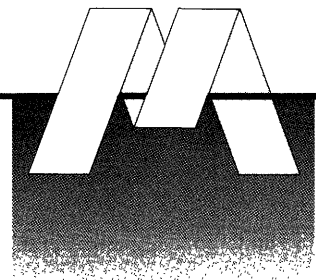


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MONITOR

SPEAR

**Evaluation of the Impact
of European Community Research Programmes
upon the Competitiveness
of European Industry - Concepts
and Approaches**

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Section I

Introduction

1.1 The Competitiveness Rationale.

During the 1980's there was a general trend towards justifying public support for research and development in terms of the impact it would have upon industrial competitiveness. In some cases this rationale was applied to the whole spectrum of research activities, but it was most commonly applied to strategic programmes of research. Such programmes were frequently concerned with the so-called 'new technologies' (information and communications, biotechnology and new materials) and often involved new structural forms. A key feature of such programmes at both national and Community level was collaboration, both between firms and between firms and academic institutions. The programmes were formulated and implemented during a period when state intervention in industrial activity was declining. To emphasise that they were not interfering with the market behaviour of firms, the programmes were described as 'pre-competitive', that is concerned with areas of research which in the longer term would have market significance but within which, in the interim, firms could work together to create a common body of knowledge which they could subsequently exploit separately in competition with their former partners, as well as with other firms. This model of research was based upon perceptions of the success of Japanese initiatives, notably the VLSI project where the main participants all subsequently gained significantly in the market. The generality of this assumption will be questioned later in this report, but as an initial rationale it will suffice.

Community programmes were part of the trend referred to above. Programmes such as ESPRIT and BRITE sought to enhance the competitive performance of different sectors of European industry. Article 130F of the Single European Act gives as the underpinning rationale for the Framework Programme that,

"The Community's aim shall be to strengthen the scientific and technological basis of European industry and to encourage it to become more competitive at international level."

Individual programmes have also adopted enhancement of competitive performance as part of their objectives but the objectives are not broken down further into a verifiable format. Whether it is possible to be more specific is one of the questions to be addressed by this study but, for the moment, it is sufficient to note the widespread and underpinning presence of the competitiveness rationale. It should also be noted, however, that there are a number of other objectives for Community R&D embodied in the S.E.A. and hence that not all programmes need embody a contribution to competitiveness in their objectives.

1.2 Evaluation and Competitiveness.

Panels appointed to evaluate Community programmes have already had to pass judgement on the contribution made to competitiveness. It is instructive to examine how the issue was treated in the cases of two large programmes which explicitly addressed the competitiveness of European industry, ESPRIT¹ and BRITE².

Evaluation of the first BRITE programme (1985-1988)

The evaluation of BRITE contained a section discussing industrial competition and the role of technology. While stating that it was essential that a scientific and technical culture should be introduced into the European industrial system, the report stated:

1 Y. Farge *et al*, *Evaluation of the first BRITE programme (1985-1988)*, Commission of the European Communities, July 1988

2 *The Review of ESPRIT 1984-1988*. The Report of the ESPRIT Review Board, May 1989

"Boosting competitiveness means reducing production costs and delivery times, and improving quality, just as much as developing new products and processes. For BRITE-II, the panel recommends that the concept of competitiveness be defined more clearly in the call for proposals, and taken into account more extensively in the selection criteria."

The panel queried the incorporation of the concept of pre-competitiveness in a research programme whose primary goal was to enhance the competitiveness of European industry. This was in the context of a more general criticism of some projects being too distant from the market.

The economic impact of the programme was assessed through a questionnaire to which 177 out of 445 participants replied, and direct interviews by the panel. It was concluded that most projects should exert a genuine impact on the competitiveness of the industries concerned, even if such an impact cannot be estimated correctly.

The review of ESPRIT 1984-1988

The review of ESPRIT I began by stressing that the overall strategic goal of the programme was to provide the European IT industry with the technology base which it needs to become and stay competitive with the USA and Japan in the 1990's. Comments in the report in this area were generally restricted to detailing ways in which the technology base was enhanced, and associated matters such as dissemination of results. The benefits of collaborative working were also stressed, as were contributions to standards. In concluding and looking ahead, the report saw the problems of risk aversion in new product investment as the main feature obstructing European industry compared with the USA and Japan.

While presenting a general picture of the standing of European industry in the IT sector (through trade balance and market share data) the report did not attempt to link changes in these to the programme.

General Problems in evaluating the impact of R&D on competitiveness

As the above examples illustrate, evaluation panels have faced difficulties in dealing with, or even comprehending the competitiveness issue. One reason for this is

that the programmes they are evaluating may represent a necessary step to improvement of competitiveness but they certainly do not represent a sufficient one. An enhanced technological base still requires investment and successful entrepreneurial activity to support it. Products may draw upon multiple sources of knowledge, and an R&D project may contribute to the development of a number of products (or processes). Collectively these problems of attribution make it difficult to assess the economic return on R&D, even in industry.

A further well-known difficulty in evaluating the benefits of R&D is that deriving from the time-interval needed for many results to be applied. Since evaluations take place during or immediately after a programme, these may not yet have been felt.

A third important point is that Community spending accounts for only about 4% of non-military R&D expenditure in Member States, meaning that its impact is difficult to separate from that of R&D spending by recipients from their own or other resources.³ Nevertheless, the Community input may be relatively large in a given area for a given recipient.

1.3 Objectives of this Report.

In view of the difficulties encountered in the evaluation of competitiveness, this report has the following objectives:

- to clarify the meaning of the concept of competitiveness;
and
- to suggest guidelines for evaluation of programmes in terms of their impact upon competitiveness.

The work presented in this report is largely the result of a desk study, though it draws upon previous empirical work. Informal discussions were held with a small number of participants in the ESPRIT and BRITE programmes regarding their perceptions of the likely input of their projects on the competitive performance of their firms. The study also benefitted from comments received from members of the

3 Commission of the European Communities, *First Report on the State of Science and Technology in Europe*

SPEAR Network on Methods for Socio-Economic Evaluation of R&D.

Section 2 of the report reviews some of the **recent literature** on the nature, measurement and sources of competitiveness in order to investigate what is generally understood by the term. **Section 3** then goes on to present a more **analytical perspective** which seeks to explore the consistency of the various concepts of competitiveness through presentation of a dynamic perspective and ultimately to arrive at a view of which measures provide the best indication of competitive advantage in particular circumstances. **Section 4** draws upon the earlier material to set out **guidelines for the evaluation** of the impact of Community programmes on competitive performance; and **Section 5** draws some **conclusions** and suggests some future lines of research.

SECTION 2

Definitions of Competitiveness

In recent years a plethora of reports, books and articles have appeared on the nature, measurement and creation of competitiveness. Few issues can have enjoyed more official attention in the last decade than competitiveness, and it remains the constant concern of commentators on the industrial and management scene. Discussion of "technology gaps", of "catching up" and "falling behind" has been commonplace, yet little clear agreement has been reached other than that technology is important to the competition advantage of firms and nations and, ultimately, to the long run standard of living of a nation's citizens. Three reasons can be put forward to explain why our understanding is fragile. First and foremost the relation between technology and competition reaches to the core of the operation of a capitalist market economy, and this core is inevitably complex. Even the concepts of technology and competition admit diverse and often incompatible interpretations. Secondly, and however important as a contributory factor, technology is only one of the elements which determine patterns of competitive behaviour and there are no simple ways to isolate the technological from other important elements of firm performance. Finally, technology itself is complex. It has many dimensions, it is located in different institutions, and its mechanisms of accumulation differ considerably across its different constituent parts. For these reasons one of the central tasks in this area is to understand more clearly the nature of technology and the processes by which it accumulates. Our purpose in this section is to review some of the leading contributions to this debate, taking this as an introduction to the more analytical treatment of the problem which follows in Section 3. This brief survey of the literature establishes without doubt that there is general agreement on what competitiveness is but substantial disagreement over important details. Since the details are important for policy purposes this lack of agreement is a matter for concern. As we shall see, much of the confusion is related to the different levels at which competitiveness may be considered, supra-national, national, regional, industrial and firm. At each level different factors come into play, different indicators are appropriate and different policy conclusions follow.

A useful starting point is the recent work by Porter³ who draws attention to competing explanations of competitiveness. Some explanations run in terms of macroeconomic policies (exchange rates, interest rates, etc), others in terms of availability of labour (quantity and quality) and natural resources, others in terms of industrial policies and yet others in terms of management practices and capabilities. As he rightly comments

"none of these explanations for national competitiveness, any more than a variety of others that have been put forward, is fully satisfactory. None is sufficient by itself in rationalizing the competitive position of a nation's industries".

His own preferred definition is in terms of national productivity, where productivity is broadly defined,

"a nation's firms must relentlessly improve productivity in existing industries by raising product quality, adding desirable features, improving product technology, or boosting production efficiency".

