CHAPTER ONE

Arguments Concerning Government's Investment in Research

Oliver Mayo

ABSTRACT

The paper addresses governmental decisions to invest in the enhancement of innovation, especially in research. The example of Australia is used to show how there is a role for government that is not simply dependent on public good or market failure.

INTRODUCTION

A government can choose to invest or not in research. Since the rise of the modern nation state, all governments have chosen to invest in research; however, for much of this period, the question of whether they should has been the subject of debate, largely for political and economic reasons. I shall draw on the

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example of Australia at length, and consider only the European-American tradition to draw some conclusions about the merit of government investment and why the question is still unresolved.

In his fable *The New Atlantis* (1627), Francis Bacon looked ahead to the establishment of a government foundation: "The end of our foundation is the knowledge of causes, and secret motion of things; and the enlarging of the bounds of human empire, to the effecting of all things possible." [1] If we read Bacon's *The Advancement of Learning* also, we can see that Bacon, for all his percipience, did not envisage great corporations with the power of states, and took it for granted that the state, in the person of the monarch, would encompass the foundation.

If we look to others who have been important in developing the intellectual framework within which we now work, Adam Smith in *The Wealth of Nations* takes it for granted that the wealth generated by commerce and industry will fund research (Book I, chapter 3 and many following places).[2] While he believes that academics should be paid by their students for their lectures, he accepts without discussion a role for the state in providing the infrastructure for tertiary education. When he argued that the great English universities were too rich and failing in their duty, he did so because this made the staff idle, not because the state had no place in universities.

Thomas Jefferson, in funding the expedition of Lewis and Clark, and in many other ways, demonstrated how government might usefully fund applied research; indeed, like most of the great thinkers of the late eighteenth century he did not

1. F. Bacon, *The New Atlantis* (1627; reprinted with *The Advancement of Learning* [1605], Oxford University Press, 1906), 228.

2. A. Smith, *The Wealth of Nations* (1776; reprinted in Everyman's Library, London: J. M. Dent, 1910).

distinguish between research to understand nature and research to gain mastery over nature.

In the first half of the nineteenth century, Charles Babbage, John Henry Newman, and Wilhelm von Humboldt argued, from different points of view, that the state must support higher education and that research was an essential component of higher education. McClelland[3] provides a careful discussion of the German approach, in particular the acceptance of von Humboldt's principle that a university is a place where the teachers and the taught should live their lives in science, so that it was built into the concept of state universities in an era when only Leipzig had any capacity for competition between public and private institutions. (The German sovereign states did compete with one another to attract the best staff, Justus von Liebig's move from Hessen-Darmstadt to Bavaria being the best-known. In modern times, many governments have increased funding for research to try to reverse a real or perceived "brain drain.")

The more general argument, that innovation is necessary for economic growth of developed economies, I shall take as given. Bryant and Wells[4] is a useful source for this case.

ARGUMENTS FOR GOVERNMENT FUNDING OF RESEARCH

Why have I laid so much emphasis on the university in the introduction? In essence because, in the European world, it was the only institution that always held some persons engaged

3. C. McClelland, *State, Society and University in Germany, 1700–1914* (Cambridge University Press, 1980).

4. K. Bryant and A. Wells, eds., *A New Economic Paradigm? Innovation-Based Evolutionary Systems*, Discussions in Science and Innovation No. 4 (Canberra: Department of Industry, Science and Resources, 1998).

in advancing our understanding of the physical world. From the time of Napoleon on, the French government established new institutions with specific applied research remits, and other governments came to do the same thing, but in essence the university was the one place where research was certain to be found, however imperfectly organized and sporadically conducted. It was for this reason that all governments in Europe and North America used universities as their prime means of advancing research in the nineteenth century.

