Core competencies and the strategic management of R&D

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Abstract

There is an increasing concern amongst R&D managers and their immediate 'customers' and sponsors within companies to have reliable mechanisms to direct R&D simultaneously toward effective rapid innovation *and* accumulation of long term technological strength. This is leading R&D managers to seek analytical tools to help them identify technologies which have particular significance for competitive advantage, for multiple SBUs, and for longer term strategic positioning, and to manage them in ways which do not leave them at the mercy of business unit strategies, but situate them closer to the core of corporate strategies. This paper conducts an examination of the parallel literature on the idea of core competencies as a new paradigm in corporate strategy and shows that core competencies can be useful focusing devices for assisting in the creation of this linkage between the technological and non-technological aspects of the corporate strategy agenda. Implications are drawn out for: R&D decisions in the areas of shaping strategic research programmes; funding and organisation regimes for R&D; and measuring the effectiveness of R&D.

INTRODUCTION

The purpose of this paper is to explore the possibility that the core competence paradigm (CCP) has something useful to offer to those concerned with the strategic management of R&D in large firms. Our starting assumption is that there is a *prima facie* similarity between the CCP and the emerging literature on the strategic management of R&D on one crucial issue. This issue is the conceptualisation of the diversified firm not as a collection of *discrete* strategic business units (SBUs), but as a collection of SBUs which draw on certain common *corporate* resources.

The CCP (Prahalad & Hamel, 1990) argues that corporations can identify core competencies which are firm-specific accumulations of expertise resulting from previous investments and from learning-by-doing. These competencies are seen as longer-lived assets than the particular product-market business units which exploit those competencies. The prescriptive implication which follows is that core competencies become pivots of strategy-making, and that excessive de-centralisation of control to SBUs can endanger their continued development and value. Comparing this with the field of R&D management: the 70s and 80s were decades which were largely dominated by a trend of decentralisation of R&D funding and control to SBUs, in an attempt to ensure that R&D was market-driven and that innovation success rates would improve. Recently however, opinion has swung to the view that excessive decentralisation has damaged long-term accumulation of technology and reduced effectiveness in the movement of technology skills between SBUs (Coombs & Richards, 1993a; Dussauge *et al.*, 1992). This has led in turn to an emerging interest in re-claiming corporate control of some aspects of technology management.

The structure of the paper is as follows. Section 1 presents a brief synopsis of the CCP, drawing out the role of technologies in the construction and application of core competencies. Section 2 reviews some of the recent literature on strategic management of technology, selectively drawing out those issues that relate to the management of technologies that cut across several business units. In section 3 these two themes are brought together to present a simple model of how core competencies can play a role in guiding the strategic management of technology. Section 4 explores the implications of this approach for R&D decision-making in the areas of long-term research programmes, funding regimes, organisational structures, and the measurement of the effectiveness of R&D.

1. THE CORE COMPETENCE PARADIGM

The following compressed summary is based on Prahalad and Hamel's well-known paper in *Harvard Business Review* (May, 1990). Some aspects of their approach will be modified as the argument of this paper is developed in later sections.

Core Competencies (CCs) can be thought of as consisting of bodies of technological expertise (both product and process) *and* the organisational capacity to deploy that expertise effectively. Thus they are not simply technological in character, they are also organisational. They are embellished and strengthened through continued use (in other words they are subject to positive returns), and are therefore to some extent firm-specific and non-transferable. Indeed, the definition of CCs given by Prahalad & Hamel insists that not only must they give access to multiple markets, and confer specific advantages to customers, but they must also be difficult to imitate.

CCs are not monolithic. They have an internal structure which is composed of a number of *capabilities*. Thus a CC exists as a specific combination of capabilities. Capabilities are not defined in very great detail by Prahalad & Hamel but appear to be more disaggregated than competencies and map more closely onto technologically defined domains of knowledge and expertise. The organisational dimension of a CC appears to lie in part in the ability to *combine* appropriate capabilities into specific competencies.

Competencies are given a physical and commercial reality in *core products*, which have a market-leading performance in a specific area of the customer's *functionality*

requirements. The often quoted examples here are Canon's laser-printer engines, and Honda's high revving, smoothly performing internal combustion engines. Core products are then deployed in a variety of *end-products*. Thus the model can be represented as in Figure 1, which is adapted from the familiar figure in Prahalad and Hamel (1990).