The clarity of this view is not always matched in the other literature.

At the level of the individual firm matters seem more straightforward; competitiveness is concerned with generating superior product and process attributes relative to rivals and articulating these advantages to gain market position. A recent case study by Lehnard⁴ makes this abundantly clear. It concerns a household products company located in the USA which recognised that over the longer term, 20 years or so, its competitive position would be eroded by foreign competition and that it must transform its product range and manufacturing processes if it was to survive. Thus it undertook a six year research and development programme to redesign its product range while simultaneously automating the production process. The programme was overwhelmingly successful, cutting labour requirements from 600 to 171 operatives and permitting substantial real reductions (between 42% and 62%) in the real cost of its products. The success of the programme was reflected in an expanding market share in US and European markets, a 30% pre-tax rate of return on the investment and a greatly enhanced future design capability. In short, this company became more competitive by investing

3 M. Porter, 1990, *The Competitive Advantage of Nations*, Macmillan

4 A.P. Lehnard, 1987, 'Revitalizing the Manufacture and Design of Mature Global Products' in B.R. Guile and H. Brooks (eds), *Technology and Global Industry*, Natural Academy Press

in product and process superiority relative to its rivals and reaped the reward one would expect it to reap in an international market economy.

This differential advantage view of competitiveness is endorsed by the President's Commission Study (1985) in the USA.

"A firm is competitive if it can produce products or services of superior quality or lower cost than its domestic or international competitors".

This carries over to the national level as well but with qualifications.

"While there are parallels between competitiveness at the firm level and at the national level, the definition of the latter is much more complex. It is unlikely that all sectors of a nation's economy will be equally competitive in world market. Success in one industry can reduce competitiveness in another, as wages and factor costs are bid up. Nevertheless, while the definition of competitiveness does not require that all industries be equally strong, we reap benefits from maintaining a level of diversity in our industrial base."

Similarly Cox and Kreigbaum⁵ identify greater competitiveness with lower prices or higher quality compared to rival firms. The general theme here is one of relating competitiveness to market performance, a view endorsed by a separate study (Cabinet Office on Commerce and Trade).⁶ There it is argued that

"no single indicator can adequately measure our competitive standing in world markets. However, competitiveness is best measured by four key indicators: (1) labour productivity, (2) real wage growth, (3) real returns as capital employed in industry, and (4) position in world trade. These measures come closest to reflecting a nation's ability to meet the challenges of international markets while increasing the real incomes of its citizens. Any one of these indicators can be influenced by factors other than competitiveness. Taken together, however, they present a corroborating picture of a nation's competitive position. Each shows a different

5 J.Cox and H.Kreigbaum, 1989. *Innovation and Industrial Strength. A Study in the United Kingdom, West Germany, the United States and Japan*

6 Cabinet Office on Commerce and Trade, 1982. *An Assessment of US Competitiveness in High Technology Industries*

facet of our competitiveness."

Moreover, the report continues,

"Just as it is inappropriate to focus on only one indicator, US performance along these indicators of competitiveness must be evaluated over time. The trends in these key indicators are at least as important as current performance. Trends are essential in assessing our future competitiveness and represent vital indications of whether the United States is making the progress necessary to meet its national goals. Understanding these trends is also crucial to understanding the long-term implications of the recent economic upturn for US competitiveness".

We endorse entirely the dynamic view of competition which is entailed by the emphasis on trends.

However it is intrinsic to this market based view that not all sectors can be competitive just as not all firms within sectors can be competitive. As the report observes

"finally, US competitiveness is not defined as the ability of any single US industry to remain viable. If any one US industry cannot be competitive, then resources should flow to other industries in which they can be used more effectively. This benefits our productivity and hence our economic growth. All industries cannot be competitive, because increasing competitiveness in one industry will allow it to build up wages and attract resources away from others and reduce their competitiveness. Competitiveness also does not distinguish among industries simply due to classification as "basic" or "high tech". Both basic and high tech industries can be competitive if they utilise resources productively: any industries that cannot will remain stagnant or decline. It is in the US national interest to maintain a broad and diverse industrial base in which many industries achieve high levels of productivity.

The link between technology and market performance is emphasized in a recent study from the Office of Technology Assessment.⁷ It is argued that technology is the key to competitive success.

7 Office of Technology Assessment 1990. *Making Things Better: Competing in Manufacturing*

"Nations that rely on low wages to sell their goods in the world market are, by definition, poor, whereas superior technology raises productivity and thus supports rising standards of living. Moreover, technology is a steady, predictable source of advantage, while others may shift with political currents. For example, a nation's fiscal and monetary policies affect the value of its currency, which in turn affects the saleability of its manufactured goods in the world market. But macroeconomic policies are changeable and are far beyond the control of private firms."

Consequently there are no simple remedies for loss of competitiveness but nonetheless the basis of competitive success in the USA is to be found in enhanced technology. Increasing investments in physical, human and knowledge capital, developing closer links between firms, their suppliers and customers, encouraging the diffusion of technology to smaller firms and public support for the development of risky long term technologies: these are the remedies which are proposed. In similar vein, Rothwell and Zegveld⁸ in their review of technology policies, identify three elements of a balanced and integrated technology policy to restore industrial competitiveness. These are: technical opportunity - this defines the capacity to change the ways in which things are currently done and includes, for example, the technical and scientific infrastructure; the structure and dynamics of the industrial sector in terms of propensities to innovation and propensities to grow - crudely, this links "demand pull" to "technology push"; and the size and structure of market demand - i.e. the incentives to innovate. Together these factors constitute the most significant structural dimensions of competitiveness. Governments can intervene to influence each of these elements as well as their interdependence.

Within this generally agreed theme of relating competitiveness to market performance some interesting disagreements emerge. One concerns the question of whether competition is other than a zero-sum game. Thus in a US Department of Commerce publication⁹ it is argued that

"the principle of comparative advantage should remind us that a nation cannot be competitive in all products or services even if productivity in these industries is high relative to other countries. Moreover, efforts to make certain industries more competitive will make other industries less competitive . . . the situation [is] a zero-sum game."

8 R. Rothwell and W.Zegveld, 1981, *Industrial Innovation and Public Policy*, Pinter, London

9 US Department of Commerce, International Trade Administration, 1987. *Improving US Competitiveness*

By contrast, the President's Commission report argues that

"competitiveness is not a zero-sum game. All nations benefit from and depend on the economic growth of other nations. As other nations grow, they provide large export markets for US goods as well as low-cost sources of supply for products in which the United States lacks a comparative advantage. The United States can buy products where it has no advantage from other nations and reallocate its own resources to high productivity uses. Every nation can improve its competitiveness, and all nations will benefit. The goal of competitiveness is not to create disadvantages for our trading partners but to strengthen and better deploy the advantages of America has at its command."

By way of comment it is clear that this quotation runs together concepts of absolute and comparative advantage, resource productivity and competitiveness which could, with some justification, be clarified. It is true that absolute advantage must be distinguished from competitiveness because competitiveness is necessarily a relative concept, indeed it is a tautology to state that an improvement in the comparative advantage of country A in industry X entails a corresponding increase in the comparative advantage of country B in industry Y. To that extent comparative advantage is both relative and symmetric. However, we would contend that to equate comparative advantage with competitiveness is too simple-minded. Comparative advantage is a static concept. By contrast policy makers and industrial managers need to have dynamic concepts of competitiveness. These are bound to be more general in scope than the question of resource productivity.

As far as indicators of competitiveness are concerned there is no clear cut opinion to be found, it rather depends on the level at which competitiveness is defined. As we have seen, Porter equates competitiveness to a broadly defined notion of productivity, while the Cabinet Office study takes a more eclectic view. There is general agreement that the level of the trade balance of a country is not an ideal indicator. Thus the same Cabinet Office study argues that

"there is no empirical evidence that nations with current account surpluses have been able to outperform nations with deficits in terms of economic growth. Nevertheless, intelligent examination of our trade balance and its composition does provide some indication about our competitiveness that merit our concern".

Table 1 Measures of Competitive Performance, Potential and Process

		Time Horizon		
		Performance	Potential	Process
Level of Analysis	Country	Export market share % manufacturing in total output Balance of trade Export growth Profitability	Comparative advantage Cost competitiveness Productivity Price competitiveness Technology indicators Access to resources	Commitment to international business Government policies Education/training
	Industry	Export market share Balance of trade Export growth Profitability	Cost competitiveness Productivity Price competitiveness Technology indicators	Commitment to international business
	Firm	Export market share Export dependency Export growth Profitability	Cost competitiveness Productivity Price competitiveness Technology indicators	Ownership advantage Commitment to international business Marketing aptitude Management relations Closeness to customer Economies of scale and scope
	Product	Export market share Export growth Profitability	Cost competitiveness Productivity Price competitiveness Quality competitiveness Technology indicators	Product champion

From: P.J.Buckley, C.L.Pass and K.Prescott, "Measure of International Competitiveness: A Critical Survey", Journal of Marketing Management 1988, 4, No.2,

As we shall see in Section 3 there is more to be said on this matter.

