AN ABC OF R & D: IS AUSTRALIA'S RECORD AS BLACK AS IT HAS BEEN PAINTED?

Francis G. Castles
DISCUSSION PAPER NO. 206
March 1989
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ISBN: 0 7315 0192 6
ISSN: 0725 430X

* The author wishes to thank Paul Bourke for the initial impetus which led to this paper and Vance Merrill for his most helpful comments.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>i</td>
</tr>
<tr>
<td>I. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>II. The Case for the Prosecution</td>
<td>4</td>
</tr>
<tr>
<td>- Some Basic Data</td>
<td>4</td>
</tr>
<tr>
<td>- A Basic Comparison</td>
<td>7</td>
</tr>
<tr>
<td>III. The Case for the Defence</td>
<td>9</td>
</tr>
<tr>
<td>- Some Preliminary Questions</td>
<td>9</td>
</tr>
<tr>
<td>- Competitive Export Markets, Politics and R &amp; D Performance</td>
<td>14</td>
</tr>
<tr>
<td>IV. Assessing Past Performance and Future Prospects</td>
<td>19</td>
</tr>
<tr>
<td>Appendix</td>
<td>21</td>
</tr>
<tr>
<td>- Data, Definitions and Sources</td>
<td>21</td>
</tr>
<tr>
<td>- Equations</td>
<td>22</td>
</tr>
<tr>
<td>- Footnotes</td>
<td>24</td>
</tr>
</tbody>
</table>
SUMMARY

This paper seeks critically to evaluate the present policy debate on the level and development of Australian Research and Development expenditures. Its perspective is comparative in that it uses data for some 18 OECD countries in order to establish the extent to which Australian R & D performance is lower than might be expected for a nation of its wealth, population size, export performance and political character.

In Section II R & D expenditures are disaggregated by input - industry, government, defence and higher education - and by effort (i.e. the shares of industry and government). It is argued that even when we control for wealth and population, Australia is unusual in the weakness of its industrial R & D input and the extent of its governmental effort.

In Section III a number of preliminary questions are addressed that must be answered in order to establish Australia's relative performance vis-a-vis other nations. These include the causal question of how market performance and R & D expenditures are linked and questions concerning the impetus and areas of likely government intervention in R & D.

The Section continues by examining R & D performance in relation to export performance in different areas and to the presence or absence of corporatist political arrangements. On this basis, it is argued that Australia's performance is more or less spot-on for a country with its export structure and political complexion.

Finally, two other issues pertinent to the present policy debate are discussed: (1) whether greater inputs into educational R & D are likely to provide an infrastructure for greater industrial research and development and (2) the impediments the government confronts in transforming Australia's industrial strategy.
'Research and development are viewed as crucial to the restructuring process and support programmes are specifically directed at high growth, strong international demand sectors.'

ACTU, *Australia Reconstructed*, p.xii.

'To put it in perspective, Australia's total private R & D investment is now about the same as that of the Volvo motor company in Sweden.'

The *Age*, 22.4.1987.

I. Introduction

Research and Development performance and how to improve it has in recent years become an important focus of attention in the debate on national economic development. That debate has had a substantial comparative component. Other nations, it is argued, spend vastly more than Australia on R & D and the prudence of that course is apparently vindicated by the greater success of their manufactured products in world markets and concomitant high economic growth performance. In much of the debate, it is not other nations in general which provide the exemplars, but one in particular. Japan is quite correctly adjudged the industrial policy success story of our generation and a vital key to that success is seen to be R & D expenditures which outstrip those of all other advanced industrial nations. For many commentators, the contrast between Australia's and Japan's postwar economic growth conjoined with the latest figures on total R & D expenditure as a percentage of GDP (Australia 1.13% and Japan 2.81%) are enough.1 O.E.D.

If R & D is the key to successful industrial policy, then the obvious question is how Australia can improve its R & D performance. For a Labor government at least, the very question appears to presuppose the answer. Since the market has conspicuously failed to generate sufficient research activity, the government must intervene to provide more. Arguably such a strategy is peculiarly congenial to Australia, given that she has been amongst the industrial nations in which government effort has hitherto been greatest in terms of government share of total R & D funding. Measured
In terms of the relative R & D effort made by government and industry, the Australian tradition of intervention is markedly at variance with the Japanese exemplar. However that may no longer be very relevant, since the current Australian strategy seems to be moving in a Japanese direction, with less funding of direct research on the CSIRO model, but greater efforts to create incentives for industrial investment in R & D and, if the recent White Paper on Higher Education is to be believed, additional spending on education required to provide infrastructure support for industrial development.\(^2\) Certainly, Japan is not an example that can be used for a root and branch attack on industrial policy premised on government intervention, given the well-documented role of the Ministry of International Trade and Industry (MITI) in expanding Japan’s industrial base, not least through the supply of cheap capital for R & D.\(^3\)

