evaluate new ideas and inventions very early in the innovation process — before large sums of money are spent on further development.

Early evaluation has three important benefits for economic development agencies that support individuals and companies pursuing technological innovation. First, it facilitates the communication of evaluation results back to innovators. Feedback is critical in maintaining a supportive environment for prospective innovators. The lack of adequate feedback is a frustrating and discouraging experience for them, whereas constructive feedback can stimulate further creative activity.

Second, individuals who have an appreciation for the innovation process are more likely to be productive because they are less likely to waste time pursuing ideas that are not feasible. And third, early evaluation not only reduces the time, money and effort wasted on ideas with low potential, but also helps innovators to uncover strategies to develop and commercialise promising ideas.

PIES was initially developed in 1974 at the Experimental Center for Invention and Innovation in the United States with financial support from the US National Science Foundation, the US National Bureau of Standards and the US Small Business Administration (Baker, 1980). It has been used to evaluate an estimated 30,000 ideas and inventions primarily in the United States and Canada.

A study incorporating the PIES protocol found that it was effective in discriminating between success and failure in a 1223 case sample in the United States (Knotts, Jones and Udell, 2003). Table 3 contains the results for each of the major product evaluation categories.

Table 3: PIES Evaluation Results

<table>
<thead>
<tr>
<th>Product Evaluation Categories</th>
<th>Successful Firms (n=93)</th>
<th>Failed Firms (n=1130)</th>
<th>Significance (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score</td>
<td>Mean Score</td>
<td></td>
</tr>
<tr>
<td>Social Impact</td>
<td>82.4%</td>
<td>81.4%</td>
<td>NS</td>
</tr>
<tr>
<td>Business Risk</td>
<td>91.0%</td>
<td>84.0%</td>
<td>0.010</td>
</tr>
<tr>
<td>Demand Analysis</td>
<td>64.6%</td>
<td>58.0%</td>
<td>0.001</td>
</tr>
<tr>
<td>Market Acceptance</td>
<td>72.3%</td>
<td>66.4%</td>
<td>0.001</td>
</tr>
<tr>
<td>Competitive Capability</td>
<td>60.4%</td>
<td>57.9%</td>
<td>0.010</td>
</tr>
<tr>
<td>Experience &amp; Strategy</td>
<td>66.7%</td>
<td>59.7%</td>
<td>0.001</td>
</tr>
<tr>
<td>Venture Assessment</td>
<td>66.2%</td>
<td>59.1%</td>
<td>0.001</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>71.5%</td>
<td>66.8%</td>
<td>0.001</td>
</tr>
</tbody>
</table>

For each product evaluation category, the difference between the mean scores for failed firms and successful firms is significant except for social impact. This exception might have been the result of a de-selection process in which firms with products that were illegal, unsafe or inappropriate for the mass market might have chosen to withdraw earlier from the program. Overall, failed firms had a lower total product mean rating than successful firms (66.8 percent to 71.5 percent, p < 0.001).

A continuous improvement program has been in place since PIES was first introduced and it is now in its eleventh version. A modified version designed for European use has been launched in the United Kingdom at the University of Nottingham, with a rollout into the European Union to follow. An Australian
version is under development at the University of Canberra, designed for advisers in Australian economic development agencies. The Australian version will not only position the PIES system firmly within the Australian context, but it will also be adapted to fully integrate the services sector. In each case, the intent remains the same - to stimulate innovation and hence economic development by providing an efficient and effective means of separating the wheat from the chaff very early in the innovation process. What follows is a description of PIES and the 44 criteria that make up the system.

PIES focuses on commercial feasibility as opposed to market success because market success is a function of both commercial potential and management skill. Many commercially feasible ideas have failed not because of inherent conceptual defects, but because of poor management. Almost without exception, a preliminary evaluation is undertaken with imperfect or inadequate information and is based on subjective qualitative criteria. Hence, preliminary evaluation decisions are necessarily made with an element of uncertainty. Experience overseas has shown that self-assessment generally tends to be unrealistically optimistic compared with an objective assessment carried out by an independent evaluator or adviser who is trained and experienced (Udell, 1989).

PIES consists of an evaluation for commercial potential and an evaluation for commercial readiness. The criteria used to evaluate commercial potential are clustered into social criteria, business risk criteria, demand analysis criteria, market acceptance criteria and competition criteria depicted in Figure 1.

Figure 1: Commercial Potential

Enterprise systems around the world have matured considerably and social criteria are an important element in new product and service decision-making. Expectations about social responsibility originate from a variety of sources — such as government, advocates of various popular causes, the public, employees and shareholders — and
the importance of social criteria is likely to increase. Social criteria include legality, safety, environmental impact and social impact.

