Chapter 9

Strategic directions for UK defence research and development

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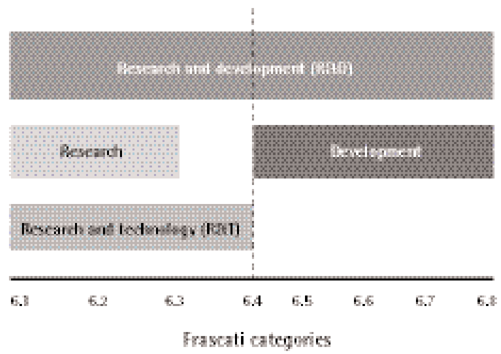
This chapter will argue that measuring the value of research and development can greatly improve its strategic direction, by giving decision makers better evidence. It will explore the problems of directing R&D by first summarising the transformation in commercial technology management in the 1990s that was brought about by improvements in the way the value of R&D was measured. Exploring some of the reasons why these insights could not be straightforwardly applied to defence, the chapter will look at recent work that provides evidence of the value of defence R&D. It will then examine some of the implications for the direction of the UK defence R&D base, concluding with some suggestions for its future direction.

Definitions

The terms research and technology (R&T) and research and development (R&D) are sometimes confused or used interchangeably. Here, R&T will refer to early stage technology generation activity, sometimes also termed "blue skies" research or, in UK defence circles, "corporate and applied research". *R&D* encompasses R&T activity as well as "development", which is mainly focused on a known application. Development is often mainly concerned with the demonstration of technology, risk reduction, system integration, trials and tests, and evaluation activity. In terms of the Frascati definitions, we refer to R&T here as referring to those activities that Frascati termed 6.1 to 6.3, and R&D to all the activity from 6.1 to 6.8, as illustrated in figure 1.

Figure 1: Frascati definitions of research and development terms



Commercial technology management transformation

Large commercial companies take their R&D spend very seriously, especially in the electronics, communications, pharmaceutical and hydrocarbon sectors, where the technology base is pivotal to the ability to compete. Significant improvements could be made to the way R&D was directed once it proved possible to measure the value of it. During the early 1990s there was a fashion to "nail down corporate R&D spend". Led by certain management consultancies, various discounted cash-flow and net present value financial techniques were applied to R&D projects, with the result that the projects were often found wanting. This forced R&D managers to analyse and measure the value of what they were doing, or face having it cut.

The overall outcome was often a reorganisation to make corporate R&D more accountable to the operating divisions. This in turn led to project scrutiny using net present value techniques that resulted in a more short-term focus overall, although the positive effect was that R&D became more closely aligned with the business needs of the firm. But the same phenomena also delivered some disadvantages to firms, which lost their ability to compete using technology when their foreshortened new-product pipelines eventually ran dry.

In the 1990s, however, the technology pendulum started to swing the other way. New financial techniques were developed based on real option value thinking, which better captured the true value of R&D. This was in line with a more general trend to express the value of R&D in terms of the options for future action that it could buy the firm. Options thinking improved commercial technology management, as R&D managers sought to balance a portfolio of options to deliver maximum future value to their firms.

Many firms consequently increased their R&D investment: some as a response to an earlier lack of new products, others as a deliberate policy to compete with better-managed technology. These improvements continue today, so that some pharmaceutical companies –GlaxoSmithKline, Roche and Merck Sharp & Dohme, for example – now have superbly managed R&D pipelines based on highly sophisticated option valuation techniques.

The value of defence R&D

Much of this thinking passed by the defence sector; it apparently made little sense to measure only the *financial* value of defence R&D projects because they were concerned with the delivery of *military* value. What would the net present value of a defence project matter, if the resulting equipment delivered inferior military utility? These difficulties in estimating the value of defence R&D go very deep, possibly back to the fundamentals of modern economics. In *The Wealth of Nations* Adam Smith argued that the only thing more important than prosperity was defence, which occupied a unique place in national policy:

Further, commerce sinks courage and extinguishes martial spirit; the defence of the country is handed over to a special class, and the bulk of the people grow effeminate and dastardly, as was shown by the fact that in 1745 four or five thousand naked unarmed Highlanders would have overturned the government of Great Britain with little difficulty if they had not been opposed by a standing army.