Both the Australian debate on R & D’s role in industrial development and policy recommendations based on it, rest on analysis which is almost invariably unduly simplistic. A whole host of questions need to be considered. Does the argument that more R & D is required to play a larger role in competitive export markets necessarily imply that past and present Australian performance was and is substandard? In any case, what do we mean when we say that Australia’s R & D performance has been poor? Do we simply mean that it comes low in the international league table for some or all categories of R & D expenditure or do we mean that it is low for a country at our level of GDP, population size and role in the international division of labour? Are the assumptions we normally make about the linkages between economic growth, international competitiveness and research input reasonable ones, and, in particular, are they appropriate for assessing past Australian R & D performance? The underlying premise of government policy is that R & D expenditure causes international competitiveness which in turn leads to economic growth. But what if the relationship were the other way around, with
Industrial development causing greater R & D expenditure, or, perhaps, reciprocal, with greater competitiveness and higher levels of R & D linked in a chain of mutually reinforcing causation? Clearly, our causal assumptions have implications for how we assess past and present R & D performance and the prospects for purposive policy action. So too might an analysis which distinguished the impact of R & D spending in different sectors. Are all forms of R & D spending equally effective in promoting industrial development or are some irrelevant to the present restructuring concerns of the government? Finally, to what extent are negative appraisals of our performance based on an understanding of industrial policy realities and to what extent do they serve as a moral justification for the policy on which the government is presently embarked?

This paper does not pretend to offer final answers to all these questions. What I hope to show is that no sensible assessment of R & D performance is possible without some consideration of these matters. Moreover, such an assessment cannot be made on the basis of ad hoc comparison with particular nations. An adequate understanding of Australia's R & D performance can only come from juxtaposing her record to that of the widest possible range of other industrial nations. To do that means relying on statistical evidence and for that purpose I have utilised OECD data on the R & D performance of some 20 member states circa 1985. But although statistical analysis is presented here, my purpose is by no means to provide a definitive account of the causes and consequences of R & D expenditure in advanced capitalist states, much less to burden the reader with the complex paraphernalia of a multitude of regression equations, which are relegated to an Appendix for those who might be interested. Rather, it is to demonstrate the problematical character of much of the evidence and the questionableness of many of the assumptions on which assessments of past R & D performance have been made.
II. The Case for the Prosecution

In this section, I examine the available cross-national data on R & D expenditures and present an analysis of how Australia's performance contrasts with nations of comparable wealth and population size. Variants of such data presentation and analysis - usually with far fewer than 20 cases - generally constitute the case for the prosecution in Australia's indictment as an R & D laggard.

Some Basic Data

Table 1 presents some basic comparative data on R & D expenditure. The first two columns provide a breakdown of R & D expenditure into industry and government funded expenditures and the next two into higher education R & D and government funded defence R & D. It is important to note that these categories are not mutually exclusive, and that defence R & D as presented here is exclusively a function of government spending and that higher education is largely so. The fifth column presents data on total gross domestic expenditure on research and development. The figures in these five columns are expressed in terms of percentages of Gross Domestic Product - hereinafter described as R & D input - and, hence, are not quasi-definitionally linked to national economic success in the manner that would follow from presentation in real expenditure terms (i.e. per capita expenditures expressed in $US or purchasing power parities). The sixth and seventh columns again relate to the industry and government funded shares of R & D respectively, but this time expressed as percentages of total R & D effort.
<table>
<thead>
<tr>
<th>Countries</th>
<th>Industry Input (IND)</th>
<th>Government Input (GOV)</th>
<th>Higher Education (HE)</th>
<th>Defence Input (DEF)</th>
<th>Total Input (TOT)</th>
<th>Industry Effort (INDS)</th>
<th>Government Effort (GOVS)</th>
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<td>46.1</td>
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<td>1.39</td>
<td>.37</td>
<td>.930</td>
<td>2.77</td>
<td>47.9</td>
<td>50.3</td>
</tr>
</tbody>
</table>