It is noteworthy that there was a parallel development of technological research, which often produced new science, as the industrial revolution spread throughout the Western world. However, this was largely funded by the new capitalists who conducted research, though they did not call it that, because it would further their goals. In doing so, they bore out Adam Smith's expectations. They were an elite. Ideas of the universal availability of schooling for all were hardly in the air, let alone higher education for all who could benefit from it, as is the case in many countries today.

Why did governments engage in research from the eighteenth century onwards? Why did they send scientists with their best mariners on voyages of exploration? Why did they send naval expeditions to observe the transit of Venus, or to prepare better charts of southern waters? A prime motivation was to support colonization, but in a sense this was subsidiary to the idea of national security. A prize for accurate determination of longitude might further science, but it would primarily help the navy. To this day, governments fund research for defense purposes, on a prodigious scale.

Education is a more important reason for funding research, insofar as it affects the ordinary citizen in time of peace. The eighteenth- and nineteenth-century writers whom I have cited already all recognized that healthy higher education requires

that at least some of the teachers be engaged in creating new knowledge, in finding out more about the world in which we live, the universe in which the world sits. I have not found a single argument against the idea that universities should conduct research, and if they are to conduct research, who will pay for it? As we evolve from primitive forms of government like monarchy, we may find that private citizens more and more expect to fund higher education. However, there is no society in the world that provides evidence that the market will fund higher education for 30 or 40 percent of any given generation. The taxpayer has to do it.

Governments also fund research to enhance wealth creation, for the general well-being of a nation. This is perhaps the most contentious kind of research funding. As Macaulay would have said, every schoolboy knows that governments cannot pick winners. Everyone can point to costly failures by government in this regard, and yet it is the mechanism used by virtually all funding bodies, whether government or private, at the level of the individual scientist or the individual project or research program: funds are provided to those who are adjudged most likely to use them well and to produce results of high quality, by the standards of the day. Nevertheless, the very idea of general taxpayer support for such research remains contentious, particularly in libertarian circles.

Market failure is the ground that is perhaps most respectable for government to occupy. If we consider agriculture, we find that its mode of organization in all of the most advanced Western societies is such that very few individual primary producers can fund their own research or have a big enough stake in its outcome to take full advantage of it. Such producers will not see it as in their own interest to contribute to the funding of research unless they can do it collectively and gain collective benefits. Accordingly, governments have historically funded a

substantial quantum of agricultural research in all countries. This is changing; agribusiness now operates on such a scale that it can fund some of its own research. It is noteworthy that even where this is the case, government still funds significant research, both within government institutions and the industries themselves. It may be that, in certain economies, this particular market failure is ending. If true, it will put small producers at a bigger disadvantage than at present, because they will not be able to fund their own individually targeted research.

That something may be happening in the United States or Germany does not mean that it is happening everywhere. Consider the wool industry in Australia. This industry was established about 190 years ago, and has been successful for about 150 of those years. A century ago, it was the major factor in giving Australia the highest income per capita in the world. Eighty years ago, in a period of relatively low prosperity, the Australian government recognized that individual growers were not wealthy enough to fund the research they needed to solve general industry problems, and instituted mechanisms to solve problems on a national scale. The establishment of the Commonwealth Scientific and Industrial Research Organization (as it is today) recognized that a nation of fewer than ten million people sparsely spread over a whole continent would not find sufficient resources anywhere to address major industrial and environmental problems. What is noteworthy is that, when the government took an initiative to employ scientists to solve such problems such as parasites in sheep, wealthy individuals from the industry supported the work further financially, with the enthusiastic, informed collaboration that is the best way to take research results into agriculture. But government initiative, with a national rather than a parochial per-

spective, was needed in the state of development of Australia at the time.

If we look at the wool industry, we see that on-farm turnover was about AUD6000 million in 1990, and with the generally accepted means of funding—whereby graziers contributed one half of one percent of gross turnover and government matched this—there was some AUD60 million available to support research for the wool industry. However, market conditions a decade later have halved the contribution by producers and therefore the matching contribution from government, so that at a time when research is desperately needed to maintain the competitiveness of an inherently highly variable and expensive natural fiber, the funds available from the industry have in real terms dropped by over 75 percent. This is a real market failure as there are still some 40,000 wool growers and the top 20 percent do not produce 80 percent of the wool. Individual producers cannot capture the benefits of research and therefore should not be funding it for themselves; they are simply too small to fund projects that each cost one million Australian dollars or more.