The principle of a variety of technologies (capabilities), being combined in many permutations to create a variety of end-products is not in itself new. The specific feature of the CC paradigm seems to be the emphasis on the intervening concepts of CCs and core products. These are, in essence, *particular* combinations of capabilities, which are robust over time, confer specific advantages to the supplier and the customer, and therefore create a *preferred* and firm-specific migration path from technological knowledge to end products for the firm in question. Once this is recognized by a firm, it is then argued that they can use their CCs as an 'orientation device' to shape strategic choices about acquisition of new technologies and development of new end products. Basically, if a technology strengthens your CCs you should acquire it, and if a product exploits your CCs, you should make it. This approach seems to create a need within the company for intelligence and forecasts concerning technical trends and market trends, in order to 'steer' the evolution of the CCs.

Some of the practical implications of this perspective are defined by contrasting the CC paradigm with an outlook based on seeing a corporation as a collection of more or less autonomous SBUs. It is pointed out that a business run as a portfolio of SBUs is in

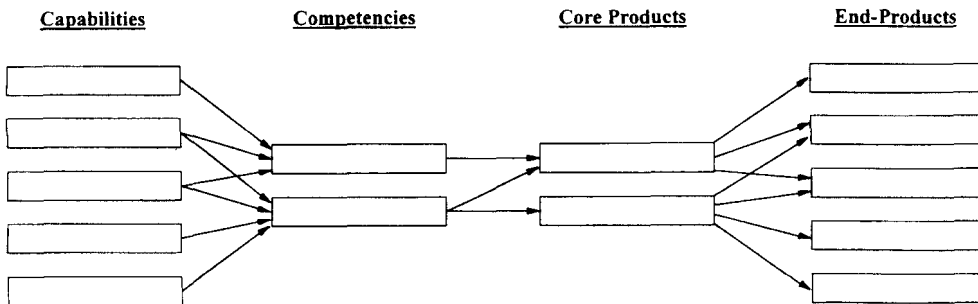| Capabilities | Competencies | Core Products | End-Products |

Figure 1

danger of dissipating CCs, or even of inadvertently outsourcing them. CCs can get 'imprisoned' within one SBU and not be made available to other SBUs. The people who are the embodiment of the CCs can be insufficiently *mobile* with respect to the SBUs.

It is clear then, that in the context of large multiproduct firms, the concept of CC is designed to act as a representation of the overlaps and synergies between products. These overlaps and synergies are what make the diversification pattern of the firm rational rather than *random*, and in addition, they make the firm capable of specific differentiations of its products which confer competitive advantage. Without the use of CCs a firms' products are less likely to be competitive, and less likely to add new cumulative skills to the firms' armoury.

2. TRENDS IN THE STRATEGIC MANAGEMENT OF TECHNOLOGY AND R&D[1]

For over twenty years Britain's major R&D-performing firms have been progressively modifying and adjusting their policies with the enduring intention of making their R&D activity market-driven, and integrated into the business strategies of the business-units which the R&D serves. This trend is wholly consistent with the received wisdom about what makes for successful innovation. The outcomes of this steady process of evolution are complex; some prominent features are:

● where firms have corporate R&D labs, the balance of their funding has shifted from corporate to business-unit sources, which are more closely monitored through customer-contractor relationships.
● many corporate labs have either shrunk absolutely, or have reduced in relative importance within the total R&D effort of a company. This is reflected in the growth of de-centralised R&D at division or business-unit level. This tendency has been fuelled by mergers and acquisitions which have brought previously separate R&D facilities under one corporate parent. These divisional or business-unit level R&D facilities are by

definition market-driven, and do not have a brief to undertake work outside the business areas of their controlling division.
● This de-centralisation of R&D has permitted new and more intimate arrangements to develop which bring technical, commercial and operations staff together at business-unit level in effective teams for product and process innovation. This is a major historical gain for UK firms, and should not be under-estimated.[2]

However, there are also a number of negative consequences which have arisen from this de-centralisation of R&D, which have been aggravated by other contextual features.

