IPA Submission to Productivity Commission
Review of Public Support for Science and Innovation[1]

An apparently strong economic argument exists to support the public funding of science. The standard analysis, however, rests on a series of assumptions. Each of these assumptions will be examined in turn and each will be shown to be defective. Furthermore the standard analysis abstracts from 'real-world' issues that have considerable impact on actual policy conclusions. In many instances effective government funding of science would require the government to have information or foresight that others do not, and cannot have. Finally, the standard analysis ignores industrial organisation questions that also undermine the usual policy conclusions. In sum, the standard economic analysis that suggests a substantial role for government in funding science is flawed.

Research and Development as a Public Good

Kenneth Arrow argues that markets will fail in the face of three factors; indivisibility, inapproriability, and uncertainty.[2] He then argues that 'invention', which he defines as the 'production of knowledge', suffers from all three conditions, and therefore the market will underinvest in basic R&D.[3] The first point to note is that Arrow is very specific: the market will underinvest in *basic* R&D, not *all* R&D. The second issue relates to what exactly constitutes an 'underinvestment'? This question is quite important. In this regard Richard Romano[4] is worth quoting in full: "In the frictionless perfectly competitive market, with no barriers to the use of information, *the market will provide no R&D investment*" (emphasis added). The third point, of course, is to ask whether Arrow is correct in his classification of R&D? We defer discussion of the second point.

Goods and services with Arrow's characteristics are usually described as 'public goods'. Public goods have two characteristics: they are non-excludable (indivisible) and non-rival (inappropriable). Excludability relates to the ability of person x preventing person y from consuming a good or service. Rivalry relates to person x's consumption reducing person y's ability to consume the same good or service.

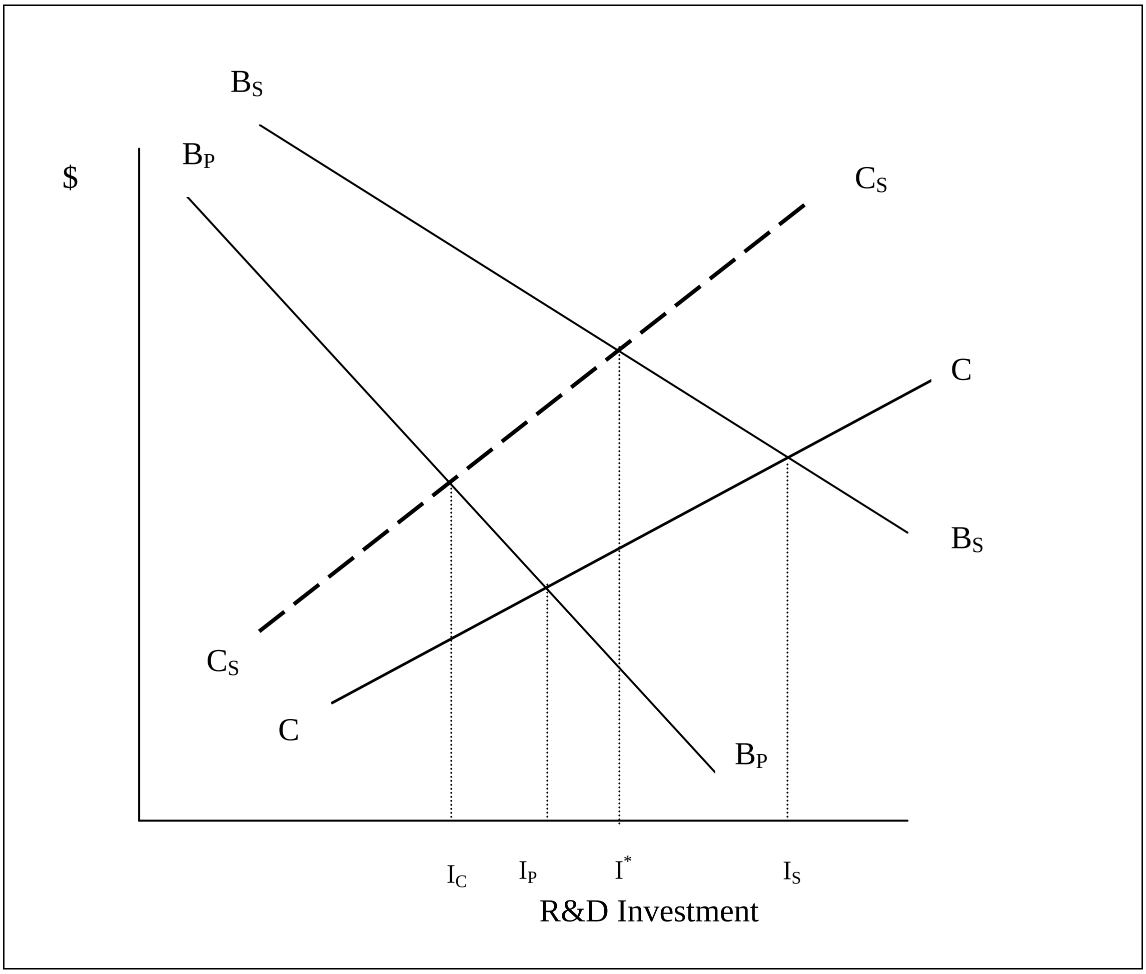
Many discussions about R&D activity implicitly assume that R&D is a pure public good, or that the tragedy of the commons prevails. The tragedy of the commons is often described as an 'open-access' property rights regime. In this type of arrangement anyone can use a resource, but cannot exclude anyone else using the same resource. Examples of the tragedy of the commons include fishing grounds in international waters and traffic congestion. The argument goes that private firms would not undertake R&D simply because their competitors would immediately copy the output and the originator of the R&D would not earn a return. This argument, however, is *not* about rivalry, but about excludability.[5]