If we turn to investment in research by the private sector, the reasons for such funding are rather different. First, there is benevolence, to regard it most positively. Individuals and corporate entities give money to research out of the goodness of their hearts or for general well-being. Foundations such as Rockefeller, Wellcome, and Ford are prime examples, and have unquestionably been of great benefit to humanity. However, they have not been subjected to the pressures of the market—they have, as mentioned above, worked by "picking winners." Furthermore, we need to recognize that there are moral arguments against foundations. John Stuart Mill provided some: he argued that the establishment of any perpetuity should not depend on the founder's wishes, otherwise we

"make the dead, judges of the exigencies of the living." [5] Having established the impropriety of a foundation, Mill determined on utilitarian grounds that foundations are, in general, good in their effects because, without them, there will be insufficient resources for the purposes to which they are addressed. He recognized that, at any particular point in time, the market would not find sufficient resources for education, research, or any of the purposes for which foundations were established. To repeat, he first established a sound argument that perpetual foundations were morally unsound.

The prime motive of all research is curiosity: how is it that things are as they are, and how might they be if we knew how to change them? As has frequently been pointed out, Charles Darwin, who did more than anyone else except, perhaps, Copernicus and Freud to change our Western view of our place in nature, never undertook a day's paid employment in his life. Moreover, his contribution, unlike that of Freud, has stood the test of time. While few independently wealthy scientists may be pointed to today, Darwin was not the only example of his kind between 1750 and 1900. It was an era when enormous advances were produced by people whom today some sneer at as amateurs. They do so foolishly, because the love of the thing is the most important driver for progress in any field of human endeavor.

Second, the private sector funds education because it needs an educated workforce, and it pays people who will do much more research than teaching because it knows that such people are essential for healthy advanced teaching to exist; the German arguments of 200 years ago have long been settled.

Finally, and very important but not necessarily as important

5. J. S. Mill, *Early Essays*, ed. J. W. M. Gibbs (London: George Bell, 1897).

as many think, is profit. The reason for my caveat is that there are still, especially in Australia, people who regard research as a cost rather than an investment. The private sector funds an enormous quantum of research in all advanced societies, including basic research in public institutions, in order to stay in business, to grow, and to be successful. Whatever the precise role of basic research in economic growth, one has, as noted earlier, to accept that some research is needed for economic growth. At the level of the enterprise, innovation is not simply application of research, but research is a significant component of innovation, especially in new and rapidly changing industries.

Before I attempt to evaluate the merits and balance of the different arguments, I will look further at the example of Australia.

THE CASE OF AUSTRALIA

European Australia developed as a set of distinct colonies, and science and technology have always been hampered by the rivalry among these colonies. Initially, research was also hampered by the small scale of any activity compared with what could be undertaken in Europe or North America, and by the consequent lack of specialization that ensured relative inefficiency, however enterprising individual innovators might be. Despite these difficulties, research related to industry did begin before Australia became a nation, mostly to support agriculture and mining, industries in which new ideas might be imported but in which those ideas had to be tested locally. Todd[6] gives a vivid picture of the development of local technology

6. J. Todd, *Colonial Technology: Science and the Transfer of Innovation to Australia* (Cambridge University Press, 1995).

and research capacity in livestock vaccines and gold ore processing between 1880 and 1910.