● business-unit 'ownership' of R&D is very effective at consolidating strength within the existing technological regime applying in that company at that time. If that regime is a competitive one, all well and good. If the technological regime of the company becomes less competitive, the business-unit ownership of R&D could run the risk of digging a deeper hole for the company.
● If new 'generic' technologies emerge which are 'competence-destroying' (Anderson & Tushman, 1990) for such business-units, (e.g. new materials technologies which render existing manufacturing processes obsolete) their R&D infrastructure may not be able to cope. This has been a feature of the 80s and the 90s.

The natural place to look for a compensating source of technical competence in these circumstances is the corporate parent and its R&D capacity, which will generally be oriented to longer term strategic research. But, for a significant proportion of UK companies, this corporate competence is weak. The weakness at corporate level arises from two major sources.

● First, the process of de-centralisation, within a flat or slow-growing total R&D-funding regime, has weakened both competencies and organisational influence of corporate R&D.
● Second, there is an Anglo-Saxon bias toward corporate management 'styles'[3] which are *financially* oriented, rather than

oriented toward strategic co-ordination of the activities of a portfolio of businesses.

The combination of these two factors has meant that the overall technology and skill portfolio of a diversified corporate structure can often become simply *invisible* to the company. There is no responsible individual or structure to 'own' this problem. Consequently there can be serious deficiencies in transferring relevant technical expertise between member divisions or business units of a large corporate structure, and there can be further deficiencies in assuring sponsorship for new technologies which might be relevant to more than one division.

What these points add up to is a significant shift in the organisational focus of UK R&D organisation towards products and markets, and away from technologies. This shift is wholly appropriate at the business-unit level, but wholly inappropriate at the level of a collection of business within a corporate structure. It has led to a relative under-performance of UK firms in identifying, adapting to, and commercialising newer technologies which fall outside the established competencies of individual businesses. At the risk of exaggeration, we might say that firms have learnt the lesson of the 1970s — 'innovations are about market-pull and not about technology-push' — rather too well!

We can summarise this argument by identifying two paradigms of R&D organisation, one of which relates to the early days of organised R&D before the focus on 'market-driven' R&D' emerged, and the other which captures the 'market-driven' philosophy. These are Paradigms 1 and 2; shown in the boxes below.[4]

There is significant evidence however, that many R&D managers and chief executives have been trying to correct these problems which have emerged as a result of the shift toward decentralised R&D. In the research conducted at CROMTEC for the EC SAST8 project we found that one favoured method for this is the creation of a corporate unit for strategic management of technology with the following functions:

- to analyse the structure of the overall technology portfolio;
- to ensure that a technological competence in one business is known to and available to other potential user businesses in the group;
- to identify technical competencies which straddle businesses and to take step to strengthen them through 'horizontal' organisational links and through small special budgets.
- to consider the overall technology portfolio and inject an appreciation of this portfolio into the broader strategic management process of the company.

This trend is an interesting and significant one in our view. It represents a considered institutional response to the challenge of new technologies, and could enhance the possibilities for UK companies to move towards the practice of their foreign counterparts on the specific issue of commitment to continuous technological renewal. At the risk of over-simplification we can identify it as a third 'emerging' paradigm (see box).

Paradigm 3 is clearly predicated on transcending the old debates about market-pull and technology-push. It aims at combining the market-driven benefits which come from de-centralised business-funded R&D, with the benefits of corporate sponsorship of the technology base, and cross-fertilisation of technologies and businesses.[5] Furthermore

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PARADIGM 1	
Period of dominance:	1950–1970
Characteristics:	centralisation and corporate dominance in some or all of:
	● funding of R&D
	● ownership of R&D
	● control of R&D
Drivers:	technology-push thinking, relative novelty of R&D in historical terms, and a period of growing R&D spend.

PARADIGM 2	
Period:	from 1970 till the late 80s
Characteristics:	decentralisation and business unit dominance in some or all of: ● funding of R&D ● ownership of R&D ● control of R&D
Drivers:	flatter R&D budgets; perceived failure of technology push thinking; general move in management thinking and practice towards 'market focus'.