To draw this brief survey together we present in Table 1 the results of a comprehensive review of measures of competitiveness produced by a team at the University of Bradford.¹⁰ The authors classify these measures in two dimensions, the level at which competition is analysed and uses the time horizon to distinguish between competitive performance, its sustainability through the generation of competitive potential and management of the competitive process. The measures indicated place most emphasis on competitiveness in foreign markets (which may not be the case for a firm or product) but this stress is consistent with Community ideas of competitiveness relative to other global trading blocks. The review stresses that single measures of competitiveness do not capture all of the elements of the concept and that the measures are inter-related. While an excellent review of the existing conventional wisdom, it reflects that consensus by emphasising the static aspects over the dynamic. Since our prime concern is with technical change, it is only natural that the latter assumes greater importance. In the next Section, we attempt to build upon the foundations set out previously but to emphasise the dynamic process which characterises technical change. From this theoretical viewpoint we may then prioritise among the range of measures of competitiveness presented to us.

10 P.J.Buckley, C.L.Pass and K.Prescott, 'Measures of International Competitiveness: A Critical Survey', *Journal of Marketing Management*, 1988, 4, No.2. 175-200

SECTION 3

An Analytical Perspective

In the previous section we reviewed some of the recent investigations of competitive performance in modern economies, and it will be clear from this review that there is no simple way in which the nature of competitiveness can be summarized. Whatever it is, it is multi-dimensional and it relates to the dynamics of structural change and the diffusion of technologies and organisational behaviours. It is certainly not a time independent concept, and the systematic forces which are at work, must be matched carefully with those random forces which make the results of competition so unpredictable.

For the policy maker, anxious to improve competitive performance, this is no doubt frustrating to hear. However, a better understanding of the complexities of competition can only help the better design and implementation of competition enhancing policies. We shall turn to this topic in our final section. One task now is to present as clear a statement as is possible of the nature of competition and of the meaning of, and sources of competitive advantage.

3.1 The Importance of Competition

Underlying all of the recent concern with the competitive strength of firms and nations is, we believe, a perception that it is of primary importance in determining standards of living both absolutely, and relatively across nations. The share of the world's wealth generating capability a nation can command, in conjunction with its share of the world's population, determines its standard of living. Competitiveness it seems is the key to gaining a greater share of world wealth generation and with it a

higher standard of living. Moreover, there are good reasons to expect competitive success to be cumulative for considerable periods of time so that, to use the well worn phrase, 'the rich get richer and the poor get poorer'. While this element of cumulative causation is important in the history of nations and firms, it is also true that competitive success can be reversed, that nations and firms which seem uncompetitive at one stage of history, shake off their constraints and rise rapidly in relative importance. Any understanding of competition must be able to incorporate these important elements of historical change and turbulence. Mokyr's recent book ¹¹ is an outstanding account of how the technological position of industries and nations can be transformed over time.

Of course, it goes without saying, that the competitiveness of nations is nothing more than an appropriate aggregate of the competitiveness of the firms which they contain: measured either in terms of production or in terms of ownership, for in a world of direct investment and capital mobility, the two can differ substantially. To understand competitiveness we have to be sensitive to the different levels at which it is generated and of the important feedbacks which link the various levels.

3.2 Contrasting Views : Equilibrium and Process

One of the great contrasts of modern economic thought, is the disparity between what the economist means by greater competition and what the businessman means by greater competition. At its most fundamental, this is a conflict between competition as a state of equilibrium and competitive as a process of change.

The economist's concern is with the efficiency of market mechanisms in allocating given resources in an efficient way, and this has led to the view of a competitive situation as one in which two independent conditions hold. First, a situation is more competitive the less able is the businessman to influence the price at which his product is sold. In the limit of perfect competition, a firm can sell as much as it wants at a market determined price, over which it has no influence. Secondly, a situation is more competitive if a firm's profits are closer to the limit at which it would just consider keeping its capital in that line of business. The first condition is a question of market structure, perfect competition is more closely approximated, the greater the number of competing firms in line of production. The second condition is a question of freedom of entry and exit, that is of the mobility of capital and managerial capability within and

11 J. Mokyr, *The Lever of Riches*, Oxford University Press, 1990

between industries.

It is this line of argument which leads to the contrast between monopoly, a single producer, and perfect competition, very many producers, with a whole spectrum of monopolistic competition and oligopoly/duopoly situations in between. What unifies this approach is not so much the emphasis on numbers of firms and entry/exit conditions, but rather the concern with positions of market equilibrium, that is, situations in which no firm has any incentive to change its production or pricing behaviour.

To the businessman, this is rather difficult to grasp, for it omits what is the most obvious element, namely the **changes** which occur as a result of rivalrous behaviour. From this viewpoint, a market in equilibrium is one in which the forces of competition have ceased to act. The economist's view, quite valid in terms of its concern with efficient resource allocation, offends common sense when it comes to discussing the competitive behaviour of everyday business activity. Rivalry means behaving differently from other firms, differently in a way which conveys competitive advantage and alters the prevailing balance between the rival producers. The economist's traditional concern with equilibrium simply rules such considerations out of bounds. As Hayek perceptively noted,

"if the state of affairs assumed by the theory of perfect competition ever existed, it would not only deprive of their scope all the activities which the verb 'to compete' describes, but would make them virtually impossible" ¹²

In short, verbs define actions but in the traditional concept of competition, the use of equilibrium denies the possibility for action. Correspondingly, actions which firms take to enhance their competitiveness, price reductions, improvements in product quality, advertising campaigns, are deemed to be imperfections which diminish competition and introduce elements of monopoly that reduce efficiency. This paradox that competitive behaviours are judged to have anti-competitive consequences, is at the root of the difficulty in making sense of competition.

The simple point is that competitive behaviours cannot be understood by reference to equilibrium but only by reference to a process of change driven by differential

12 F. Hayek, 1948, 'Economic Theory and the Meaning of Competition' in *Individualism and Economic Order*, Chicago

behaviour. It is because firms strive to be different that a situation is competitive, and clearly the development of technology is of prime importance in this regard. Some additional paradoxes which follow from the equilibrium view are worth noting. In conditions of perfect competition, the firms are not rivals, for by definition they can sell whatever amounts they please at current prices. Indeed, the most competitive situation in the traditional view is one in which all rivalry has been eliminated. This may help in understanding outcomes in the world market for wheat or some other standardized commodity, but it could not be further removed from the conditions of competition among the industrial nations. Secondly, in equilibrium there can be no scope for entrepreneurial behaviour, for entrepreneurship and equilibrium are incompatible concepts. However, entrepreneurship is a highly valued business trait precisely because of its connotations as a competitive force. Clearly, the equilibrium view is not helping us to come to terms with vital elements of competitive behaviour.

Our solution to this difficulty, is to view competition as a process of change driven by variety in behaviour across firms. It is an open ended process in which new economic states are to be discovered, and while it may not be predictable in terms of its outcomes, it is possible to be confident about the mechanisms at work. The approach we shall take may be summed up in terms of the following three questions:

- a) What dimensions of differential behaviour yield competitive advantage?
- b) What mechanisms generate those differential behaviours?;and
- c) What mechanisms resolve these behaviours into competitive outcomes.

Clearly this triad forms a basis for classifying policies to enhance competitive performance, as is briefly explored below. It is hardly surprising that technical change is a key element in the process view of competition. No economist has perceived this more clearly than Schumpeter, for his 'gale of creative destruction' depends on the differential behaviour of competing firms, and their drive to be different is premised on their search for a decisive cost or quality advantage. But, innovation is an exploratory process and experimental behaviour is a necessary feature of real world competition with all the uncertainties and lack of predictability that this entails. That it appears from some points of view to entail duplication and waste of resources is inevitable, for our view of competition is that it is a learning process premised on imperfect knowledge. There is no more destructive feature of an economic theory than the one which claims perfect knowledge for decision makers and policy makers.