R&D is non-rival, but can be excludable.[6] The legal system operates well in this regard. Most R&D activity does not fall into the definition of being a pure public good. In other words, the case of R&D is not a good fit to the theoretical literature on market failure. Keith Pavitt argues that the 'publicness' of R&D is a mistaken application of theory, and displays an ignorance of empirical evidence. He states, "Risk aversion, low or zero marginal cost of application, and the difficulties in appropriating benefits have become standard explanations for the public subsidy of science. … Over time progressively fewer references have been made to the empirical evidence, and more to the standard theorems of welfare economics. Whilst it might be advantageous in the economics classroom to assume that basic science is instantly applicable and easily transferable, … such assumptions are empirically invalid, and have effectively restricted debate."[7]

Spillover and Market Failure: The Standard Economic Analysis

The standard economic argument for government subsidy is the existence of positive externality, or spillovers. This notion is the appropriability concept discussed earlier. The benefits of R&D are not entirely appropriable. To the extent that an innovator cannot appropriate 100 percent of his invention, the argument goes, there will be an underinvestment in R&D.[8] The 'solution' to this underinvestment is a government subsidy, or tax concession.

The diagram below shows the usual economic analysis that underpins the argument for public subsidy of science.



The B_PB_P curve shows the private benefits of undertaking R&D investment while the CC curve shows the (private) costs of undertaking R&D investment. Due to the existence of spillovers, the social benefit of R&D (denoted B_SB_S) is greater than the private benefit. The innovator would set their private benefit equal to their private costs and invest I_P in R&D. If the innovator took social benefits into account, however, they would set social benefits equal to cost and invest I_S in R&D. The difference (I_S – I_P) constitutes underinvestment in R&D and provides a basis for public intervention. Charles Jones and John Williams calibrate a theoretical growth model and estimate underinvestment to be two to four times current R&D investment.[9] This latter figure implies US gross domestic expenditure on R&D should increase from (about) $291 billion to $1.167 trillion.[10]