PARADIGM 3	
Period:	1990s onwards?
Characteristics:	● integration of elements from paradigm 1 and 2 ● conceptual separation of technology funding and product funding product funding ● mixed corporate and business unit funding with attention to subtle balance of incentives ● shared corporate and business unit ownership of R&D portfolio and resources
Drivers:	● increasing scale and global character of many R&D players: more R&D units to manage ● perceived negative effects of paradigm 2 ● 'completion' of the institutional learning process through which industrial firms have 'normalised' their ability to organise R&D in diversified companies

paradigm 3 extends beyond 'traditional' concepts of the boundaries of R&D management. It includes 'upstream' issues such as novel modes of technology-sourcing including collaboration, networks, and technology driven acquisitions. It also includes 'downstream' issues such as concurrent engineering and the use of 'time-to-market' as a competitive weapon. It therefore impinges in a variety of ways on the traditional agenda of strategic management which is the 'home territory' of the core competence paradigm. We can now turn to examine this interaction in more detail.

3. THE LINK BETWEEN CORE COMPETENCIES AND STRATEGIC MANAGEMENT OF R&D

If we now try to combine the language and concepts of these two discourses, we find some initial straightforward results:

● One of the responsibilities of R&D is to acquire, generate and husband the *technological capabilities* which are important building blocks of core competencies.

● Many of those capabilities are relevant to more than one SBU, and R&D managers are often the 'default' location of the responsibility for protecting the technological interests of SBU managers when funding regimes make it difficult for SBUs to co-operate.

● The *application* of the technological capabilities of R&D in specific innovation projects to produce new functionalities in products and processes depends on complex *coordination processes* which also involve the marketing and operations functions. These coordination processes, which span the whole SBU and often beyond the SBU into other parts of the corporation, are in fact an important part of the *organisational* dimension of core competencies. These coordination process have a firm-specific character which results from the accumulation of specific experience in constrained market and technological domains.

Thus the R&D function is not itself the site of the core competencies of the corporation, but it has two major articulations or points of contact with those core competencies. The first articulation is the *investment* mode: in which a number of R&D and R&D-related activities are concerned with managing and developing a portfolio of technological capabilities in such a way that it directly feeds into the core competencies of the corporation. It follows that this cannot be done adequately unless these core competencies have been identified. The second articulation is the *harvesting* mode, in which the R&D function participates with other SBU functions in the market-driven exploitation of core competencies to produce specific artefacts or services for customers. This approach is summarised in Figure 2.

Starting at the top of Figure 2 and working down, we see the following features:

1. The strategic research programme of the corporation is principally responsible for generating and maintaining those technological capabilities which are important components of the core competencies. This strategic research programme will, typically, be managed and funded at arms-length from individual SBUs so that its programme cannot be damaged by short-term pressures from the businesses. However, appropriate organisational structures will be needed to give the technical and business managers from the SBUs the opportunity to participate in the 'steering' of the programme, without
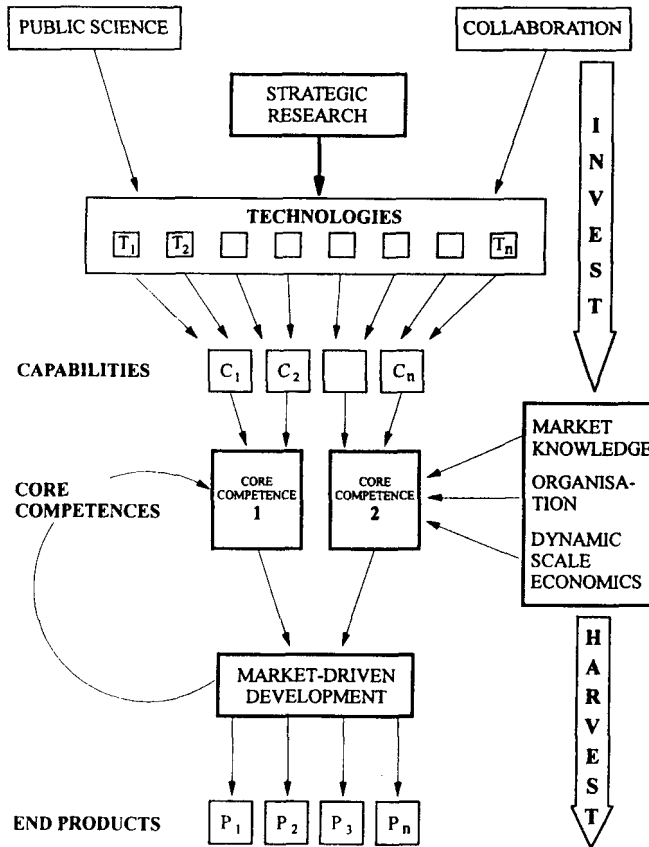
Figure 2

actually having direct control of the funding. This funding which will typically be a corporate levy on businesses, or a straightforward subvention from corporate profits.