Note 1. Data definitions and sources in Appendix
These figures present a somewhat mixed, but generally doleful, picture of Australia’s R & D performance. The percentage of GDP devoted to R & D by industry is extraordinarily low by international standards, seemingly a further aspect of the investment weakness of Australian business that has recently become the bien connu of the ACTU. Only Greece, Ireland, New Zealand and Spain manifest a lower R & D input by industry. On the other hand, government input measures up rather better, being in the top half of the distribution and at a level roughly comparable with countries such as Canada, Finland and Norway. Wherever government R & D funding is going, the university sector is not presently a major recipient of largesse. In utilising a mere .29 of a per cent of GDP on higher education research, Australia ranks 13th of these countries - in much the same league as Belgium and Finland, but otherwise only outspending Greece, Ireland, Italy, New Zealand and Spain. Defence R & D is not a major category of spending for most countries, although, as we shall see, it is a crucial factor accounting for variation in government R & D appropriations. Australia is in the top half of the distribution here, but the gap between it and the leading nations - France, Germany, Sweden, the UK and the USA - is very large.

It will be noted that in most countries R & D financed by industry substantially outweighs that financed by government. Compare columns 1 and 2 and 6 and 7. The consequences of that disparity come home to roost in column 5 which shows Australia’s total R & D input measured as a percentage of GDP to be equal 15th with Italy and otherwise outspending only Greece, Ireland, New Zealand and Spain, the four poorest countries in this OECD subset. Columns 6 and 7 put figures to the disparity of industry and government effort already noted in the contrast between Australia and Japan in the introduction. Only in Greece and New Zealand is industry’s share of total R & D lower and government’s share larger than in Australia. Japan is the polar opposite to Australia, having the second largest industry share (after Switzerland) and the smallest government share (with Switzerland close behind).
A Basic Comparison

Even the most fervent of protagonists of the R & D strategy for industrial growth might concede that Australia is unlikely to find it easy to scale the heights achieved by Japan and Switzerland in terms of both total R & D effort and industry effort. Japan has a vastly larger population and Switzerland is markedly richer. For somewhat different reasons, they can afford to do more and the same of course goes for countries like the USA and Germany, which are both bigger and richer. What we should be doing to is to compare like with like and ask how Australia's R & D performance matches up with other countries, having taken account of both population size and GDP per capita.

The data in Table 2 enable us to do just that. They show how much better or worse each of these 20 countries performed on the seven measures of R & D input and effort when statistical adjustments are made to control for wealth and population. Looking at the column for total R & D input, for instance, shows that while Sweden spent approximately 1 per cent of GDP more than might be expected, Canada, at the other extreme, spent nearly 1 per cent less. Australia's position in the input distributions is not significantly different from that revealed from the raw data in Table 1. In respect of higher education R & D, we retain our 13th rank order position, although our company becomes arguably somewhat more select, with our performance outstripping Denmark, Norway, Switzerland and the US as well as Ireland, New Zealand and Spain. We remain in the top half of the distribution for government appropriations, but, interestingly, our performance is almost spot-on for a country of our size and wealth. Australian government R & D effort may be large, but in input terms it is roughly par for the course. More crucially, adjustments for population and wealth do nothing to alleviate the picture of Australia as a serious laggard in respect of both industrial and total R & D input. After Canada, our industrial R & D input was lower than for any other country in the group, with spending more than 1/2 a per cent less of GDP than might have been expected, and that performance was
### Table 2: Differences between predicted and actual values of R&D input and effort correcting for GDP Per Capita and Population Size. (Differences in 1-5 expressed as percentages of GDP; in 6-7 as percentages of gross expenditure on R&D.)

<table>
<thead>
<tr>
<th>Countries:</th>
<th>(1) Industry Input (IND)</th>
<th>(2) Government Input (GOV)</th>
<th>(3) Higher Education (HE)</th>
<th>(4) Defence Input (DEF)</th>
<th>(5) Total Input (TOT)</th>
<th>(6) Industry Effort (INDS)</th>
<th>(7) Government Effort (GOVS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-.568</td>
<td>-.002</td>
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<td>-.085</td>
<td>-.607</td>
<td>-17.893</td>
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Note 1. Figures in parenthesis refer to equations in Appendix.
translated into an overall input .607 below the OECD norm, making for a rank of 16th in the total R & D league table. In respect of R & D effort, wealth and population make even less difference. Because Greece is poor, it ceases to be so extreme, leaving New Zealand then Australia as the two countries in which government effort is largest and industry effort least.