It is often useful to wrap the process view of competition in the metaphor of a race. Any race has three elements: the competitors and their behaviours; the set of rules which

define legitimate competitive behaviour; and the criteria which identify success and failure. Any such race in which all the competitors performed identically, would not only be unusual, it would also be entirely predictable and devoid of interest. For what is important about any race is its inherent unpredictability, the scope for surprise, the fall of the favourite, the triumph of the dark horse are the essence of the serious competition. Moreover, while an economic race may have some attributes of a sprint, it is perhaps better thought of as a race without an end, in which competitors join, gain benefits along the way and ultimately drop out. Staying the distance becomes the principal distinguishing characteristic of the competitive firm. As in any race, there is an ordering of participants at any point, but being first is not the only satisfactory position. So, it is in competition. The possibility of competition depends on a divergence of views across firms as to the appropriate policies with respect to range of products, prices and methods of manufacture. Thus, the mechanisms by which opportunities to behave differently arise, and the way in which firms conduct and act on these opportunities, are not only central to the competitive race, but central to the policies to influence its outcomes. ¹³

3.3 The Competitive Process

The first task in elaborating a process view of competition is to distinguish carefully between the competing units and the environment which selects between their behaviours. Markets provide the environment, markets for outputs as well as markets for inputs, and firms compete in both domains in terms of prices (e.g. product price and wages offered to particular groups of employees) and quality (e.g. product quality and working conditions). But, markets are much more than price structures. They are networks of formal and informal relationships, ¹⁴ they have a rate of growth, positive or negative expanding or contracting opportunities for competition. Some markets operate continuously, others only at infrequent intervals and questions of the frequency of market selection are important to the competitive process. Compare, for example, competition in the defence or nuclear power industries with that in the food industry to see the force of this point. More importantly, markets apply selective pressure to firms with different ferocity. How quickly a firm loses customers if it raises its relative price or reduces its relative product quality is of paramount importance in this respect. In a market of well informed customers, one might expect this reaction to be rapid, in a world of greater ignorance it is less so. An important feature of any market environment

13 For an extended discussion of this point see L. Georghiou, J.S. Metcalfe et al *Post-Innovation Performance - Technological Development and Competition*, MacMillan, 1986.

14 G.B. Richardson, 1972, 'The Organisation of Industry', *Economic Journal*, vol.82

is always the degree of intelligence with which users can make their selections between rival product/price offering. Moreover, there is no reason to expect this selective pressure to be the same for all firms. Market segmentation is a well known phenomenon and firms which have accumulated goodwill from their customers clearly enjoy some reduction in selective pressure.

When we turn to the question of the units of competition, we face one of the issues which makes the discussion of competition so complex, namely the different levels at which competition operates. We shall distinguish and discuss competition at three different levels, recognising that intermediate levels of analysis, for example, an industrial sector, may be appropriate in some circumstances. These levels are the transformation process, the business unit or firm, and the nation. Before we elaborate on the competitive process we must also dwell briefly on the different dimensions of technology which are relevant; namely, knowledge, skills and artefacts. Artefacts are the most obvious dimension of technology in terms of the competition process, they are the products and associated methods of production which firms deploy to gain competition advantage. For the analysis of technology, the artefacts provide the most direct measure of technological progress, either *ex post*, in terms of past improvement or *ex ante*, in terms of forecast improvement. Underpinning the capability to produce and improve the artefacts are the knowledge of skill bases centred in firms and other institutions. (It was recently argued that skills and research manpower are the main driving forces of competitiveness¹⁵) Over the longer term it is the ability to create these less tangible dimensions of technology which is the ultimate determinant of competition advantage. With these distinctions in mind we turn to our three levels of competition.

The Transformation Process

At this level we find the basic units of market competition, namely the products and their associated methods of manufacture. We call such a product/process pairing a transformation process and emphasize its unity as far as competition is concerned. Products cannot be treated separately from their methods of manufacture, differences in both dimensions are relevant to the way in which competition operates. Clearly, technology is virtually synonymous with the concept of a transformation process both in terms of the respective artefacts and in terms of the skills and underpinning knowledge which make production possible. Moreover, this is true both at a point in time and over time in terms of the opportunities to use enhanced skills and knowledge to improve the products and their methods of manufacture. As we shall emphasise

15 R.B.Reich, 'Who is Us?' *Harvard Business Review*, January-February 1990

below, the ability of firms to maintain a momentum of improvement in their transformation processes, is a necessary condition for long term competitive survival.

In introducing technology at this point, we can go further. Any product and its method of manufacture can be presented in terms of a set of associated performance characteristics, the product characteristics determining its application and what users will pay for it, and the manufacturing characteristics determining the inputs which are required and the corresponding costs of production. Indeed, a useful tool for any analysis of competition is a mapping of how the performance characteristics of different transformation processes stand relative to each other, and how they move over time. A map identifies the key performance characteristics which define competition advantage, it identifies the inherent limits on those performance characteristics and plots the trajectories of advance for the performance characteristics. Mapping of this kind we see as a fundamental tool for strategy and policy formation.¹⁶ Such a device provides an immediate picture of the differential behaviour of rival firms in the technological dimension.

Not only is this the fundamental level of market competition, it is the level where the process of competitive change is most rapid and the level at which competitive advantage is most clearly defined. In modern conditions the process is played on an international stage.

The Business Unit/Firm

Every transformation process is operated for a purpose by an organisation and this organisation is what we term a business unit, or business for short. It is the level at which all the relevant decisions are made concerning the operation of a transformation process. In the case of small firms, the business unit (the unit of operational management) and the firm (the unit of ownership) are one and the same. For larger firms this is rarely so, they typically are organised into several business units each one responsible for a given transformation process. The relation between the umbrella firm and the constituent business, is often a key element in the competitive behaviour of the latter. Central strategy often determines the funds available for investment, and the performance of R and D activity, both of which greatly influence the performance of business units. A crucial point here is that competition at the level of the business unit, is different from competition at the level of the firm. If a transformation process is not economic,

16 M. Boden, 1991, *The Identification of Technology Priorities for European Research and Technology Development: A Feasibility Study*. Report for the SAST Unit, DG XII, the Commission of the European Communities

then it will not survive, nor will its business unit. But, the large firm can readily incorporate such changes, diversifying into new business units and diversifying itself of existing ones to ensure the survival of the firm as is appropriate. Indeed, this is a major element in the explanation of why some firms live so long, they do so by becoming different collections of business units in response to competitive pressures.

Competition at the level of the firm is also different because firms face competition in the capital market for ownership. A top management team which allows its capital market quotation to fall relative to the value of the underlying assets is courting a takeover from a management team which considers it can perform better. Moreover, the capital market also provides a source of funds over and above that generated by internal cash flows and firms compete for access to these funds. As capital markets become more closely integrated, so the competitive pressures at that level increase. What one wants of the capital market in this respect is that it works with the grain of competition at the level of transformation processes: distributing funds in such a way as to encourage the relative expansion of the more profitable business units.

Nations

Our final and most problematic unit of competition is the nation: problematic because it is not nations which compete, but rather the firms located in them. A nation is an environment not an active competitive unit. However, it is always possible to take an aggregate of business units in one nation and compare its performance with a similar aggregate drawn from another nation and make deductions about competitive performance. Such comparisons are of considerable statistical interest and employed with care they can give insights into the underlying process. This kind of literature was reviewed in Section 2 above.

However, we can give this level of analysis some genuine competitive content if we see different nations as competing for the location of wealth generating activity. Firms can choose to locate their productive activities abroad rather than domestically. Decisions to do so, depend on many factors, some macroeconomic such as tax regimes, general wage levels and exchange rates, other microeconomic, such as the supply of trained labour, and access to an R and D infrastructure. Nations which provide good environments prosper, no doubt attracting further wealth creating activity in the process. Clearly, this is a level of competition where different national policies can have considerable impact on the relative performance of their constituent firms. This has been demonstrated clearly by Porter¹⁷ who shows the importance of proximity, location and group effects in competitive performance.

Having distinguished three levels of competition, we can now turn more precisely to the determination of competitive advantage, concentrating attention for the most part on competition at the primary level, namely the transformation process cum business unit.

The fundamental point is to be able to distinguish measure of competitive advantage from measures of the consequences of competitive advantage.

3.4 Dimensions of Competitive Advantage

At its most elementary level, competition is the joint outcome of two mechanisms: choices by customers across rival products; and, choices by firms as to which products to produce at what levels of output. Thus, the basic indicators of competitive advantage relate to the quality of a product and the costs at which that product can be produced. A business unit has competitive advantage relative to a rival measured in terms of how superior is its product and process combination. Competitive advantage depends on being different in these two crucial dimensions. Thus, one can take as partial measures of competitive advantage, any number of indices of product quality or input productivity remembering that their significance is only to be found in comparison with the corresponding indices for rivals. Since there exists a multiplicity of such partial measures, an obvious question relates to how they are to be combined together to form some overall measure of competitive advantage.