2. Alongside the company's own strategic research programme, another source of input to the key technological capabilities of the company are external linkages to public science, and to the technology assets of collaborators. The role of managing these sources of technology is growing as companies find it harder to cover the whole spectrum of relevant technologies internally.

3. The technological capabilities form one important component of the core competencies. However, they are not sufficient on their own. Three other factors are potential inputs to the core competencies. The *first* and most important of these is *organisational structure*. In particular the structures which are relevant here are those which link the different functional contributors to the innovation and product development process. These are the linkages at SBU level between technologists, the marketing function, and the operations function. Because the core competencies are relevant to more than one SBU it follows that some or all of these functions will have organisational features which allow skills and knowledge to migrate between SBUs or to be shared between SBUs.

The *second* extra input to the core competencies is *dynamic scale economies*. This refers to the fact that core competencies have to be continually exercised in order for them not to atrophy. Exploitation of the competencies in one product domain actually produces new knowledge which expands and deepens the competence, making it more valuable for future exploitations in other domains. Competencies therefore become perfected and polished through being used, and increase their value to the company.

The *third* potential input to core competencies is *market knowledge*, defined broadly as the knowledge from all those market domains (which may include supplier as well as customer markets), which are necessary to enable

the core competencies to be continually translated into the core products.

4. Summarising points 1 to 3 then, we can see that the core competencies, whilst they are shaped by many factors which lie well outside the R&D function, do have as one of their significant determinants the 'technological investment' activity of the R&D function. It follows from this that the identification of appropriate technological capabilities and the management of their accumulation by R&D managers is an activity which can be conceptualised and steered using notions of core competence as a yardstick.

5. Moving now to the 'harvesting' mode of R&D; our argument is that market focused product development in specific SBUs is an activity in which the firm can exercise its core competencies towards business objectives. However, this need not mean that the activity is depleting the core competencies in any way. On the contrary, because the core competencies are to some extent the outcome of cumulative processes of exploiting particular skills and structures, then it is appropriate to identify a positive feedback process from development activities to competencies. This, of course, will not happen automatically. The company has to be organised in such a way that the learning process associated with product development actually feeds knowledge back into the core competencies.

Multiple characteristics of technology

We have used the metaphors of 'invest' and 'harvest' to describe the two principle ways in which R&D is connected to core competencies. Since the most immediate and *tangible* product of R&D is technology, it is useful at this point to consider the different modalities of technology and their relationship to investment and harvesting. Metcalfe & Boden (1992) make a useful three-fold disaggregation of technology into *knowledge, skills, and artefacts*. Technology as *knowledge* is the formal abstract representation of technology in a codified form; technology as *skills* includes the

human resources who have specific capabilities to employ technological knowledge, as well as the tacit knowledge which is not codified. Technology as *artefacts* concerns the physical objects which embody particular technologies. It is clear that these three dimensions of technology are distinct but related, and that the management and policy issues which attach to them are also distinct. When we take into account the now widely acknowledged firm-specificity of technology which has been referred to earlier in this paper, it becomes apparent that the notion of technology as artefacts may need further disaggregation. Specifically, we can see in any artefact a *functionality profile* which can be expressed in terms of the range of services it provides and the performance levels it is capable of. We can also see a specific *technological recipe* which consists of the particular choice and combination of technologies, design practices, configurations of sub-systems etc., which actually deliver the functionality. The technological recipe is more likely to be the dimension of the artefacts which exhibit the 'signature' of the specific skills and knowledge deployed by a particular firm in its construction.