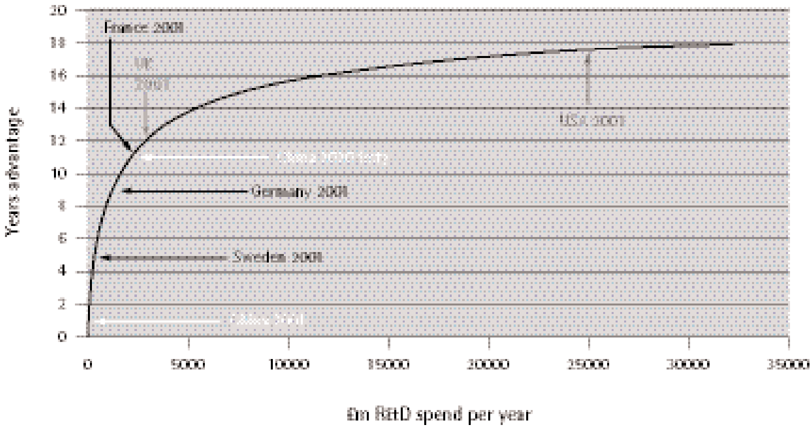
In the USA during the 1990s there was a frenzy of work based on the cost aspects of development and "value engineering", but these were never really harnessed to help direct the whole defence R&D activity. In the UK at the same time similar attempts were made, but despite the best efforts of defence output assessment studies and operational analysis, no methods emerged that were comparable to the usefulness of the commercial techniques. What chance, then, is there of measuring the value of defence R&D?

Recent work on the value of defence R&D

Some recent work commissioned by the UK Ministry of Defence offers some hope. In a paper in *Defence & Peace Economics*, Bowns, Middleton et al showed that it is possible to measure the value of defence R&D, at least comparatively, at a high level and over long periods. They used a comparative technique to compare 69 categories of like-with-like military equipment between 10 nations to give a relative measure of military equipment quality.

The underlying rationale was that, in the first place, military equipment quality is in reality very relative to other nations, since adversaries would probably be supplied with equipment designed by one of the 10 nations studied. Second, they argued that the value of defence R&D can mainly be expressed in terms of improved equipment quality, with a small exception in the area of human factors research. For most R&D, if it is not aimed at improving equipment quality, then what is it for? Their measurement shows that governments generally "get what they pay for". The paper explains a strong correlation between military equipment quality and the government defence R&D expenditure some 10-25 years earlier, illustrated in figure 2.

Figure 2: Capability advantage from R&D investment



Because all states occupy a point on this line, it was further possible to express the time advantage or disadvantage of one country over another; a high-level strategic expression of the value of defence R&D:

When describing the relative positions of nations, commentators have often described one nation as "so many years ahead" of another. It appears that this figure of speech accurately reflects the underlying situation in the case of military equipment quality.

So what now for UK defence R&D?

The UK has done well in delivering good military equipment quality against R&D expenditure since 1971. Only the high-spending USA and the Soviet Union/Russia have achieved greater equipment quality, and they show significant diminishing returns, suggesting that the UK has taken an almost optimum position, on the "knee of the curve". This seems plausible, even accepting the possibility of a pro-UK bias in this work since UK equipment was used as a baseline for comparisons. But the data also suggest that there may be a latent problem for the UK from cuts in defence R&D spending.

During the 1990s many NATO countries sought a peace dividend following the collapse of the Soviet Union. In the UK and USA some of this was manifest in cuts in R&D expenditure. But it is interesting to note that countries such as France, Germany, Italy and Spain either took smaller cuts in R&D or applied them for a shorter time, or both. The USA reversed this trend during the late 1990s, and following 9/11 has significantly increased its R&D spend.

The UK, however, was somewhat out of step with other Western countries, in that it took a series of peace dividend-style cuts in R&D spending throughout the late 1990s and into the early 2000s. It has only very recently reversed this trend, with the 2006 and 2007 R&D expenditure set to take no further cuts. Given the 10- to 25-year time lag between spend and benefit, the UK may have stored up a particularly difficult problem for the period 2010-20, as the downturn in R&D spend in the mid to late 1990s pulls through into a reduced future military equipment quality.

This problem could prove especially challenging since the UK is most likely to favour a military posture that favours smaller and smarter capabilities. But there can be no simple, fast-spending solution, because even if the UK were radically to increase its defence R&D spending tomorrow, the benefits could not be expected to pull though into increased military equipment quality until the 10- to 25-year time lag had elapsed; which would be from 2017-32. The problem might also be exacerbated as possible future adversaries such as China have been steadily increasing their R&D spend recently.