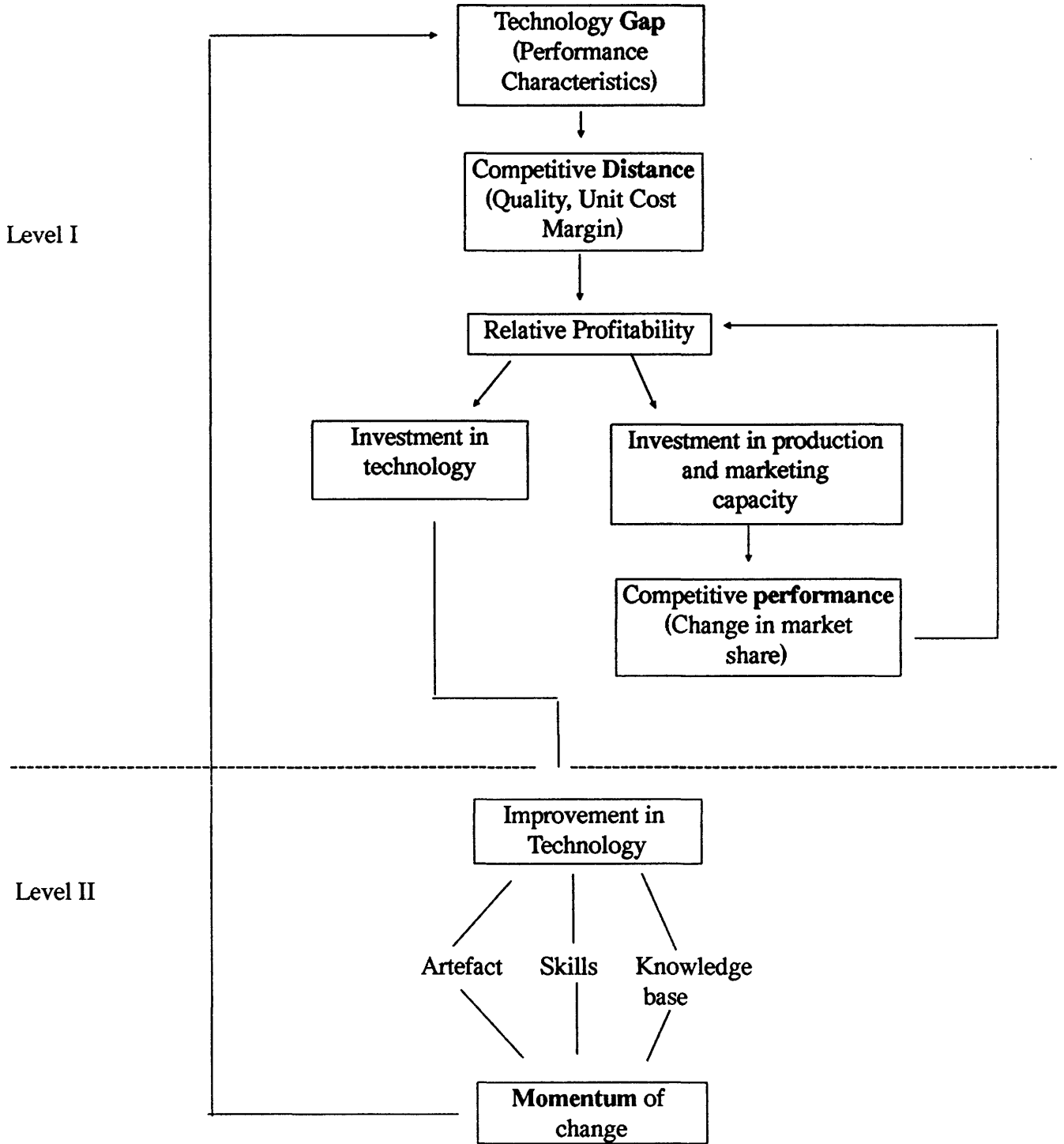
Clearly, technology in terms of its artefact performance dimensions is central to such measures of competitive advantage, but technology does not operate in isolation and its influence is modified by two sets of factors. First, as far as manufacturing efficiency is concerned, there is an inevitable element of organisation behaviour which is compounded with technology to determine factor productivity. Firms with similar transformation processes may operate them in quite different ways, and many productivity enhancing innovations are organisational and not technological in a strict sense ('just in time' inventory control is an excellent example). Similarly, competitive advantage with respect to product performance can depend on a multiplicity of non technological characteristics such as after sales support or intangible design elements which determine the morphology of a product. Secondly, competitive advantages depend on costs and product valuations which are determined in part by the relative prices of different

productive inputs and the relative valuations which users place on different product characteristics. If two firms experience the same structure of such prices, then their competitive advantage reduces to matters of technology alloyed with organisation. If they face different prices (for example, because of local scarcity of some inputs or public policies which, say, influence energy prices) then these differences in environment influence the appropriate measures of competitive advantage.

In short, the prime determinants of competitive advantage are to be found in differences in unit costs and quality of the competing products. Effectively, a competitive advantage is *any* dimension of performance which increases user's preferences for a firm's product or reduces the cost of producing that product. But this is only a starting point, for the differences between firms are not given data but are revised over time by the very behaviour of rival firms as they seek greater competitive advantage. Firms compete over the medium and long term in terms of sequences of innovations which enhance the performance characteristics of their products and manufacturing methods. Thus, the ability to sustain an appropriate momentum of technological change is the *sine qua non* of maintaining competitive advantage. This ability depends on an immense range of factors which may be grouped according to, the **opportunity** to make innovations; the **resources** available to do so; and, the **incentives** to advance technology. Ultimately maintaining competitive advantage depends on being more creative than ones rivals. Figure 1 provides an outline sketch of the principle elements involved. It distinguishes two levels of competition, in terms of artefacts in the market place (level I) and in terms of momentum of technological improvement (level II).

Figure 1

THE COMPETITIVE PROCESS



As far as technological opportunity is concerned a great deal depends on the design configuration that underpins a particular transformation process. Technology is not infinitely malleable, rather the set of concepts, theories and facts which underpin a transformation process shapes and limits the kinds of improvements in technology which can be imagined and brought into effect. Design configurations limit ultimate performance of a technology and a firm which uses a design configuration of an inferior kind is ultimately doomed to lose competitive advantage. It is only rarely the case that firms operating one design configuration make a successful transition to a competing and superior one. Quite small differences in configuration may constitute insuperable barriers to technology transfer.¹⁹ Thus, over the long term the opportunities to innovate are not spread equally across technologies; the firm with luck or foresight is the one which happens to work with the configuration which has the greater performance potential.

Opportunity is only one element in the picture, for innovation is a resource intensive process and the resources which firms can devote to formal and informal R&D are crucial in turning potential into actual performance. Notice that R&D statistics are often an imperfect indicator of the true volume of resources devoted to enhancing a firm's technology. Not only the resources devoted to R&D but the ability to manage the R&D process are crucial here. Innovation is a question of resources and resourcefulness the key insight may save a considerable degree of R&D effort. One cannot predict how creative ability will vary across individual research and development employers although it may be the case that the bigger the overall research spend the greater the expectation of competition enhancing innovations. Here we see one of the elements of cumulative causation. Firms with a high market share (*cet.par*) enjoy higher aggregate profits and have more resources to devote to R&D thus increasing their chances of gaining further competitive advantage. Moreover they can cross subsidize R&D in one business unit from profits earned in other business units. That large firms do not dominate the innovation process, particularly with regard to radical innovations, is a reflection that resources alone are not always enough.

To sum up competitive advantage has two dimensions: at a moment in time and over time. At a moment in time it is measured by those dimensions which indicate enhanced product quality or lower cost of production. Over time it is measured by the firms creativity in enhancing the corresponding dimensions of performance.

19 R.M.Henderson and K.B.Clark, 1990, 'Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms', *Administrative Science Quarterly*, vol.35

It is immediately apparent that a variety of technology policies may be directed towards the enhancement of competitive advantage in single firms or groups of firms. Broadly speaking they can be divided into policies aimed at improving artefacts (or more precisely the performance characteristics of a transformation process), at improving skills, and at improving the underpinning knowledge base. These policies may involve directing R&D resources to firms or ensuring that firms link more effectively into the higher education and other R&D institutions in a nation. Policies may also treat firms in isolation or be collaborative in nature. Whatever the pattern the proximate test of their success is how they improve the transformation process to enhance competitive advantage.

3.5 Competitive Consequences

Thus far we have focused attention on the measurement of competitive advantage in terms of product quality and unit cost recognising that each of these can be expressed in terms of many partial indicators of competitive advantage. We now have to explain what difference competitive advantage makes to competitive performance, for unless there is a clear mechanism linking the two then any definition or measure of competitive advantage amounts to very little.

We begin with one of the key points made in the introduction, that competition is a dynamic process and that it is concerned with the changing relative importance of different transformation processes. After all, this is what market mechanisms do when they work effectively. Products which users prefer and products which are produced relatively cheaply are selected for, over time, they account for an increasing proportion of total sales in a market. Thus competition as a process entails changes in the relative economic weight of competing transformation processes. It is from this perspective a multi-technology diffusion process. What we have to establish is that this process is linked directly to differences in competitive advantage as treated above.