III. The Case for the Defence

The data and analysis presented so far constitute the basis for a *prima facie* indictment of Australia’s Research and Development record. Industrial R & D input is conspicuously low and that shows up in low total R & D expenditure. Government R & D effort is unusually large, even though actual government R & D input is much as expected. The remainder of this paper attempts to demonstrate that such an indictment paints substantially too black a picture of Australia’s past R & D record. Before turning to a rather more complex comparative analysis of cross-national R & D input and effort, a number of prior issues must be addressed.

Some Preliminary Questions

*Are wealth and population the only factors we need to take into account?* When assessing policy performance, a country’s wealth and population are the first factors that come to mind. Certainly, they are quite important here. Equations 6 and 7 in the Appendix do not manifest any significant association between R & D effort and these measures. However, as equations 1-5 demonstrate, GDP per capita is significantly and positively associated with all R & D inputs other than defence and population size is associated with both total and defence inputs. Rich countries spend relatively more on almost all categories of R & D and large population is conducive to greater military research and, hence, total R & D. But the very premises of present government industrial strategy suggest the relevance of at least two other factors associated with the level of R & D expenditure: the nature of export markets and the political capacity
to promote change. Were such causal linkages absent, present government initiatives would make no sense. Those initiatives are premised on the argument that in order to find a niche of comparative advantage in the manufactured exports market we must undertake more R & D and that government activity to promote greater R & D input is a viable means of achieving that end.

R & D and markets - how are they linked? In policy rhetoric, the link between R & D expenditure and export markets involves a one-way traffic. More R & D leads to a larger market share - invent a better mousetrap and the world will beat a path to your door, even if the door be situated in the Antipodes! But, whilst regarding the R & D/ international market nexus as unidirectional may make perfect sense in respect of policy recommendations for future action, it offers little assistance in explaining existing R & D input or indicting past performance. Leaving aside political capacity for the moment, we must assume that R & D expenditure decisions reflect perceptions of the likely gain to be made from investments in research. Where the perception of such gains is low, we might expect R & D inputs to be low. This involves a logic of reciprocal causation of the kind that is always present when human intentionality is in question. We carry out actions or fail to carry them out because of our knowledge of their likely effectiveness. On that basis, we may argue that R & D industrial inputs in Australia have been low because her entrepreneurs have failed to perceive much opportunity of profit in the export manufacturing sector.

This is not just an exercise in logic-chopping, it is a practical reality of Australian industrial life. Vast international manufacturing companies invest in research because they know that if their competitors overseas get an edge on them they will lose market share and hence profits. In Australia's hitherto largely protected market place, significant others have been other domestic firms and international competition has been firmly shut out. In the new industrial climate created by deregulation, it is doubtlessly true that industry requires additional R & D
expenditure, and quite possibly an additional boost in terms of government intervention, given that we are starting well behind the eight ball. But to understand where Australia presently stands in comparative perspective involves a recognition of the past (and present?) weakness of our position in competitive export markets.

In these terms, it is much less extraordinary that Australia’s present industrial R & D input is so far behind that of other OECD nations - in terms of export market share of all manufacturing industries, she ranks 18th (with only Greece and New Zealand lower) and in terms of per capita value of manufactured exports 19th (only Greece is lower). 6

Are total R & D figures a reliable guide to industrial policy success? The usual figures bandied about in political debate are those referring to total R & D expenditures and industrial R & D. I have already departed from this practice by a disaggregation into industry, government, higher education and defence sub-heads. One obvious reason for this, is, as already demonstrated, that performance varies quite appreciably from one area to another. Our government R & D effort is actually high, higher education and defence show up only marginally weaker than other advanced nations, and our supposed shortcomings are only truly manifested in the industrial arena. But there is another even better reason for disaggregation; namely that the constraints on expenditure in each area may be quite different. The export market linkage is no more unidimensional than it is unidirectional. In the international division of labour, countries specialise - some concentrate on manufactured goods, others on primary products, either agricultural or raw materials. Some countries concentrate their manufacturing purely on exclusively civilian markets, whilst others seek to sell the products of their arms industries. That being so, it is natural to suppose that the R & D/export market linkage is likely to be different in each case. International competitiveness in manufacturing is likely to be associated with the extent of industrial R &D, but competitiveness in primary
industry or the arms business is likely to be linked to R & D inputs focussed specifically on those markets. Finally, disaggregation is crucial if we wish to be able to explore whether R & D inputs in one arena impact in others. A crucial premise of the government's White Paper on Higher Education is that educational inputs are conducive to building a sounder infrastructure for industry research and development. This premise cannot be put to even the most approximate test until we disaggregate and seek separately to explain the separate components of R & D expenditure.