The development of vaccines drew on the innovations of Louis Pasteur, which the Pasteur Institute was spreading overseas through local subsidiaries. Australians recognized the need to use these new approaches to solve the problem of anthrax in the eastern states and hoped that it might also provide an approach to the biological control of rabbits. The former was successful, and vaccines produced locally by a small private company and a small public institute displaced the semi-imported Pasteur product. As well as stimulating the development of local enterprises, this major livestock problem also led to fruitful collaboration, in at least two colonies, among state departments of agriculture, universities, graziers, and the small commercial and manufacturing sector. Indeed, the companies that were established have successors that are still in business today.

Solution of practical problems led to technological innovation and scientific advance but, perhaps crucially for the future, not to development of indigenous technologies that might generate whole new industries. Scale was a factor in this outcome, but so were the needs of derivative industries (mining, agriculture based on established livestock and crop plants) and the availability of starter technologies.

When the Commonwealth of Australia was established in 1901, it had no role in research and development, or in education. Although politicians called for establishment of a department of agriculture, with research responsibilities, as early as 1901, it was not until World War I revealed Britain's, and by extension Australia's, hazardous dependence on German technology that the establishment of a research body with a national mandate was taken seriously. This is recounted by Currie and Graham. The focus of most of the proponents was

agriculture, the basis of Australia's wealth. There was widespread recognition that productivity was low, that science could increase it, and that market failure was hindering progress. But it was not all agriculture: Prime Minister William Morris Hughes announced in 1915 that a national body would be formed, "There must be a combination of science and business capacity."[7]

A body, the Commonwealth Institute of Science and Industry, was not set up until 1921, and it was not until 1926 that a truly national body was established, the Council for Scientific and Industrial Research. This occurred despite the urging of the most influential people in the community, such as Sir John Monash, one of the few generals to emerge from World War I with his reputation enhanced, a brilliant engineer who had made a substantial fortune through innovation in building materials before the war, who after the war devoted himself to public service. As president of the Australasian Association for the Advancement of Science, he said in 1924:

> The short-sighted neglect of successive Governments to make financial provision even for the bare statutory functions of the Institute have falsified the hope that under such able guidance it would become a source of varied and useful output of scientific knowledge and an inspiration to our scientific workers. We can but hope that, in course of time, a more educated public opinion will bear fruit in an adequate endowment by the State in this and in other fields of that pursuit of science which is, beyond dispute, the greatest social force in modern civilization.[8]

I am following the development of one institution because, although Australia had a proud record in innovation in agri-

7. G. Currie and J. Graham, *The Origins of CSIRO: Science and Commonwealth Government, 1901–1926* (Melbourne: CSIRO, 1966), 34.

8. Ibid., 129.

culture, mining, and mineral processing, it had a very small research effort. Universities and other tertiary institutions (schools of mines, agricultural colleges) have had a primary training role rather than a major research role. It has been estimated that in 1938 research and development constituted less than 0.1 percent of GDP (Gross Domestic Product), rising to about one percent by 1968.[9] Thus, the single institute, later council, whose expenditure is shown in Table 1, could make a significant difference to the national effort.

As the council's core funding from the treasury rose, so did the contributions from other government bodies and, more important, from industry. The council tackled major agricultural and environmental problems, which were no respecters of State boundaries. In this period, the peak level of industry funding was well over 20 percent. The Council was filling a gap; it was not crowding rural industry out of research and development; rural industry had not been able to fund its own research and development because producers were too small to capture the benefits, and overseas research and development was not always relevant to Australia's industries and environments: market failure at its simplest. From the trough of the Great Depression, the treasury appropriation rose every year, and ballooned during World War II, as the council addressed the problems of wartime production for an isolated, threatened nation. Secondary industry boomed in Australia, and technologies previously seen as too hard or too big, especially electronics and aircraft manufacture, were started. Government laboratories complemented but did not displace those developed by industry.

9. C. B. Schedvin, *Shaping Science and Industry: A History of Australia's Council for Scientific and Industrial Research, 1926–49* (Sydney: Allen and Unwin, 1987).