The first point to note is that competitiveness is a relative concept. To talk of the competitiveness of a business unit in isolation is meaningless, any indicator which focuses on a single business or product is without content. To say, for example, that a business is competitive because it earned $X\%$ on its capital is an empty statement. All statements of competitiveness are comparative and involve the pair wise comparisons of competing businesses, or the comparison of a single business with some aggregate of its competitors. Thus competitiveness is a **chain relationship**, a given business may be competitive against one firm and uncompetitive relative to another.

In broader comparisons one can compare a business with the average of its rivals in a particular market context to assess its competitive advantage. What then follows from a knowledge of the firm's position in this chain?

One might expect first that competitive advantage would be reflected in the market share of a business, the market being identified (usually with difficulty one should add) in terms of all those businesses selling products which are used for the same purpose by an identified group of customers. But in leading us to the position that a more competitive business is one with a relatively high market share this is clearly misleading. Market share is a static measure. At best, share of market is a reflection of past competitive performance, what we need is an appropriate dynamic measure. However, when we turn to the change in market share over a given time period matters are immediately more clear cut, and the following definitions suggest themselves:

- a business is more competitive than its rival if its market share over a given period is increasing more quickly than that of its rival;
- two businesses are equally competitive if their market shares are changing at the same rate.

More generally we can say that a firm is competitive if its market share is increasing and uncompetitive if its market share is declining. If its market share is constant then it has neither competitive advantage nor disadvantage. Notice carefully that while the change in market share is the measure of competitiveness this does not rule out the possibility that competition advantage depends on the level of market share, through factors such as scale effects. We simply emphasise that because competitiveness is a process, the measures of competitive outcomes must be based on the measurement of change.

These definitions require a little more explanation. Naturally they depend on the length of time period chosen for the comparison, a period which eliminates short term market noise and the general effects of the trade cycle is desirable. What this period is will vary from one market context to another and depends in part on the frequency with which consumers make competition choices between rival products. In some markets choices are made continuously and the time period for defining changes in market share will be short. In others, e.g. defence capital equipment choices are made at infrequent intervals and the corresponding time period must be longer. Furthermore, by changing market share we mean market share which is sustainable, that is, consistent with the fundamentals of competitive performance. A business can buy market share in a temporary fashion if it reduces its price drasti-

cally but unless it has the capacity to supply the greater market this will not be a sustainable strategy. In any practical situation the identification of the relevant market may present considerable challenges, especially in periods of rapid technological change. These qualifications apart, the important point about the change in market share criterion is that it captures the dynamics of change, in a simple yet powerful way. How is the change in market share criterion related to the measurement of competitive advantage?

Again we are faced with the inherent complexity of the concept of competition and we have to step back to the underlying elementary, fundamental market processes.

Consider a business whose market share is increasing steadily over time. We can treat this from two angles, growth in market demand and expansion of the capacity to supply the product in question. On the demand side the price of the product and its quality relative to rivals must be such that consumers are switching towards this product more and more users accept it and reject other products when making their purchasing decisions. On the supply side the firm must be able to validate the increasing demand with an expanding rate of production. That is the price must be such relative to the unit cost of production to induce the required rate of expansion and provide the flow of investment funds which is required so to do. A higher price relative to rivals would mean a higher rate of capacity expansion and a lower rate of demand growth, and conversely for a lower price. When the market overall is not declining over time the forces of competition lead to a rather obvious result, namely that businesses maintain a rough balance between the size of their market and the capacity to supply it. Competition in declining markets, where there is systematic excess capacity, raises some interesting problems but this is rarely the situation found in technologically intensive industries. The upshot of all this is that the quality of the products a firm supplies and its cost of production taken relative to the average of those of its rivals, determines its profitability and whether its market share is increasing or declining over the relevant time period.

The relation with competitive advantage becomes clear if we take a case in which all the businesses would grow at the same rate if they enjoyed the same profitability cum rate of return on invested capital. Differences in growth are traceable directly to differences in profitability. This is a special case but it leads to an important result. Namely a business which is increasing its overall market share must have a positive competitive advantage relative to the average for its rivals, where competitive advantage is measured in terms of a combined index of product quality and unit cost of production. Competitive advantage translates directly into increases in the economic

importance of that business in the market place. Correspondingly for the firm with declining market share. It follows that a firm whose market share is constant has neither competitive advantages nor disadvantages on average relative to its rivals. It is at an advantage relative to some and at a disadvantage relative to others in the chain but overall these positive and negative effects wash out.

This base case is instructive for it provides us with the conditions under which changes in market share are related to competitive advantage in the way we would expect, that is, firms with advantages improve their market position over time. A better quality product attracts demand and increases profitability, so that output can grow faster and market share increase. Similarly, a lower cost of production enables price to be lower to attract demand and profitability to be greater so that capacity can increase. Either way the causation is the same: from competitive advantage to profitability to changes in market share, that is, changes in the relative position of a business in the market place. The crucial point to emphasise is that it is the differences between firms in product quality and unit cost which drive this dynamic process. So far the argument has hinged on all the competitors having a common propensity to expand. If this is not so and the propensity to expand is positively correlated with profitability, an outcome which might be imposed by an efficient capital market, this would reinforce the link between competitive advantage and changes in market share. Indeed the operation of the capital market is central to the dynamics of the competitive process. To sum up, the competitive consequences of a firm's competitive advantages depend crucially upon the working of several aspects of the market mechanism. There is no simple link between competitive advantage as conventionally understood and the dynamics of the competitive process. Thus a technology policy aimed at enhancing competitive advantages may be successful on its own terms and yet not have the desired effect in terms of wealth creation because the competitive process is distorted in some other directions. This leads us to a general proposition of some importance. The returns to technology policy are enhanced the more other policies ensure undistorted product markets which choose fairly and efficiently between the products of rival producers, undistorted factor markets which are free of localised imperfections, and undistorted capital markets which distribute proportionately more resources to firms with greater competitive advantages, that is, firms which are intrinsically more profitable.

3.6 The National Picture

One advantage of the dynamic approach is that it aggregates readily to the national level, permits international comparisons, and provides a direct link with

changes in the balance of trade of competing nations.

The analogue to market share for a nation as a whole is the share of the world's wealth generating capacity (industry by industry or for national productive activity as a whole) located within its borders. The difference between this and the share of world consumption of the same products taken by its population translates directly into its balance of payments (trade account) when the latter is expressed as fraction of its domestic production. A payments deficit occurs when a nation's share in world consumption exceeds its share in world production, and conversely for a surplus. But like the market share level of the previous section the balance of payments indicates nothing about current competitiveness, it is at most a cumulated reflection of past competitiveness. However, the current change in the balance of payments yields a different story. Notice first that the overall share of a nation in world consumption is likely to change relatively slowly under the influence of relative population and per capita income growth. Even at the industry level it is likely to be relatively sluggish. However, the same is not true for shares in world production which empirically can be seen to change substantially in a short space of time. Any reduction in the share of world production is matched by a decline in the trade balance ratio and it is this decline which is indicative of lack of competitive advantage in international markets. Conversely a rising production share produces an increase in the trade balance ratio. Thus it is not the sign and magnitude of the trade balance ratio which reflects national competitive advantage but rather the sign and magnitude of the **change in the trade balance ratio**. Given the consequence of enhanced national competitiveness is an enhanced share of world productive activity, the link between national competitiveness and national competitive advantage follows exactly the line suggested above. Competitive advantage, measured in this case relative to world average performance, produces a rising share of world production given that the competing nations have equivalent propensities to invest in the capacity to produce.

Of course this leaves unsaid a great deal about the multiplicity of factors which determine natural differences in competitive advantage and the policies which may influence these differences. Without in any way attempting to be exhaustive, the following classification may nonetheless be useful. At a general level are policies which determine the national environment faced by all firms without any intended bias between industries and firms. The exchange rate, taxation, industrial relations, public support of education and scientific research would be typical 'climate setting' policies. Clearly they influence the profitability of domestic production and to this extent repel or attract flows of overseas investment. Such policies also impinge directly on the efficiency of market selection mechanisms, particularly with respect to resource mobility and the efficiency of the capital market. At a second level,

policies may be targeted at particular groups of firms (not always coterminous with a single industry) with the aim of enhancing the competitiveness of the group. Support of collaborative research is a good example of a group support policy which extends to users and producers of a particular set of technologies. Such policies may be further subdivided into those which influence the rate of experimentation in new technology and those which influence the diffusion of new technology by encouraging growth in production and application. At a third level are policies which target the performance of individual firms and business units, as with specific R&D subsidies.

It has not been our intention to provide a full taxonomy of policy but we consider the following distinction between levels and purposes shown in Table 2 is worthy of further elaboration. It will be clear that the precise policy instruments employed need to be sensitive to the distinction between levels and forces drawn here. Indeed this provides the convenient stage to make a transition to the third section of this paper, when we treat the more practical aspects of competitiveness and evaluation.