*Under what circumstances is the government likely to act*? Analysis suggests that firms are likely to amalgamate in such a way as to reap the benefit of economies of scale. The high cost of R & D involved in maintaining or increasing market share in hi-tech and large-scale manufacturing markets is clearly a factor conducive to the development of vast multinational corporations. It is notable that the countries that rank high on industrial R & D in Table 1 are amongst those with the highest number of large corporations, especially if an appropriate discount for population size is made. If firms are likely to act in such a way as to optimise industrial R & D expenditures without any stimulus beyond corporate profit, one would expect government action in the industrial sector to be a function of a desire to shift the character of a nation's niche of comparative advantage (the motivation suggested for MITI's activities in early postwar Japan) together with the political capacity to effect such change. In the recent public policy literature, that capacity has been argued to emanate from the existence or adoption of the practices of corporatist intermediation. Broadly, that form of intermediation rests on the replacement of conflict between business, labour and government by some sort of social partnership ideology. It is on such an argument that the Accord becomes the linchpin of present industrial strategy.
In which arenas is government action most likely to occur? If government intervention in the industrial sector is likely to be a consequence of a major industrial policy shift pursued by corporatist means, government's role in other R & D arenas is arguably more natural. The defence industry is substantially a government monopoly on both supply and demand sides. We would expect government appropriations for R & D to be high where military expenditure is high, and particularly so where governments seek to be competitive suppliers of weapons on a hi-tech world market in which other governments are the only legitimate buyers. In the primary export sector, what R & D there is is also likely predominantly to emanate from government funded endeavours. Far more than is the case in manufacturing, the optimum scale of primary production is restricted by control problems arising from inherently decentralised operating conditions. For any given farm or mining enterprise, however large, the overhead costs of basic research are likely to be too high to be met by individuals or firms. This clearly gives rise to a collective action problem⁹ - in terms of national productivity such research is desirable, but it is unlikely to be undertaken by those who would most benefit. Under these circumstances, it is probable that the level of primary sector R & D is likely to be sub-optimal and, insofar as it takes place, is likely to be largely as a consequence of the government deciding to act on behalf of the community as a whole. Finally, since higher education R & D input is not immediately demand-led in the sense of being directly part of the process of generating profit in a competitive market, one must suspect that it too is likely to be an arena for government intervention. Indeed, where the intention is to shift the parameters of comparative advantage, education is presumably the most obvious focus for a restructuring and enhancement of national R & D endeavour. In a mixed economy, it may be impossible to tell industry where and how much to invest; it may, however, be possible to increase the quantity and quality of the human capital inputs it uses!
Competitive Export Markets, Politics and R & D Performance

The implications that can be derived from consideration of these questions may be examined by the elaboration of a rather more complex comparative model of R & D performance incorporating measures of export performance and the capacity to effect political change. Findings are presented in the columns of Table 3 in the same fashion as previously, with figures representing the difference between actual performance and that predicted on the basis of the factors controlled for in the equations, which themselves appear in the Appendix, numbered B-15 respectively. An additional Equation 16 attempts to explore some complexities which emerge from Equation 15.

With the exception of Equation 16, all findings are based on the full 20 OECD group. However, for various reasons particular attention was paid to the effects of the including Japan in the sample. First, there is the general point that Japan has been found to be an extreme case or 'outlier' across a wide range of public policy outcomes and, on occasions, one suspects that the presence or absence of particular relationships is almost exclusively a function of the inclusion or exclusion of Japan in the analysis. With some caveats explicitly discussed in the text, that is not the case here. Second, our measure of political capacity - corporatism - is highly sensitive to the Japanese case, since commentators are far from agreed about whether Japan qualifies as corporatist. In fact, my chosen measure is a conservative one in categorising Japan as non-corporatist, possibly somewhat biasing the findings against the political capacity hypothesis, since on most R & D measures Japan's performance is outstanding. I comment in the text where corporatism proves significant in the sample excluding Japan and not in the larger sample. Third, there are some reasons for believing OECD figures on Japanese higher education R & D expenditure to be exaggerated and where analysis pertinent to higher education is undertaken, I note any caveats to the analysis that are warranted with reference to the more restricted sample.
Table 3: Differences between predicted and actual values of R&D input and effort correcting for GDP Per Capita, Population Size, Export Competiveness and Corporatism. (Differences in 8-12 and 15-16 expressed as percentages of GDP; in 13-14 as percentages of gross expenditure on R&D.)

