The Econometrics of Science, Research and Innovation

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How do we measure the value of science, education and research? How much do education, and university research, contribute to innovation? In a world where information and technology can be transferred rapidly, and economies are often interconnected, the answers to these questions are far from simple. They rely in part on the public policies of individual countries. For example, both the costs and the benefits of higher education depend significantly on a nation's taxation system, among other facets of its economy (see e.g. Alstadsaeter [1]).

However, if we are to gain a good understanding of the benefits of education, research and innovation then we are almost bound to combine data from different countries, and to attempt to assess (or model, as an econometrician would put it) both the similarities and the differences. If we work with information from just a single nation, such as Australia, we limit ourselves to the policy, institutional and other characteristics of that country.

Moreover, by confining ourselves to just one country we make it particularly difficult to infer the potentially massive effects of linkages with other economies. Would it have been possible to envisage and predict India's burgeoning software industry without comparing the quality and price of programming skills there to those in other countries, such as the US?

There is substantial international literature on measuring the contributions made by education and research to innovation. Seven years ago, at a time of relative global optimism, the US Council on Competitiveness quantified and analysed the factors that drive innovation (Porter & Stern [6]). It developed an econometric model for innovation, fitted the model to international data, and introduced an "innovation index" for assessing the strengths of innovation in different countries.

The Council concluded that America's standing as an innovator was under threat, and argued in favour of a new US innovation strategy, including measures such as reversing "the downward slide of federal support for R&D" and "attending to the vitality of basic research at universities". "The United States must rebuild its dwindling pool of scientists and engineers", wrote Porter and Stern. It would also be necessary to make "a concerted effort to rebuild undergraduate and graduate training in technical disciplines".

In a *Science* editorial in May last year, on benchmarks for science funding, Marburger [5] called for "econometric models that encompass enough variables in a sufficient number of countries to produce reasonable simulations of the effect of specific policy choices". Current econometric tools, such as those used by Porter & Stern and in the studies reported below, are admittedly rather primitive, although this may be a necessary reflection of the quality and quantity of the available data. More detailed work is needed, Marburger argued, to answer questions such as, "How much should a nation spend on science? What kind of science? How much from private versus public sectors?"

In Australia, similar questions are being asked with increasing frequency. The current Australian Productivity Commission enquiry "into the economic, social and environmental returns on public support for science and innovation in Australia" will be considering issues such as these as it develops methodology and prepares its report, due in March next year.

Independently of the Commission's deliberations, a series of three papers on "Assessing Australia's innovative capacity" has examined our position in the world of innovation, and discussed how our performance might be encouraged and improved (Gans & Hayes [2, 3], Gans & Stern [4]). The most recent report updates the earlier ones, using data for the years 1975 to 2004.

Each of these studies involves a statistical regression onto around a dozen variables. That is, the "response variable" representing innovation is expressed as a linear form in a dozen measurable quantities, such as expenditure on university research, which might help explain innovation; plus an error term representing other quantities impacting on innovation, but for which data are not readily available. The methodology used in all three reports is based on that of Porter & Stern, and in particular, innovation is quantified, for any given country, as the logarithm of the number of patents granted.

Gans & Hayes [3] note that "2004 saw Australia's Innovation Index record a small decline. Together with Austria's improved index this decline saw Australia's OECD ranking fall from 14th in 2003 to 15th in 2004". A feature that all three studies share is the very similar leverage they reveal for two key statistical variables, "Percentage of R&D funded by industry" and "Percentage of R&D performed by universities".

Indeed, the relative leverage that these two items of expenditure have on innovation equals 1.4, 0.9 and 1.0 in the reports of Gans & Stern [4] and Gans & Hayes [2, 3], respectively. Here we define "relative leverage" in terms of the ratio of the regression coefficients. In the case of the most recent report, where the coefficient ratio is almost identical to 1, the statistical significance of the respective coefficients is particularly high.

Reflecting results such as these, the conclusions and recommendations of the four reports (Porter & Stern [6], Gans & Stern [4], Gans & Hayes [2, 3]) argue strongly in favour of both private- and public-sector support for research. The reports stress the importance of interaction between both these parts of the economy. Resonating with the points made earlier by Porter & Stern, each of the three Australian reports recommends that authorities "ensure a world-class pool of trained innovators by maintaining a high level of university excellence and providing incentives for students to pursue science and engineering careers"; and "enhance the university system so that it is responsive to the science and technology requirements of emerging cluster areas".

We began this article by noting the challenges of comparing science, research and innovation among different countries. The 29 OECD nations whose data contribute to the work of Gans & Hayes [3], vary greatly in terms of the ways they motivate and fund science and research. Some of these differences, as well as potential interactions among the explanatory variables, might be taken into account in a more complex model. However, in the absence of more detailed data it seems difficult to be significantly more definitive or more specific, and to respond adequately to Marburger's call for a relatively sophisticated approach. This inherent limitation is bound to restrict the scope and authority of enquiries such as that by the Australian Productivity Commission.

Indeed, while more advanced econometric techniques would have the capacity to "torture the data until it confesses", it is unlikely that fancier tools would alter the conclusions drawn by simpler arguments in all four of the reports discussed above — that R&D expenditure in both public and private sectors, education expenditure and IP protection all have very strong, positive impacts on innovation.

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References

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