Using this four fold conceptualisation of technology as knowledge, skills, recipes, and functionality profiles we can now revisit the issues of investing and harvesting, in the context of core competencies. Clearly, the investment mode of R&D is concerned with the first two dimensions: knowledge and skills. Decisions on R&D projects in this strategic part of the R&D portfolio are very much influenced by considerations of what new knowledge and skills can be acquired through the projects. Strategic management of knowledge and skill acquisition therefore needs to be prepared to use performance targets and measures of success which are expressed in terms of knowledge and skills rather than in terms of products or artefacts. This issue is discussed further in the final section of the paper. In the harvesting mode however, the strategic technology management issues revolve around the intrinsic strengths and weaknesses of the technological recipes available to any particular firm. In essence, the decisions often boil down to the question: 'do we have a technological solution to this product

specification which is cost-effective, proprietary, and which will please the customer'? In the 'ideal' state, if the firm's 'technological recipes' are embedded in core products, which are genuinely derived from core competencies, which in turn do satisfy Prahalad & Hamel's criteria of being difficult to imitate, then the firm's recipes will actually *define* much of what can be achieved in functionality terms in that particular technical area. At the other extreme, if the recipes are based on mature technology with little proprietary content, or if the functionality can be provided by a range of widely differing recipes, then the technologies of the firm are not being effectively deployed in a manner consistent with the core competence approach.

4. R&D DECISIONS AND CORE COMPETENCIES

We can now review some familiar areas of R&D decision making in the light of the arguments developed so far.

4.1. Criteria for longer term R&D projects

R&D managers often have difficulty deciding on the technical content of the longer term component of their R&D portfolio and justifying their decisions to managers from business units and from other functional areas in the company. There are usually competing demands on limited budgets arising from groups of researchers who are attached to particular technologies, as well as genuine uncertainties about the potential benefits which might be realised from different avenues of investigation and development. However, if the company of which the R&D function is a part has made an explicit identification of its core competencies, then this can help to clarify the choices somewhat. Basically, competing projects or programmes can be evaluated from the standpoint of the question 'does this project offer the prospect of developing existing knowledge or skills; or acquiring new knowledge or skills, *which would contribute directly to any of our core competencies?'*

Of course, it is easy to say this in principle, and much more difficult to do in practice. In some companies, it may be that

core competencies will have been defined in a very generic way, making the task of linking technologies to them very difficult. Residual technical uncertainties often will not permit a definite prediction of whether a programme will evolve in the direction expected. However, these difficulties and others are always attached to R&D decisions, especially at the longer-term end of the portfolio. What is more certain is that the shape and content of long-term R&D portfolios is no longer something which corporations are prepared to leave solely to the judgement of senior R&D executives. Some sort of transparent and readily accessible set of decision criteria are increasingly required, in order at the very least to enable the R&D programme to have some perceived legitimacy within the wider realms of the company. This presents a 'problem of justification' for R&D managers. The use of core competencies as yardsticks for the shape and direction of long term R&D programmes is a potential source of help, in solving this problem. The manner in which an appeal to core competencies may help with the defining of a 'strategic' component to an R&D portfolio may be as much about the *process* of the decision as about its actual content. Part of the difficulty with such decisions is the absence of a good 'common language' which R&D managers and general managers can use to discuss R&D projects and their benefits. Core competencies as a concept has the merit that it is not an R&D term, but comes from the language of general strategic management. Therefore it may be more acceptable to general managers to agree to an R&D programme couched in this language, rather than one couched in a narrower and more technical language.

4.2. Funding and organisation of R&D

These arguments about the use of core competencies as a conceptual tool to shape strategic R&D also have consequences for a model of organisation and funding which is beginning to emerge as dominant in many large and diversified R&D-intensive companies. The main features of this approach, which is consistent with the 'paradigm three'

approach described in section 2 above[6], are as follows:

- Longer term elements of the R&D portfolio funded corporately rather than by SBUs in order to insulate them from short term pressures, and to reflect the fact that the projects are often relevant to more than one SBU.
- The long term R&D should be organised not around generic scientific disciplines but around specific technological capabilities which map onto the core competencies.[7]
- Technical and non-technical managers from the business units should be involved in a formal review procedure which enables them to participate in the steering of the long term R&D, and to learn how it may be relevant to their own SBUs, but with only limited direct authority over the content and management of the programme itself. The aim is to achieve shared ownership and legitimacy without a great deal of detailed horse-trading over specific projects.
- In companies where technology is a frequent source of competitive advantage, the organisation and funding of R&D may do much more than simply respond to the strategic agenda and the core competencies defined 'from above'. It may play a very substantial part in the setting of the agendas and the defining of the core competencies and their future evolution. This aspect of strategic technology management is, in general, underdeveloped in the UK.