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Note 1. Figures in parenthesis refer to equations in Appendix.
Column 8 presents the difference (residuals) between actual values of industry funded R & D and those which would be predicted on the basis of GDP per capita, population, the value of export manufactures per capita and corporatist arrangements. The corresponding Equation 8 in the Appendix shows population size and export manufacturing to be major determinants of industry input. Clearly, there is a link between competitive manufacturing for the international market and research and development by industry of the kind postulated in present industrial policy, although, of course, the associations reported here do not speak to the direction of the causality involved. Taking this factor into account does, however, have a quite dramatic impact on Australia's status as an industrial R & D laggard. Instead of being 19th in the distribution, as in Table 1, she now comes 10th, with a value almost exactly as predicted by Equation 8. In respect of a possible political effect, it may be noted that corporatism is not significantly associated with industrial R & D input in the 20 country sample, but it is in that excluding Japan ($t = 2.15$). This latter finding may be regarded as a modest, but interesting, plus for the government and ACTU's Accord strategy.

Column 9 shows the residuals resulting from correcting government appropriations for R & D for the impact of GNP per capita, population, arms exports per capita, primary exports as a percentage of total exports and corporatism. Earlier, we argued that government intervention was most likely to occur in areas of competitive exporting where the state is the sole legitimate actor (the arms business) or where there were impediments to collective action by individuals and firms (primary sector industries). Both hypotheses are confirmed by Equation 9, together with the positive effect of GNP per capita. On this basis, government input in Australia is actually quite low, ranking 12th in the 20 nation sample. Given, in particular, Australia's historical concentration on primary industry exports, we cannot claim, nor be unduly criticised for, an unusually high degree of government intervention.
- Column 10 contains the residuals that result when higher education R & D is corrected for the effects of GNP per capita, population size and corporatism. Equation 10 and the figures in column 10 are based on the entire sample and demonstrate a modest positive effect of corporatist intermediation and this is much strengthened (I = 2.44) in the sample excluding Japan. Again, there is some modest support here for an aspect of the present government's strategy. Where corporatist arrangements are in place, there is some tendency for higher education R & D to be greater. Assuming, I think quite reasonably, that in Australia circa 1985 any corporatist effects of the Accord strategy were yet to be manifested outside the industrial relations sphere, the record for higher education R & D as depicted in Column 10 actually shows Australia's performance to be marginally better than predicted. The White Paper promise, if fulfilled, of greater expenditures is, at least, compatible with a corporatist interpretation of present policy.

- Column 11 shows Australia to be a very average performer in respect of defence R & D. This is an area of relatively little concern in practical terms, and the chief interest is in Equation 11, which demonstrates the decisive impact of competitiveness in the arms export business on defence R & D.

- Column 12 is also of little remark and is only included for comprehensiveness. Equation 12 simply demonstrates that total R & D is effectively the sum of government and industry appropriations for R & D. As I have noted above, only by disaggregating into these and further sub-categories can one really come to grips with what makes R & D tick.

- Column 13 presents the residuals that emerge when we correct industry R & D effort for the same set of factors as were used to create Column 8. As the contrast between Equations 8 and 13 demonstrate, the results are almost identical, except that in this instance the evidence for a positive effect of corporatism in the full
sample is rather stronger than previously. In Table 1, the raw data for industry input and effort manifested some considerable divergences. These disappear when we control for export competitiveness in manufacturing.

- Column 14 presents the residuals for government effort correcting for the same factors used to generate column 9. Equation 14 contrasted with Equation 9 also demonstrates some degree of convergence between government input and effort. There remains, however, some difference insofar as in Equation 14 the influence of GDP per capita is much weaker (only significant at .1 level) and that of arms exporting is negligible. What is common to government input and effort is the impact of the primary sector. Countries which are major primary exporters tend to manifest substantial government R & D effort, and adjusting for this factor confirms our previous finding that government intervention has not been peculiarly great in Australia.