TABLE 1. Expenditure and revenue sources, 1926/27 to 1948/49 (£ thousands)

		DERIVED FROM		
Fiscal Year	*Total Expenditure*	*Commonwealth Treasury*	*Other Government Bodies*	*Private Industry*
1926/27	45	45		
1927/28	83	82		2
1928/29	105	102		2
1929/30	142	109	30	5
1930/31	157	115	21	21
1931/32	122	70	37	15
1932/33	117	64	43	10
1933/34	125	80	29	15
1934/35	150	106	21	23
1935/36	180	122	20	37
1936/37	218	158	20	40
1937/38	264	196	19	50
1938/39	277	200	19	59
1939/40	306	232	17	57
1940/41	366	287	26	53
1941/42	431	346	18	66
1942/43	541	435	18	89
1943/44	677	561	18	98
1944/45	922	776	18	128
1945/46	1118	1009	18	91
1946/47	1505	1380	12	113
1947/48	1814	1698	14	103
1948/49	1994	1849	15	130

SOURCE: Currie and Graham 1966, Schedvin 1987.

Success of government research under the artificial condition of war prompted successive, fairly *dirigiste* governments to strengthen CSIR, renamed CSIRO, and the defense and nuclear laboratories. However, high tariff barriers and cash-starved universities did not engender innovation. Continued success for the cyclical but relatively efficient agricultural and mining sectors allowed the small economy to grow hugely for

two decades after the war. The need for change did not become widely apparent for another decade, and for the last two decades of the century, successive governments tried a huge range of methods to encourage innovation.

Table 2 shows CSIRO's sources of research and development funding for the most recent years available. What happened nationally at the same time? Expenditure rose and fell in actual dollars, because of changes in business expenditure on research and development (BERD). In 1998–99, BERD was about AUD3733 million, a fall of 5 percent in the previous year, and 9 percent from the year before that. BERD represented about 0.67 percent of GDP. The peak was 0.86 percent in 1995–96.

In international comparisons, Australia is below average for Organization for Economic Cooperation and Development countries for BERD, and slightly above average for government expenditure on research and development (GERD), so that a hasty conclusion might be that government expenditure was crowding out private expenditure. However, this would be to conclude that crowding out was occurring in Australia at a total level of expenditure far below the OECD average. Table 3 shows actual expenditures and Table 4 the OECD comparative figures.

What we can see immediately from Tables 2 and 3 is that there is no detectable crowding out. Until 1997, BERD expanded faster than public expenditures on research and development (PERD), over almost a twenty-year period. During the same time, the largest single government agency expanded its external income relatively rapidly, while government funding also rose. However, once base government funds plateaued, so did external income, for which CSIRO has a target of 30 percent of total expenditure.

As noted above, BERD declined in the last year shown. This

TABLE 2. CSIRO Income from all sources 1978 to 1999 (CSIRO Annual Reports)

	Appropriation	*Other Governments*	*CRC*	*Other Competitive*	*Private Industry*	*Total*
1978–79	168.9	—	—	10.6	11.6	191.0
1979–80	195.1	—	—	12.3	14.1	221.4
1980–81	248.6	—	—	15.8	18.6	283.1
1981–82	288.6	—	—	17.3	24.8	330.7
1982–83	326.6	—	—	19.0	30.7	376.3
1983–84	328.6	—	—	19.2	29.8	377.6
1984–85	319.3	—	—	20.6	40.3	380.4
1985–86	328.2	—	—	23.7	56.5	418.4
1986–87	367.9	—	—	33.2	45.0	445.9
1987–88	346.5	—	—	42.8	61.5	451.6
1988–89	348.1	—	—	54.4	69.5	472.0
1989–90	375.2	—	—	63.2	63.0	501.4
1990–91	414.3	—	—	62.2	94.5	571.1
1991–92	442.2	—	2.7	60.8	114.8	620.5
1992–93	432.6	—	8.3	82.0	175.8	698.7
1993–94	456.1	—	16.8	55.3	174.0	702.2
1994–95*	458.6	49.0	26.9	58.5	61.2	654.2
1995–96	417.8	49.8	28.4	57.5	66.4	619.9
1996–97	443.8	48.4	34.0	64.5	74.7	665.4
1997–98	417.5	52.3	32.5	63.9	77.5	693.7
1998–99	474.6	63.1	32.3	66.8	69.4	705.2