There are, however, some difficulties that the standard analysis glosses over. There are costs associated with public intervention. The total (social) costs are shown in the diagram as the C_SC_S curve. If we were to set the social costs equal to the social benefits, then an amount I^* should be invested in R&D. It is not clear, however, that I^* falls to the right of I_P. The figure is drawn showing that it does, but the social costs of intervening in the market may be far higher than expected, and the equilibrium point may be to the left of the private equilibrium. There is a further complication. If social benefits of R&D spill out of the firm into society, the costs of intervention may spill into the firm. For example, public science may increase the wages of scientists but not necessarily increase either the quantity or quality of scientists.[11] If the innovator set his private benefit of R&D equal to the social costs then the equilibrium R&D level (I_C) will always be to the left of the private equilibrium (I_P). To what extent does public subsidy to R&D 'crowd out' private R&D?[12]

There are two strands to the literature addressing this question. Three studies (including two literature reviews) published in 2000 shed some light on the issue from a micro-economic perspective. In short, it is unclear whether public support for R&D crowds out private R&D. Paul David and Bronwyn Hall find that the supply of trained scientists is very important in determining this question. If public intervention simply increases the wages of scientists and engineers then crowding out can occur.[13] In a review of econometric evidence, Paul David, Bronwyn Hall and Andrew Toole conclude, "the overall findings are ambivalent".[14] Finally, Bronwyn Hall and John van Reenen argue that \$1 of tax subsidy generates \$1 of additional R&D.[15] This implies no crowding out. It is premature, however, to draw that conclusion. Hall and van Reenen include the administrative costs of raising tax revenue, but *do not take account of the deadweight cost of taxation*. The social costs of government providing \$1 of R&D tax subsidy are far higher than Hall and van Reenen estimate. In other words, their result is consistent with equilibrium being at I_C.

The second literature that provides insight into 'crowding out' is endogenous growth theory. Technology and technical progress plays an important role in driving economic growth in these models. An important assumption that requires examination is the notion that *all* R&D drives economic growth. This is a generally accepted approximation. In 2003, however, the OECD published an official report into '*The Sources of Economic Growth in OECD Countries*'.[16] As part of that analysis the OECD disaggregate R&D into a private and public component. As expected there is a positive and statistically significant relationship between overall R&D and economic growth, and also between private R&D and economic growth. In contrast to the usual assumption there is a statistically significant *negative* relationship between public R&D and economic growth.[17] The OECD report expresses some surprise at this result, suggesting that more sophisticated estimation techniques or more complicated analysis may reverse the unfavourable result for public R&D. Indeed, that may be the case; conversely until that analysis is actually performed we cannot know what the outcome will be. As the OECD concede, "at face value [the results] suggest *publicly-performed R&D crowds out resources that could be alternatively used by the private sector*, including private R&D. There is some evidence of this effect in studies that have looked in detail at the role of different forms of R&D and the interaction between them."[18] Clearly, those studies that show a positive relationship between all R&D and private R&D and economic growth are incomplete. In order to justify public expenditure on R&D, a positive relationship between public R&D and economic growth must be found.

In describing the benefits to R&D, both private and public, we encounter Hayek's information problem, "how to secure the best use of resources known to any of the members of society, for ends whose relative importance only these individuals know."[19] The information problem implies that only the innovator can know what B_PB_P might be. It is possible to establish the benefits of R&D after the fact, but this type of analysis relies on look-back bias and data snooping. Nobody can know B_SB_S – the extent of future use of current knowledge can only be known when future entrepreneurs apply that knowledge. In other words, B_SB_S can only be determined after the fact.