- Column 15 returns to the question of industry R & D input to test a further supposition about current industrial strategy. The question now is whether there are any grounds for the view that a higher level of funds directed to higher education R & D may serve as infrastructural support for industry R & D input. That is the bottom line of the White Paper strategy. Australia must build on newly devised corporatist arrangements to bolster higher educational spending and that will in turn flow through into industry R & D. Equation 10 offered evidence compatible with the first half of the argument. The evidence from Equation 15 is more equivocal in respect of the second half of the argument. Controlling for GNP per capita, population, per capita manufactured exports and corporatism, there is no significant association between higher education R & D and industrial R & D in the sample excluding Japan, although there is a moderately strong one when Japan is included ($t = 2.58$).
Given the strong discount on evidence on relationships concerning higher education R & D based on what is probably misleading Japanese data, this a disappointment for protagonists of the White Paper strategy, the more so since we already know from the sample excluding Japan that corporatism has a moderate positive effect on industrial R & D input and find that, in the same sample without corporatism, higher education R & D is also moderately associated with industry R & D input. On the one hand, this demonstrates that the two variables confound each other in Equation 15 and, on the other, suggests the possibility of an interactive effect between corporatism and higher education R & D of a kind that might imply a stronger relationship where high levels of educational input are conjoint with corporatist arrangements than the additive effect of either acting separately. Equation 16 tests this supposition and proves more successful than its predecessor. The interactive term is significantly associated with industrial R & D input and the degree of explained variance is somewhat improved as contrasted with Equation 15, whether or not based on the sample including Japan. If Australian industrial policy were to be guided by this model, it would suggest strongly that once corporatist arrangements were in place in Australia, bolstering higher educational R & D could be the key to improving industrial R & D input. If the figures in Equation 16 were taken literally - and, of course, they should not be; countries don't become corporatist overnight - a corporatist transformation would lead to an increase in industrial R & D input of .28 of a per cent of GDP and a subsequent doubling of the higher education budget would increase it by a further .28 of a per cent.

IV. Assessing Past Performance and Future Prospects

That is heady stuff for John Dawkins and the higher education lobby, but a realistic appraisal suggests a need for some caution. Like so much in the analysis of R & D
performance, assessment of the probable effects of corporatism are subject to
caveats about the assumed direction of causality. According to an important line of
argument, corporatism is itself a response to the economic vulnerability attendant on
small nations competing in competitive manufactured export markets. But to the
extent that this is the case, the task of creating viable forms of corporatist
intermediation in Australia is unlikely to be an easy one.

It involves fighting against the tide of our past industrial structure. Much the same
point emerges from an attempt to be realistic about our past R & D performance.
Even if the analysis presented here suggests points of leverage for change along lines
consonant with the industrial strategy of the Hawke government, it suggests still
more strongly that Australia's R & D record is rather as one might expect it to be,
given our niche of comparative advantage in world trade. Primary exporting nations
with a weak political capacity to effect industrial restructuring can hardly be
expected to spend as much on R & D as corporatist nations specialising in
manufactured exports. Moreover, in the former nations, there is likely to be a
tendency for government to undertake much of the research and development that does
occur.

Of course, it is wholly understandable that the protagonists of industrial
restructuring should present past performance as extraordinarily weak and ignore
the fact of reciprocal causation in their rhetoric. To do so makes the tasks of future
change appear more urgent and more readily resolvable. It is, however, a
normative judgement of Australia's past premised on a perception of the need for
change. Whether obscuring the realities of past industrial policy genuinely facilitates
purposive change is a moot point.
Appendix:

Data, Definitions and Sources

All variables are measured for the nearest available point to 1985. Except where explicitly noted, all derive or are calculated from OECD, OECD in Figures, Supplement to the OECD Observer, No 152, June/July 1988.

IND. Gross Domestic Expenditure on R & D (GERD) financed by industry as a percentage of GDP.

GOV. GERD financed by government as a percentage of GDP.

HE. Higher education sector R & D as a percentage of GDP.

DEF. Government budget appropriations on defence R & D as a percentage of GDP.

TOT. GERD as a percentage of GDP.

INDS. GERD financed by industry as a percentage of GERD.

GOVS. GERD financed by government as a percentage of GERD.

GDP. Log of per capita GDP using purchasing power parities.


CORP. Corporatism. Corporatist nations score 1; others 0 (for countries and source, see footnote 11).


ARMS. Arms exports per capita (calculated from Table 7.1 on the leading exporters of major weapons in the SIPRI Yearbook 1986, London: Oxford University Press Nations which do not appear in that table score 0 although they may have some small-scale export trade).

PRIM. Percentage share of merchandise exports in the categories fuels, minerals and metals and other primary commodities (World Bank 1986, pp.461).