* Change in method of presentation. Competitive rural industry (wool, etc.) funds accounted for differently.

is generally agreed to have been the result of a reduction (from 150 percent to 125 percent) of the allowable deduction of the cost of research and development for tax purposes.[10] Whether the decline is real may be argued for years, because advocates of reduced government expenditure on research and develop-

10. R. Batterham, *The Chance to Change: Discussion Paper by the Chief Scientist* (Canberra: Department of Industry, Science and Resources, 2000).

TABLE 3. National Australian expenditure of research and development at current prices ($M)

	GROSS EXPENDITURE ON RESEARCH AND DEVELOPMENT		
	BERD	*Public ERD*	*GERD*
1978–79	245.8	808.8	1053.8
1981–82	373.7	1188.1	1561.8
1984–85	731.1	1684.5	2415.6
1986–87	1288.6	2085.7	3374.3
1987–88	1505.8	2229.1	3734.9
1988–89	1798.3	2482.4	4280.7
1990–91	2099.8	3122.2	5222.0
1992–93	2861.9	3621.0	6482.9
1994–95	3508.3	3958.4	7466.7
1996–97	4246.9	4557.9	8804.8
1998–99	3991.7	4858.3	8850.0

SOURCE: Supplied by Dr. Derek Byars, ABS.

ment (and tax forgone is equivalent to expenditure) consider that tax-driven research expenditure may include much creative rebadging of other expenditure. Other changes may make future increases more difficult to achieve: over the period 1996–99, the Australian Mathematical Society has shown that university teaching staff in mathematics and computing science declined by 13.5 percent, and there were smaller declines in many other sciences.

As Table 4 shows, Australia's overall expenditure on research and development is not high in OECD terms. Hence, we might not expect crowding out, if it occurs only at very high levels of government expenditure. However, since BERD is so labile in regard to incentives, it clearly can be increased through policy initiatives, just as PERD can be held static, agency by agency.

What I have not discussed, partly because of space and partly because of lack of expertise, is the relationship of national culture, character, and experience to investment that is

TABLE 4. R&D expenditure as a percentage of GDP

	AUSTRALIA			OECD
	BERD	*PERD*	*GERD*	*GERD*
1981	0.19	0.69	1.0	2.0
1985			1.1	2.3
1990	0.54	0.72	1.3	2.4
1991				2.3
1993	0.67		1.5	2.2
1995	0.73		1.6	2.2
1996			1.6	2.2
1997	0.78			2.2
1998				2.2
1999	0.71		1.6	2.2*

*Of which BERD = 1.5.
SOURCE: OECD, 2000.

inherently both risky and long-term. Australian investors in the preprivatization era always accepted risk as an essential part of investment, and in effect gambled, especially on mining exploration. There has, as yet, been no acceptance that investment in research on a large scale is a portfolio activity in which individual programs of work are no safer than a search for gold in new country, but overall the returns will be substantial. The central-limit theorem is not part of the Australian psyche.

ARGUMENTS AGAINST GOVERNMENT FUNDING OF RESEARCH

The first argument is a moral one: government has no right to exact taxes for the purpose of funding any activity that could in principle be carried out in the private sector. Because the experiment of zero public expenditure on research has never been tried in any country that uses the results of research (one cannot count a monstrous aberration like the Khmer Repub-

lic), one can only speculate what the outcome would be. However, there is substantial evidence of market failure in many research areas, especially agriculture (as already discussed at length), preventive medicine (and public health in general) and the environment, so most people would accept that there is no absolute moral or ethical reason for government not to fund research.