James Buchanan has emphasised a distinction in those costs that can be objectively measured, and those costs that impact upon choice.[20] Choice-influencing cost is subjective, and is described as being "that which the decision-maker sacrifices or gives up when he makes a choice."[21] Objective cost, however, is different and does not imply choice. Cost in this context relates to "the market value of the alternative product that might be produced … cost is measured directly by prospective money outlays."[22] Objective cost is the *ex post* cost of undertaking a particular activity, not the *ex ante* cost. This tells us the cost of achieving a particular outcome once a choice has already been made, but nothing of the choice itself. This is an important distinction. The objective cost, the cost that can be subsidised, is only a portion of the subjective cost that an innovator might consider. Yet, economists treat it as the total cost. As Buchanan indicates, "That which happens after choice is made is what economists seem to be talking about when they draw their cost curves on the blackboards and what accountants seem to be concerning themselves with."[23] In other words, the CC curve is an objective *ex post* type cost.

The argument has emphasised that the standard analysis has conceptual difficulties. There are also a number of industrial organisation issues that the literature never addresses. For example, are the firms under discussion operating under conditions of perfect competition, or do they have some degree of market power? If firms do have market power then there may be an over-investment in R&D.[24] In any event, what type of investment are we talking about? Many R&D projects end in commercial failure. Should we include or exclude investments that fail? The implicit assumption that many economists seem to make is that all R&D activity is valuable even if it is not profitable.

Economists also have great difficulty in explaining how these spillovers or positive externalities actually occur. Zvi Griliches provides a specific definition of R&D spillover as the following: "ideas borrowed by research teams of industry *i* from the research results of industry *j*."[25] What does it mean to 'borrow' an idea? Broadly speaking, it seems that there exists six possibilities of how an asset can be acquired: by purchase, purchase at less than factor cost, theft, gift, acquisition following loss, or acquisition following abandonment. None of these constitute an externality. Ideas can be copied, and that appears to be Griliches' view. If they are copied with permission, no externality occurs. If they are copied without permission a theft has occurred. This is a property right problem, not an externality problem. It seems that R&D spillovers, following the Griliches definition, can either be the result of some loss or abandonment. To the extent that externalities are due to a loss, the question arises why the owners of the innovation do not recover their property? Richard Nelson argues, "External economies result from [the fact] that research results often are of little value to the firm that sponsors the research, though of great value to another firm …”.[26] Spillovers occur because ideas are abandoned – hardly a basis for government intervention.

Conclusion

The intellectual basis for government funding of science is flawed. The costs are higher than currently believed, while the benefits are far lower than estimated. In any event, the standard theoretical economic model has practical difficulties. It may well be a tool that explains economic theory and logic under classroom conditions, but it has severe shortcomings as a practical guide to policy. For example, it is silent on a number of important issues:

- How large are the externalities?
- How are externalities measured ex ante?
- What R&D activity should be subsidised?
- Which firms should be subsidised?

The government spends a substantial amount on public science and innovation. It is not clear that any substantial benefit is derived from that expenditure. It must be emphasised that just because an economist can imagine a market failure, it does not follow that actual markets do fail.

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[1] This submission is authored by Sinclair Davidson and is based on a forthcoming IPA Backgrounder.

[2] K J Arrow, 1962, "Economic Welfare and the Allocation of Resources for Invention", In *The Rate and Direction of Inventive Activity*. Princeton University Press. Reproduced in N. Rosenberg (ed). 1971. The Economics of Technological Change: Selected Readings. Harmondsworth: Penguin Books.

[3] Much is made of uncertainty in the economic literature, especially in the innovation and R&D literatures. The impact uncertainty has on the real economy, as opposed to theoretical analyses is oversold. Gordon Tullock has written, "Actually, most economic actions are taken under conditions of imperfect knowledge and under circumstances where the outcome cannot be known with certainty. *In this respect applied research does not differ from other forms of economic activity*" (emphasis added). Gordon Tullock, 1966, *The organization of inquiry*, Volume 3, The Selected Works of Gordon Tullock, Liberty Fund: Indianapolis, 2005, pg. 16.