An innovator needs to understand the types and levels of risk involved in a project; the extent to which these risks can be resolved or avoided through planning, financing, and marketing; whether or not the project can survive these risks; and whether or not the innovator wants to assume these risks. Business risk criteria focus on the tradeoff between the risks associated with developing a new product or service idea and the potential returns from going ahead. Risk criteria include functional feasibility, production feasibility, stage of development and investment costs. Return criteria include payback and profitability. Risk reduction criteria include marketing research and research and development.

One of the most important questions in determining commercial potential is demand. Demand analysis criteria are also difficult to evaluate because they require some insight into the behaviour patterns of the marketplace. Even very sophisticated techniques involve a certain amount of guesswork and knowledge about the firm planning to sell the new product. Demand analysis criteria, although general at the preliminary evaluation stage, are designed to explore several key aspects about demand including the nature of market potential, the resources required to service the market, trend of demand, stability of demand, product life cycle and product line potential.

Market acceptance criteria focus on the rate at which the marketplace is likely to accept a new product or service. There are a variety of reasons why people or institutions either accept or reject new products and services. The rate of acceptance, in turn, affects the life-cycle. For example, a slow rate of adoption might mean the introductory period will be long and the innovator will need substantial financial reserves to cover this profitless period. The extent to which the market is penetrated also affects the potential for profit and the potential value to a prospective innovator. Some of these criteria are market oriented, whereas others are marketing oriented. In the first category are customer (user) oriented criteria that address perceptions and attitudes including compatibility, learning and need. In the second category are criteria related to marketing a new product or service such as dependence, visibility, promotion, distribution and service.

Some new products and services may enter a marketplace in which existing competition is already intense. Competitive criteria focus on existing products, processes, or services. The claim that 'There's no other product like it' usually reflects an impractical or narrow definition of competing products or services. Competitive criteria focus on how well an idea fares when compared with its potential direct and indirect competition on the basis of appearance, function, design durability, price and intellectual property protection.

The second part of the PIES protocol is designed to evaluate commercial readiness. The commercial readiness criteria are clustered into experience and resources, commercialisation strategies and market structure issues depicted in Figure 2.

For the most part, an innovation is the result of a successful marriage between commercial potential and commercial readiness. It is a harsh fact of life that not all individuals and organisations have the 'right stuff' to turn a good idea into a commercial success. However, having the right stuff is a relative matter. There are no hard and fast rules that can be used to predict if the right stuff is available in terms of skills, experience and resources. The right stuff in one situation may be woefully inadequate in another.
The experience and resources criteria vary depending upon the technical sophistication of the idea and the nature of the market it faces. At times, very sophisticated technologies can be relatively easy to market. It is also true that some very simple ideas can require a high degree of management, marketing or financial expertise to launch successfully. The experience and resources criteria are not only concerned with the need for key resources and capabilities, but also identifying what the innovator can provide and what help may be required. These criteria include the technical, managerial, financial and marketing sophistication required to develop and successfully launch the innovation.

The nature of the market combines with the nature of the idea to dictate which commercialisation strategies can be used to introduce an innovation into the marketplace. Projects that require a high level of marketing expertise, or major financial commitments, are probably best transferred or licensed to those who have these resources. In contrast, ideas that have relatively modest resource requirements may be good candidates for new venture start-ups or even part-time enterprises. Distribution is also part of the commercialisation strategy criteria and addresses the best ways in which to design the supply chain.

Launching a new product or service is far more difficult than most innovators anticipate. This is in part due to the complexity of the innovation process and the presence of unexpected barriers along the way. Market structure issues address the attractiveness of the market, the barriers to market entry, an assessment of risk and the expected value of the innovation. Market structure serves as a capstone judgment about the various market forces at work. These criteria do not reflect upon the merits or demerits of the idea, but they have a good deal to do with its potential for success. There are many good ideas that have been impaled upon the thorns of an unattractive market and some markets are simply not worth entering because the risks are too high or the rewards are too low.

Having evaluated an idea across all 44 criteria, an innovator and their adviser are in a position to make an informed judgment about the prospects for investing further in the innovation process. If the result is positive, then the strategy for further development can be charted with explicit purpose. If the result is negative, then having engaged in a process of objective evaluation will enable them to understand why. Understanding why is especially important for a prospective innovator if development assistance is not forthcoming.

Conclusion
Evidence suggests that Australia will need to raise its performance amongst
exporting nations in order to achieve long-term economic development objectives. Lifting Australia’s capacity for radical innovation plays a crucial role in improving competitive industrial performance. Economic development programs need to recognise the risks and match the processes of the innovation process by placing greater emphasis on early evaluation. The Preliminary Innovation Evaluation System (PIES) is one means of applying a structured methodology to the early evaluation of new ideas. Its benefit lies in increasing the efficiency and effectiveness of economic development agencies and others to improve Australia’s innovative capacity and competitive industrial performance.

References


Udell, G. G. (2002), Exploring the Rewards and Risks of Invention and Innovation, WIN Innovation Center, Southwest Missouri State University, Missouri, p. 15.