Second, there is the argument that government funding of research is inherently inefficient, so that most research should not be conducted or funded by government and its agencies. This is a matter of degree; as noted, there are many examples of waste in publicly funded research and of failure of "picking winners" as a strategy, yet private nonprofit research is funded in much the same way. Accordingly, if one accepts that government has a place in funding research of some kind, concern about waste is an argument for better public accountability, rather than for zero public funding.

The set of connected arguments that is most discussed in recent years is that popularized by Terence Kealey.[11] The arguments are not wholly new, indeed perhaps date back to Joseph Priestley and Herbert Spencer, but I shall address Kealey's account because it has received a considerable degree of media credence despite some cogent criticism (see especially David,[12] Mayo,[13] and Nelson;[14] I shall only repeat material from those papers where they impinge directly on my argument).

11. T. Kealey, *The Economic Laws of Scientific Research* (Basingstoke, Eng.: Macmillan, 1996).

12. P. A. David, "From Magic Carpet to Calypso Science Policy," review of *The Economic Laws of Scientific Research*, by Terence Kealey, *Research Policy* 26: 229–55.

13. O. Mayo, review of *The Economic Laws of Scientific Research*, by Terence Kealey, *Australian Journal of Statistics* 39: 116–18.

14. R. R. Nelson, review of *The Economic Laws of Scientific Research*, by Terence Kealey, *Issues in Science and Technology* 14: 90–92.

Kealey's first argument is that the model of wealth creation through research that has been used to justify public expenditure on research is flawed. That is, he claims that policy in general is based on the idea that government-funded academic research produces outcomes that are taken up by industry in the form of technology based on the research and that this leads to economic growth. It is not clear that all governments accept this argument, but there is certainly a public "cargo cult" approach to science that matches this caricature. Kealey's view, which appears to be widely shared, is that technology is the main driver of wealth generation and demands for technology create a marketplace for research which ensures, as marketplaces are said to do, that the right research will be done. He concludes that the free market will supply sufficient basic science, by "sufficient" meaning at least as much as is supplied by any existing government policy. Private waste is irrelevant to the argument since it is private capital at risk, not the taxpayer's coerced funds.

In pursuit of this conclusion, Kealey claims to have derived a set of laws of research funding:

> The First Law of Funding for Civil Research and Development states that the percentage of national GDP spent increases with national GDP per capita.
>
> The Second Law of Funding for Civil Research and Development states that public and private funding displace each other.
>
> The Third Law of Funding for Civil Research and Development states that the public and private displacements are not equal: public funds displace more than they do themselves provide.[15]

Laws of this kind are empirical generalizations from large bodies of data. They have been very useful in science as it

15. Kealey, 245.

becomes more quantitative—for example, Dollo's Law from biology. In general terms, it states that evolution is irreversible. In the form that Dollo stated the law in 1896, it was more precise and explicit, and counterexamples were rapidly discovered. This is how science advances; a generalization is made, tested and, if not falsified, is usefully predictive. Theory is developed that has the law as a deductive outcome. We can now explain how it is that organs lost in an evolutionary lineage are never regained in that lineage, and that is how Dollo's Law is remembered today.[16]

As yet we have no theory capable of yielding Kealey's laws, because we are at the stage of testing it empirically. The evidence for the first law suggests that it is approximately true, but that the form of the relationship is not straightforward. David has suggested that the observed relationship arises partly through invalid comparison of a group of poor countries and rich countries. It may be true over time within one country but differ in functional form among countries.

The Australian evidence tabulated above forms a counterexample to the universality of application of the second law and the third law.