4.3. Measuring the effectiveness of R&D

There is now a rising concern with the need to measure the effectiveness of R&D. This can be seen as a specific instance of the more general trend to tighten management surveillance and control, and to ask searching questions of any functional area about its contribution to the company, and the efficiency of its processes. The problem of measuring the effectiveness and efficiency of R&D has been addressed several times over the years.[8] The prevailing concern of liter-

ature has been whether it is possible to identify direct financial benefits from R&D and relate them to the associated programme costs. Whilst this aspect of measurement is clearly interesting, it relates primarily only to the harvesting mode of R&D as discussed earlier. One of the implications of the linkage of R&D to investment in core competencies is that a case can be made for trying to measure the extent to which knowledge and skills are actually accumulated in those technical areas that are agreed as significant contributors to core competencies. These dimensions of technology are even harder to relate directly to financial outcomes than artefacts, and it seems more appropriate to use bibliometric and peer-review styles of measurement in this area.

There is some evidence that this can be done. Lillystone (1993) presents an approach designed to suit the needs of a large industrial gases company. Miyazaki (1993) has shown in great detail how bibliometric techniques applied both to scientific papers and to patents can be used to measure and compare the capabilities and competencies of eight large electronics companies in a specific technical field, namely optoelectronics.

The merits of investing significant effort in setting up systems to monitor technology accumulation in this way must obviously be judged on the basis of the scale of the company's investment in competence-building, and on whether the measures would have any operational value in terms of motivation. However, in this area as in many other areas of R&D and technology management, it is hard to escape the view that more performance measurement will be done in future. In part this is an inevitable corollary of the trend to more detailed and careful planning processes at the front end of R&D. The increased linking of post-project evaluations to pre-project benefit statements is likely to be a significant feature of all R&D management in future.

5. CONCLUSION

This paper has argued that there is an increasing concern amongst R&D managers and their immediate 'customers' and sponsors within companies to have reliable mechanisms to direct R&D simultaneously toward effective rapid innovation and accumulation of long term technological strength. This is leading R&D managers to seek analytical tools to help them identify technologies which have particular significance for competitive advantage, for multiple SBUs, and for longer term strategic positioning, but situate them closer to the core of corporate strategies. An examination of the parallel literature on the idea of core competencies as a new paradigm in corporate strategy has shown that competencies can be useful focusing devices for assisting in the creation of this linkage between the technological and non-technological aspects of the corporate strategy agenda. Further research on the specific core competencies of particular companies, and on the connections between these competencies and their R&D sub-unit strategies is now required in order to develop this idea. The level of detail analysis required to do this adequately is such that long-term case studies would probably be the best vehicle. Such work would lend itself to being linked to practical exercises in technology strategy development in case-study companies.

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NOTES

1. This section draws heavily on the findings of a research project carried out for the SAST programme of DGXII of the European Commission. The final report has recently been published (Coombs & Richards, 1993b).

2. The author carried out a study of de-centralisation of R&D in 24 large UK firms in the early 1990s (Coombs & Richards, 1993a). Amongst the firms studied, the major reason for de-centralisation was the desire to achieve better innovation performance. For most of the firms, this was felt to have been successful to some degree.

3. We are using 'styles' in the sense defined by Goold & Campbell (1987).

4. The boxes are taken from Coombs & Richards (1993a).

5. We have concentrated on presenting these issues as they emerged from the SAST project, and from the earlier work reported in Coombs & Richards (1993a). However it is clear that the broad approach taken here has significant resonances with other recent work in the field. See for example 'Third generation R&D', Roussel et al. (1991), and Rothwell's 'Fifth-Generation Innovation Process' (1992). Rubenstein (1989) also addresses some of these issues.

6. See also 'best practices' numbers 1 to 7 in the list of 13 provided by Krause & Liu (1993).

7. To give an example; a major glass-making company organises its long term R&D around a small number of areas such as the 'melting, forming and coating of glass'. These aspects of the manufacture and use of glass are relevant to all of their businesses, and all require the deployment of a variety of scientific and technical skills and specialists.

8. For a review, see Lillystone, D. (1993), unpublished M.Sc Thesis, UMIST.