HEC. HE * CORP.
Equations

Figures are unstandardised regression coefficients. T-values in parenthesis.

(1) \[ \text{IND} = -10.359 + 2.702 \text{GDP} + .217 \text{POP} \]
   \[\text{Adj. R}^2 = .30\]

(2) \[ \text{GOV} = -5.533 + 1.487 \text{GDP} + .162 \text{POP} \]
   \[\text{Adj. R}^2 = .44\]

(3) \[ \text{HE} = -3.089 + .83 \text{GDP} + .005 \text{POP} \]
   \[\text{Adj. R}^2 = .32\]

(4) \[ \text{DEF} = -2.347 + .536 \text{GDP} + .257 \text{POP} \]
   \[\text{Adj. R}^2 = .36\]

(5) \[ \text{TOT} = -16.1 + 4.24 \text{GDP} + .447 \text{POP} \]
   \[\text{Adj. R}^2 = .50\]

(6) \[ \text{INDS} = -159.984 + 51.195 \text{GDP} + .84 \text{POP} \]
   \[\text{Adj. R}^2 = .08\]

(7) \[ \text{GOVS} = 246.05 - 48.104 \text{GDP} - 3.058 \text{POP} \]
   \[\text{Adj. R}^2 = .07\]

(8) \[ \text{IND} = -3.711 + .804 \text{GDP} + .803 \text{POP} + .291 \text{MAN} + .293 \text{CORP} \]
   \[\text{Adj. R}^2 = .64\]
\( \text{GOV} = 3.499 + .007 \text{GDP} + .165 \text{POP} + .003 \text{ARMS} + .003 \text{PRIM} + .144 \text{CORP} \)

\[
\begin{array}{ccc}
2.33 & 1.69 & (2.36) \\
\end{array}
\]

\( \text{Adj. R}^2 = .75 \)

\( \text{HE} = -1.97 + .528 \text{GDP} + .075 \text{POP} + .130 \text{CORP} \)

\[
\begin{array}{ccc}
1.87 & 1.27 & (2.08) \\
\end{array}
\]

\( \text{Adj. R}^2 = .43 \)

\( \text{DEF} = -1.756 + .418 \text{GDP} + .103 \text{POP} + .008 \text{ARMS} - .053 \text{CORP} \)

\[
\begin{array}{ccc}
1.01 & 1.14 & (3.44) \\
\end{array}
\]

\( \text{Adj. R}^2 = .80 \)

\( \text{TOT} = .014 + 1.047 \text{IND} + 1.032 \text{GOV} \)

\[
\begin{array}{ccc}
32.49 & 16.30 \\
\end{array}
\]

\( \text{Adj. R}^2 = .99 \)

\( \text{INDS} = 42.408 - 6.84 \text{GDP} + 12.415 \text{POP} + 10 \text{MAN} + 8.803 \text{CORP} \)

\[
\begin{array}{ccc}
.36 & 3.12 & (5.13) \\
\end{array}
\]

\( \text{Adj. R}^2 = .72 \)

\( \text{GOVS} = 210.174 - 45.853 \text{GDP} + 1.02 \text{POP} + .158 \text{ARMS} + .494 \text{PRIM} + 2.827 \text{CORP} \)

\[
\begin{array}{ccc}
1.92 & 1.16 & (4.11) \\
\end{array}
\]

\( \text{Adj. R}^2 = .60 \)

\( \text{IND} = -.006 - .018 \text{GDP} + .462 \text{POP} + .252 \text{MAN} + .154 \text{CORP} + 1.714 \text{HE} \)

\[
\begin{array}{ccc}
.02 & 2.76 & (.77) \\
\end{array}
\]

\( \text{Adj. R}^2 = .74 \)

\( \text{IND} = -4.148 + .952 \text{GDP} + .449 \text{POP} + .207 \text{MAN} + .971 \text{HEC} \)

\[
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1.49 & 3.22 & (3.89) \\
\end{array}
\]

\( \text{Adj. R}^2 = .76 \)
FOOTNOTES

1 Unless otherwise indicated all R & D expenditure figures and other data cited in the text are from or calculated from OECD, OECD in Figures, Supplement to OECD Observer, No 152, June/July 1988.


4 See ACTU/TDC 1987: Australia Reconstructed, AGPS.


13 See Katzenstein, P.J., op. cit and for an Australian application, Castles, Francis G., op. cit.