One particular concern for a small country that might try to develop a quantitatively rigorous science funding policy is that the laws do not address qualitative issues. From the Australian experience described above, such issues include the absence of an ordnance industry and its technological underpinnings in time of war, and the failure of native innovators to develop novel technologies that could lead to whole new industries. (Other small countries such as Holland and Switzerland have done so.) These laws could be regarded, if correct,

16. G. G. Simpson, *The Major Features of Evolution* (New York: Columbia University Press, 1953).

as addressing some of David's important questions for policy on government investment in research:

1. How closely linked are basic science and innovation in the high-technology sector?
2. Is there a balance of basic and applied research? If so, is it constant and universal?
3. How much of the GDP should be spent on research and development?
4. Within that proportion of GDP, how much public, how much private funding?
5. Should there be financial incentives for private-sector investment in research and development?
6. How effective are such incentives?
7. How well do Kealey's laws stand up to scrutiny?

Because of Australia's failure to develop novel industries, despite strong basic research, the answer to (1) concludes that there can be no inevitable commercial or industrial outcome from basic research. Similarly, (2)'s answer must involve recognition that one size cannot fit all. It is clear that the answer to (6) is that these incentives can be very effective within the levels of funding that Australia has achieved to date. If Australia's funding is perceived to be inadequate (a value judgment that I share), then the answer to (5), for Australia, is *yes*. In the same vein, for Australia the answer to (3) is that Australia should spend substantially more, perhaps up to the OECD average. (Australia's attractiveness to potential immigrants, customers and investors depends partly on the quality of its infrastructure, which is an argument against below-average performance, if nothing more.)

The answer to (7), overall, is that the laws do not stand up

very well to careful scrutiny, but the ideas inherent in the laws have substantial validity. That is, governments need to justify carefully any discretionary expenditure, and watch for any disruption to effective market mechanisms, while at the same time not closing their minds to real cases of market failure and the need to initiate new policy, rather than follow trends. With these ideas in mind, let us consider how one small country, Australia, might improve its innovation.

Australia's chief scientist (Batterham) has made a number of suggestions to increase innovation and wealth-creation. The ideas, possibly good in each particular case, may be summed up as "more is better." No quantitative relationship between research expenditure and wealth is proposed; no awareness of issues such as those dramatized by Kealey informs the report. Why provide five hundred special research scholarships through the Australian Research Council (the main general federal government body supporting basic research in universities), not one thousand or some other number? Why double, not increase by say 50 percent, the number of post-doctoral fellowships? Why expand the Co-operative Research Centre Program (a scheme designed to bring research providers and industry together to conduct research and education directly relevant to industry) to involve small companies, rather than introduce competitive research and development grants available only to small companies working with research providers? Such grants would be more efficient for the funding body to administer and easier for small companies to use effectively.

Following the production of this discussion paper, a major national conference made some related recommendations:

1. Public understanding of the need for improved innovation to support national well-being and competitiveness should be facilitated through a public aware-

ness campaign, improved education for innovation, and various specific programs to foster and encourage innovation by the young.

2. Industry should receive increased tax incentives, both at a basic level (up from 125 percent to 130 percent tax deduction) and if certain targets were achieved at a higher level (200 percent).
3. Industry should be able to compete for special grants for research infrastructure.
4. Funding should be doubled for a government scheme designed to achieve rapid commercialization of new technologies.
5. Funding for the ARC should be doubled over five years.
6. Co-operative Research Centres should be encouraged to focus internationally.
7. Funding should be provided to improve international mobility of researchers to and from Australia.

These proposals were costed and would in toto draw Australia closer to OECD averages for BERD and GERD.[17] However, there was still no quantitative rationale for the differential allocation of funds.

The Australian government's response was to implement (4) and (5) as stated, and to introduce a range of measures covering all other points in varying degree (Anon., 2001). However, the quantitative differences from the recommendations and the actual funding levels chosen were not explained or justified. In toto, the new proposals represent approxi-

17. *Innovation Unlocking the Future*, Final Report of the Innovation Summit Implementation Group, Canberra, 2000.

mately one-third of the increase that would be needed to bring Australia's GERD up to the OECD average. If the increases in GERD stimulate BERD substantially, then GERD may rise more, but no predictions have been presented publicly.

If a case is to be made for a change in government funding of research, whether upwards or downwards, it needs to be based on better arguments than we find to date.

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