Table 2

Focus	Level		
	Business Unit/Firm	Industrial Group	Nation
Rate of innovative experimentation	R&D subsidy	Collaborative programme	Support for training and research
Rate of selection in market		Information dissemination policy in new technology regulatory policy	Exchange rate/control of inflation

Section 4

Guidelines for Evaluation

4.1 Introduction.

In this section, the aim is to draw upon the preceding analysis to set out some general guidelines for panels charged with the evaluation of Community R&D programmes when they come to consider the impact of those programmes upon the competitiveness of European industry. These guidelines are not intended to be prescriptive or to cover all possible circumstances. Rather, the more limited objective is to offer those performing evaluations in which the impact of R&D on competitiveness is within their scope, a checklist of issues which will help them to formulate their own strategies for assessment of the extent to which this objective is being achieved.

4.2 Implications of the Analytical Perspective

In compiling these guidelines, the analytical perspective has provided a framework which has highlighted a number of issues which should be included in an evaluation of the impact upon competitiveness. To translate the conceptual treatment into a guide for action we consider five conclusions emerging from the discussion in Section 3:

(i) **Competition is a process of change driven by *variety* in behaviour across firms.**

The implication here is that when looking at a programme there should be an expectation that some projects represent experiments and that a proportion may be expected to fail in technological or market terms. Fear of failure should not cause programme managers to foreclose options and thus reduce variety. In horizontal evaluations, the same point may be applied in reference to the portfolio of programmes. An evaluation should look for evidence of these characteristics.

(ii) The ability to sustain an appropriate *momentum* of technological change is the sine qua non of maintaining competitive advantage.

We should emphasise the process view of competitiveness. The most effective Community actions are those which have a sustained effect on the behaviour of firms. Changes in behaviour in respect to collaborative behaviour provide one example of this. Structural changes in industry or in its conduct of research are another. Explicit attention should be given to behavioural impacts.

(iii) Three different dimensions of technology are relevant: knowledge, skills and artefacts.

Evaluations must be sensitive to the production of all three of these dimensions. There has tended to be an excessive emphasis on the artefact dimension. Patents and products are important but they are not the sole means of industry benefitting from R&D. The skills dimension highlights the need for the production or enhancement of **human resources** through the performance of R&D. This is consistent with the process view outlined above. The third dimension, knowledge is difficult to measure as a 'stock' but for evaluation purposes it is more important to look for a 'flow'. If knowledge is to be applied to new products and process, then **technology transfer** needs to take place. This may be intra-firm, between R&D performers and production divisions, or cross organisational boundaries. Evaluations should place strong emphasis on assessment of the effectiveness of technology transfer.

(iv) The relationship between the umbrella firm and the constituent business is often a key element in the competitive behaviour of the latter.

Industrial structure is likely to have an effect on the firm's ability to exploit its results for competitive advantage. Evaluations need to be clear about the unit of analysis, which should normally be the operating unit, but also take account of the support from parent companies. For this reason, the case of SMEs may need to be considered separately.

(v) Competitiveness is a relative concept

It follows that any questions addressed to firms about their achievements, either in technological or market terms, should ask them to place these in the context of the position of their rivals. Technology should be examined in terms of changes in the distance between firms in terms of key characteristics, and as discussed above, markets should be examined in terms of rate of change of market share.

4.3 Advance Preparation - Clarification of Objectives.

When programme objectives are articulated during the formulation and approval stages, those responsible should ensure that it is clear to **what extent the programme is justified in terms of its contribution to industrial competitiveness**. This may be a relatively unimportant element for programmes which aim to support Community objectives in other spheres (e.g. the environment) or which are primarily concerned with basic research. In these cases other issues may be given higher priority in terms of evaluation effort. A good indicator of the extent to which a programme is likely to be addressed towards enhancement of competitiveness is the intended degree of industrial participation.

As far as is possible, those concerned with defining objectives should **indicate in concrete terms what they mean by improvements in competitiveness and the route by which they envisage these being achieved**. For example, are new or improved products or processes intended and are these in existing or new markets? Who is likely to exploit them? On what timescale? At this stage answers are likely to be at a rather aggregated level but will indicate the general thrust.

This exercise should be repeated at the project selection phase. Individual applicants are already required in some cases to indicate their plans for exploitation of results. Nevertheless, selection is frequently dominated by technical criteria. **The information given by firms at the application stage provides panels with a resource which enables firms' own assessments of competitive potential to be identified**, but only if they are required to make fairly precise statements. This would have the benefit of improving project selection.

At least at the project level, and sometimes at the programme level, objectives may be revised in the light of changing circumstances (including changes in technical or market conditions. Such changes should be noted by the evaluation and, if necessary, commented on. If the available overall objectives are very general and programme objectives are rather specific then it is useful to relate the two in hierarchical form using a technique such as a logic chart. This helps to assess whether specific objectives are consistent with the achievement of overall objectives.

If the type of information described above has not been compiled at an earlier phase, then it should be requested from the programme management at an early phase of the evaluation. If it is not produced in sufficient detail at this stage, then the evaluators need to infer for themselves what the objectives were in this respect. **As with all formal objectives, the evaluation need not be constrained by them in its scope.** For example, an element of basic research may have been exploited particularly rapidly, leading to a contribution to competitive performance. The evaluators may feel that the objectives themselves were not appropriate and to comment on this.

4.4 Scope of the Evaluation.

Evaluators will need to maintain clarity on a number of issues which define the scope of the evaluation, including the level of analysis, how European industry is defined, the coverage of the programmes being evaluated and, associated with these, the impact upon non-participants. The industries to be covered are defined by the scope of the programme being evaluated, except in the case of a horizontal evaluation.

Evidence may be required at a number of levels. Where the benefits of a project are captured in a single product it is less difficult to assess performance as the product may be compared with those of rival firms (and with where the participating firm would have been without assistance). However, many pre-competitive programmes emphasise process developments and here the benefits are realised in more general improvements in firm performance. Aggregation of projects may allow a synthetic view of programme impact but where there is a large number this can be a costly exercise. **On the other hand, top down approaches which attempt to relate sectoral performance to programme impact are normally hampered by the small scale of Community programmes relative to overall industrial R&D expenditure** as well as the problems of timing and attribution. This issue is returned to below. Finally if the panel is expected to comment on the competitiveness of European industry, since as we have seen competitiveness is a relative concept, **comparison must normally be made with the situation outside Europe.** Impacts of R&D programmes are not felt solely by participants. **Both positive and negative impacts may be felt by non-participants** and these need to be taken into account.

4.5 Contextual Information.

For reasons elaborated throughout this report, it is not normally possible to relate overall sectoral economic performance directly either to the Framework Programme as a whole or to individual initiatives. Nevertheless, **an evaluation of an industrially-orientated R&D programme needs to be informed about the context both before and after.** Questions which might be raised include:

- Have appropriate industries/technologies been selected for assistance?
- Should support be more or less targeted/concentrated?
- Is sufficient provision made for variety and experimentation?
- What balance between basic, strategic and near market support is optimal for different types of firms?

It is not generally cost-effective to carry out broad ranging studies of the state of aspects of European industry within the budget of a programme evaluation. Instead, evaluators need to make the best possible use of existing information.

Information on the **technological standing** of European industry in the fields concerned may be a part of the background experience of evaluators. In addition, there may be in existence reviews commissioned by technical departments of the Commission. More general indicator-based studies may also be drawn upon, for example patents, technometrics and bibliometrics, though each has its limitations and requires expert interpretation.

The **market performance** of technology-based industries may be examined by looking at changes in market share for a selection of products and changes in trade balance ratios for industrial sectors, as recommended in Section 3. Such statistics are collected by other parts of the Commission, other organisations such as OECD and by market analysts.

To address the issue raised in 4.3 regarding **the contribution of Commission Funds** it is useful to have data on this by sector (or sub-sector if possible), relative to industrial R&D expenditure (including national support). While this is a small proportion overall it may emerge that for some countries and some sub-sectors the proportion is considerably higher. Statistics on the **size of firms supported and types of research undertaken** are also relevant.

4.6 Motivations of Firms.

In the introduction to this report it was noted that programmes were initially designed, or at least justified according to a rationale which stressed precompetitive collaboration, with cost-sharing at least implicit as a motive. However, empirical studies of collaborative R&D have indicated that firms undertake it for a number of motives, all of which satisfy our general criteria for enhancement of competitive performance, by offering over time superior products or reduced costs and sustaining the creativity necessary for survival..²⁰ These motives include the following:

- most commonly, firms do not collaborate with direct competitors in the area of competition but rather seek **complementary capabilities** which open new opportunities for them. Complementarity generally arises from a combination of different knowledge bases to form a new technological system. It may also operate in a vertical dimension through suppliers and users working together so that the former's products are more closely tuned to the latter's needs and hence gain a competitive edge.
- the traditional reasons of **cost-sharing**, where a minimum critical mass or facility is required, and **risk-sharing** where collaborators agree to pool results (having pursued different options) are also present. However, it is a frequent evaluation finding that collaboration takes longer and costs more than single company working so the benefits tend to lie in achieving what was not otherwise possible rather than in efficiency gains.
- some collaborations are designed to **establish standards**, or to influence their development. In industries such as telecommunications this can lead to important sources of competitive advantage.
- **strategic motives** for collaboration include identification of new markets, joining new networks, and exploring potential for mergers and acquisitions.