Furthermore, using the same data set of 15,000 pieces of military equipment, it is possible to plot the average age of the equipment owned by the 10 countries studied over the last 30 years. For 1971, this method shows an overall average fleet age of all equipment of all nations to be some 9.2 years. But by 2005 this had almost doubled to 17.6 years, with a hint that this ageing is accelerating. This will come as no surprise to many analysts, who will have seen a reducing "replacement frequency" for all major platforms such as aircraft and warships as the 1990s progressed. It is, however, possible to extrapolate this trend forward to 2020, when the average age might be approaching 25 years. With such an average, many longer-lasting platforms might be approaching 50 years of age.

This raises a pressing question for UK defence R&D policy makers: will it be possible to accelerate the pull-through of R&D into equipment quality in the next decade in the face of time lags, worsening competition and an ageing fleet of equipment? The consequences of failing to address this question could be serious, as UK armed forces might face a significantly reduced equipment quality advantage over potential adversaries during the period 2010-20.

That said, UK force effectiveness is made up of many factors other than equipment quality. UK military personnel are well recruited, superbly trained and well led, and operate within highly effective doctrinal and operational frameworks. This might be enough to compensate for equipment deficiencies, but we should remember that UK forces have not faced enemies with superior equipment quality since the Tiger tanks and Messerschmitt 262 jet fighters of the Second World War.

Technology insertion

One solution to this impending dilemma would be to focus on the shorter-term development issues of equipment already in or about to go into procurement. By concentrating expenditure and management focus on this area, it might be possible to accelerate the technology pull-through and ensure that new equipment is as technologically advanced as risk-averse procurement processes will allow.

This might be achieved by looking for opportunities for technology insertion: incorporating a new piece of recent (often commercial, off-the-shelf) technology into a particular part of a piece of equipment. For example, the ASTOR surveillance aircraft has had up-to-date commercial digital recording equipment installed relatively late in the procurement process, to replace its aging magnetic tape storage. But there could be difficulties with this approach, especially with the risk-reduction aspects of insertion in the later stages of equipment procurement. It would be a very brave integrated project team leader that welcomed a technology insertion event late in the process, as the National Audit Office looked closely for cost overruns and delays.

The potential for insertion may also be heavily dependent on the degree of modularity in the target equipment. Some insertion is relatively straightforward and can deliver a huge return in equipment quality with relatively minor perturbations on the rest of the system or platform. One example of this is the retro-fitting of close-in weapons systems such as Phalanx and Goalkeeper on to warships during the late 1980s. Others are much more fraught, as they pose massive system integration challenges. Perhaps it will be possible to target opportunities for technology insertion using the degree of modularity as a key criterion?

Much of this may rest on the successful implementation of open systems architecture but is complicated by massive legacy software issues. Once again, however, there is as yet little firm evidence as to what works and what does not work in technology insertion. Decision making in this area is therefore likely to suffer from a lack of evidence-based support.

Development or research?

A further complication arises from a focus purely on the development side of the process. This could trigger a reduction in the longer-term R&T work, which could store up an even worse long-term problem into the 2020s and beyond. This will need to be guarded against, because longer-term R&T may account for about half of the correlation with equipment quality. As Bowns, Middleton et al showed, "the effect of short-term R&D expenditure ('development') and of long-term ('research') is roughly equal, based on analysis of the delay between R&D spend and equipment quality".

The UK MoD is already taking other action that should improve the situation. The recent Competition of Ideas and Grand Challenge initiative should bring more innovation into the R&T processes. This might both speed technology insertion and even possibly reduce the time lags, as already mature commercial technology is fed into the R&T mix. There are still barriers to be overcome, but the fact that these actions are taking place already is clearly a positive indication.

Conclusion

Surprisingly then, despite the many difficulties, it has proved possible to find real evidence of the value of defence R&D. This is already having an impact on the strategic direction of defence R&D in the UK, and has been cited in the recently published Defence Technology Strategy. Following a similar track to the commercial R&D management improvements of the 1990s, real evidence and meaningful measurement of value may be expected to make a significant contribution to the strategic direction of UK defence technology.

However, it will be essential to know what data to look for, to put in substantial effort and to analyse the results with the appropriate tools. By applying these methods, it is already disturbing to note that following the 1990s peace dividend cuts in R&D funding, the UK may be facing a significant risk of its relative military equipment advantage being eroded during the next decade.

Remedial action is possible but difficult, since time lags mean that simple "spend now" solutions will not pull through in time. Process improvements and technology insertion into equipment that is already in procurement are likely to yield results. However, this should be done together with a safeguarding of the level of R&T spend and by introducing more innovation; otherwise even greater problems will be stored up for decades to come.

References

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