[4] Richard Ramano, 1989, "Aspects of R&D subsidization". *The Quarterly Journal of Economics*. 104: 863 – 873, pg. 863

[5] In any event, it is not clear this argument is entirely true. Terence Kealey has written, "Contrary to myth, the private sector does tons of science – because it is so profitable." See Terence Kealey, 'Can science get by without your tax money? Just ask them over at IBM', *The Times*, 5 June 2006, pg 19.

[6] Even the non-rival nature of R&D needs to be qualified. Even though knowledge and information is non-rival, it is also not free. As Terence Kealey indicates, "have you cloned an organism recently? Or etched a silicon chip? Nor have I. Even though the relevant papers are freely available, only a handful of specialists have the knowledge required to understand them." Terence Kealey, 'Science spending a waste of public money', *Financial Times*, 13 July 2004, pg. 21.

[7] Keith Pavitt, 1993, 'What do firms learn from basic research?' In Dominique Foray and Christopher Freeman (Eds) *Technology and the wealth of nations*. London: Pinter Publishers, pg. 31.

[8] As William J Baumol indicates, it is not desirable that zero spillover occurs. See William J Baumol, 2002, *The free-market innovation machine: Analyzing the growth miracle of capitalism*, Princeton: Princeton University Press, especially chapter 8.

[9] Charles I Jones and John C Williams, 1998, "Measuring the social return to R&D", *Quarterly Journal of Economics*, 113: 1119 – 1135.

[10] OECD, 2004, *OECD in Figures 2004 Edition*, Paris.

[11] See Austan Goolsbee, 1998, 'Does government R&D policy mainly benefit scientists and engineers?', *American Economic Review*, 88: 298 – 302, for a discussion of this point. Also, Paul M Romer, 2000, 'Should the government subsidize supply or demand for scientists and engineers?' *Innovation policy and the economy*, I: 221 – 252.

[12] Crowding out of private R&D by public R&D is discussed extensively by Terence Kealey in his 1996 book 'Economic Laws of Scientific Research', London: MacMillans.

[13] Paul A David and Bronwyn H Hall, 2000, 'Heart of darkness: modeling public – private interactions inside the R&D black box', *Research Policy*, 29: 1165 – 1183.

[14] Paul A David, Bronwyn H Hall and Andrew A Toole, 2000, 'Is public R&D a complement or substitute for private R&D? A review of the econometric evidence', *Research Policy*, 29: 497 – 529.

[15] Bronwyn Hall and John van Reneen, 2000, 'How effective are fiscal incentives for R&D? A review of the evidence', *Research Policy*, 29: 449 – 469.

[16] OECD, 2003, *The Sources of Economic Growth in OECD Countries*, Paris: OECD Publication Service.

[17] OECD, ibid, pg. 85.

[18] OECD, ibid. pg. 85, emphasis added.

[19] Friedrich A Hayek, 1945, The use of knowledge in society, *American Economic Review*, 35(4): 519 – 530, pg. 520.

[20] James M Buchanan, 1969, *Cost and choice: An inquiry in economic theory*, Volume 6, The Collected Works of James M Buchanan, Liberty Fund: Indianapolis.

[21] Buchanan, ibid. pg. 41.

[22] Buchanan, ibid. pg. 40.

[23] Buchanan, ibid. pg. 43.

[24] See George Eads (1974, 'US government support for civilian technology: Economic theory versus political practice', Research Policy, 3: 2 – 16) for an extensive discussion of these issues.

[25] Zvi Griliches, 1992. "The search for R&D spillovers". *Scandinavian Journal of Economics*. 94: S29 – S47. Reproduced in Z. Griliches. 1998. *R&D and productivity: The econometric evidence*. University of Chicago Press: Chicago.

[26] Richard R Nelson, 1959, 'The simple economics of basic scientific research', *The Journal of Political Economy*, 67: 297 – 306. pg. 306.