20 L.Georghiou, K.Barker and R.Williams, 'Strategic Management of Internal Collaboration', paper presented to workshop in Rosnaes, Denmark, May 1990. "*Process of Knowledge Accumulation and the Formulation of Technology Strategy*"

- **financial motives**, that is taking part in order to gain monetary support for R&D should not be ignored. An important evaluation issue is whether the support received leads to **additional** expenditure by the firm (as opposed to substituting for expenditure already planned).

In summary, since the purpose of R&D support for industry is to help industry achieve its own strategic goals, then it is important to understand the varied mechanisms by which the firms themselves expect to enhance their competitiveness. Evaluations may be informed by:

- case-studies
- interviews with participants; and/or
- surveys of participants

4.7 The Contribution to Competitiveness of Longer-Term Research.

Some Community programmes, and parts of others, are primarily concerned with basic research. This work is mainly, but not exclusively, carried out by academic and other long term research organisations. As might be expected, the problems of timing and attribution loom even larger in attempting to assess their economic impact. The balance of effect is on the side of creativity, providing knowledge that may be exploited in unforeseen ways. Knowledge of this type is often in the public domain and therefore more easily appropriated by firms outside Europe (and vice versa). Indeed, competitive differences between firms may lie more in their differential ability to gain access to this public sector knowledge base. This is not to challenge the important contribution such research makes to economic performance. It does, however, present practical problems for evaluators asked to pronounce on the contribution of a specific programme to competitiveness. Two limited approaches are possible:

- At the level of the project, **evidence of dissemination and transfer of ideas** is desirable since knowledge is unlikely to be exploited unless the above stages occur. This issue is addressed in more detail in the next section.

- At the European level, projects of this kind produce knowledge in parallel with enhancing the **skills base** of economies. As such they provide an important factor in the competition for location of wealth generating activity, providing a healthy base for European industry, and attracting further inward investment. **Evaluations may collect evidence on the manpower effects of programmes**, including both the personnel who worked directly on projects and those who were trained in association (including doctoral dissertations).

Beyond this, it is rather difficult to comment on these longer-term programmes in the context of their contribution to competitiveness. Other issues such as scientific merit and implementation efficiency remain for comment.

4.8 Technology Transfer Within and Beyond Projects

As argued in Section 4.2, the process of technology transfer is critical to the impact of the programmes on industry. Past evaluations have indicated that the diffusion of knowledge from those performing R&D to those in a position to apply it to new or improved products or processes is an important barrier to exploitation.²¹ Reasons for failures in this dimension include the commitment of senior management, lack of a skilled user base able to take up results, lack of interchange of personnel and lack of an initial exploitation strategy for the project. This area is not well understood but is clearly of great importance. Evaluations need to include it within their remit. In practice, this also means being sensitive to the different types of knowledge produced (e.g. tacit and codified) and associated transfer mechanisms.

Any benefits beyond the participants are dependent upon transmission of results to third parties. This is of particular significance to industrial competitiveness when the participating organisations are of a type not able to exploit results themselves, for example research associations, public sector laboratories or universities. Some follow through on the extent to which they are able to transfer results to industry would give a better idea of the extent to which industry benefits from EC-funded R&D.

21 K.Guy, L.Georghiou et al, *Evaluation of the Alvey Programme for Advanced Information Technology*, HMSO, London, 1991

4.9 Assessing the Impact of Programmes on Industrial Competitiveness - Generic Questions.

Each programme will raise specific questions for those charged with evaluating it and many of these will not emerge until the evaluation is in process. This section is not meant to replace these but to provide a checklist in the form of a set of generic questions which are likely to be relevant to a number of programmes in the context of assessing their economic impact. For convenience these are divided into three categories:

Technological

To what extent have the technical objectives of programmes been achieved?

As a result of the programmes have the firms concerned gained or lost ground relative to their competitors (a) within and (b) outside the Community?

How appropriate have the technical objectives been in the light of the actions of competitors? (past evaluations, interviews with strategists in industry, the Commission and independents).

Structural

What behavioural changes have been induced by participation? (e.g. increased collaboration skills, propensity to collaborate with former or new partners after funding has ceased).

What contribution has the Framework Programme made to skills and research manpower in the Community? Mechanisms include movement of firms into new areas, increases in personnel in areas, direct training support (where the destination of those qualified is industry).

What have the effects of the programme been on the structure of the industrial research community? (rationalising and uniting fragmented resources, allowing academic research to be drawn upon, integration across technological areas)

Exploitation/market-related

What evidence is there of products, prototypes, patents or plans to achieve them attributable to Framework projects?

To what extent have new techniques, tools, processes or other forms of knowhow been utilised by participants/other firms?

How well has the technology transfer process within participating firms been working? (e.g. have operating divisions taken up results produced by R&D departments?)

Has knowledge been diffused to non-participants?

What investments have firms made in further research or exploitation of results?

What factors have prevented or obstructed exploitation? (e.g. changes in strategy of participants or their partners, technological developments making outputs obsolete, inadequate investment resources).

In the areas addressed by the projects can any changes in market share be discerned?

Section 5

Concluding Remarks

In this final section we shall summarise the core of our previous discussion and suggest ways in which the process of evaluation can be enhanced.

On competitiveness our central theme has been clear: competitiveness is dynamic and it is relative. It is concerned with the changing market position of different technologies and firms and with the policies and actions which generate those changes. As we have seen in Section 2, many policies and actions influence competitiveness but they do so through two principal routes:

- by generating differential behaviours across competing firms; and
- by resolving those different behaviours into changes in relative market position.

In practical terms this implies that we look at the connection between policy instruments such as R&D support and the creation of differential advantage. For example, how European R&D policy increases the relative technological position of European firms in terms of products and the underpinning processes. As we indicated in Section 3, differential technological advantages arise at three levels:

- the underpinning knowledge
- the skills to translate knowledge into effect or action; and
- the artefacts which are subject to competition in the international marketplace.

At each level the policy instruments are different and the indicators of policy impact are also different.

For the evaluator charged with assessing the impact of EC R&D programmes we have suggested a number of practical guides consistent with our general framework. These are:

- Ensure that there is a clear understanding of the way in which programme and project objectives are intended to impact on competitive performance;
- Provide contextual information but do not expect it to be linked directly to the effect of programmes;
- Ensure that the motives of firms are clearly understood; and give weight to the impact on their behaviour.
- Follow broadly the generic issues suggested but ensure that these are adapted to the specific circumstances of programmes - there are no automatic 'recipes'.

We conclude with a warning. It is implicit in our discussion of competitiveness that it is a process operating over an extended period. Success at one point in the competitive process need not entail success in a longer time perspective. Consequently evaluation issues need to be framed with a clear understanding of the time dimension of competition. Furthermore the fact that competition is dynamic and multi-dimensional means that it is a complex phenomena. Hence it is not generally possible to attribute uniquely consequences to particular policies. The difference which policies make are often difficult to identify because of the complexity and multiplicity of sources. Used with care and due regard to the historical context the approaches and indicators we have proposed provide a coherent and fruitful way to approach these complex issues. This brief review has exposed the need for more detailed understanding of the competitive process and in particular its relation to the policies and actions which constitute the Framework programme.

Commission of the European Communities

**EUR 14198 - Evaluation of the Impact of European Community Research Programmes
upon the Competitiveness of European Industry - Concepts and
Approaches**

J.S. Metcalfe, L. Georghiou, P. Cunningham, H.M. Cameron

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This study aims at setting the theoretical basis for the analysis of the industrial competitiveness as well as providing practical guidelines to undertake the evaluation of such an issue.

In the author's view, competitiveness is dynamic and relative. It is concerned with the changing market position of different technologies and firms, and with the policies and actions which generate those changes.

For the evaluator charged with assessing the impact of EC R&D programmes, the authors suggest a number of practical guides. These are:

- Ensure that there is a clear understanding of the way in which programme and project objectives are intended to impact on competitive performance;
- Provide contextual information but do not expect it to be linked directly to the effect of programmes;
- Ensure that the motives of firms are clearly understood, and give weight to the impact on their behaviour;
- Ensure that actions are adapted to the specific circumstances of programmes - there are no automatic "recipes".

This brief review has exposed the need for more detailed understanding of the competitive process and in particular its relation to the policies and actions which constitute the Framework Programme.

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