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FLEXIBILITY IN POLICY-FORMATION

by

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## ABSTRACT

This thesis reports on a study undertaken to investigate how the concept of flexibility can be made operable in a policy setting. To expedite this, we reviewed previous research in pertinent areas and examined the conceptual foundations of flexibility. Two field studies were subsequently conducted.

The first examined a technology-specific homogeneous policy-setting. The process whereby small manufacturing firms acquire electronic data processing facilities was observed from its embryonic phase, where the technology was being appraised to its eventual implementation. Following a description of these phases, an attempt was made to outline the technological attributes which promote flexibility in such a policy-setting. These attributes are: Compatibility, Expandability, Maintainability and Supportability, Upgradability, Modularity and Portability, Potential for Innovation and Procurement Options.

The second field study was focussed on policy-formation in corporate-settings. Twenty-one large corporations, active in diverse and technologically-dynamic arenas participated in the study. Our objective was to ascertain how these organizations cope with a capricious future. Following a series of informal, open ended interviews with their senior corporate strategists, a number of practices were identified which when adopted, enhanced flexibility. These spanned issues such as being able to vary production output, interfirm cooperation and collaboration, redeployment of key personnel, shortening lines of communication to and from senior policy makers and blending of transnational portfolios. Five general capabilities were derived subsequently which underpinned these practices in the quest for strategic flexibility. These are Mobility of Resources, Variability of Thrust, Versatility of Personnel, Malleability of Organizational Structure and Manoeuvrability across business areas. Our findings indicate that although strategic flexibility appears to be intuitively simple, putting it into practice is a complex task.

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Key words: Flexibility, Strategy, Policy,  
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## CHAPTER 1

### INTRODUCTION

The prevailing ethos of policy formation is moving away from complex "blueprints" aimed at attaining objectives to a rationale oriented toward implementation. Elaborate strategies, based upon single-line forecasts of the future, are vulnerable to changes in environmental conditions and to fallible judgements concerning a venture's feasibility or a technology's capability. It is, therefore, essential to focus attention more on the ability to do things differently when situations so dictate. Given the volatile state of the world, flexibility is a subject of increasing significance.

Contemporary developments underscore the need to make timely alterations to accommodate positively new situations. The increasing pace of technological developments exerts a profound impact on products, processes and management procedures. Its diffusion also shapes new attitudes and values as a result of changing lifestyles. Furthermore, resource and market availability fluctuate according to geo-political alignments. A successful strategy, therefore, must be constantly adjusted in accordance with evolving conditions. The capricious state of affairs facing organizations means that it can

be very expensive to wait for changes to mature before engineering the necessary response.

From a technological perspective, the problem is especially acute. The diffusion of many technologies has impacts which are rarely foreseen in their entirety. In some cases the fears that are voiced are simply a reaction against the "new"; in other cases they are a genuine cry of concern. If organizations wish to enhance their control when making decisions concerning technologies, then flexibility is highly desirable.

Strategic flexibility in management refers to a capability which aids repositioning when conditions change. Flexibility implies many things: being able to respond adequately, being willing to change, or having many options. Strategic flexibility can be defined as that which affects timely alterations so that an organization can accommodate new situations in an appropriate manner.

Organizational repositioning is a delicate art. The consequences of implementing strategies are only partially predictable. A firm can not gauge all the consequences of a major acquisition, a divestment, or the absorption of a new technology. Even if such foresight were possible, reasonably precise estimates of the significance and timing of after-actions would need to be known well in advance to formulate viable plans. The future is easier to cope with when the repertoire of corporate capabilities includes specific mechanisms which allow

strategies to be modified accordingly. It is, therefore, clearly prudent to search for an approach which is less tightly coupled to precisely calibrated images of the future.

This dissertation addresses the search for the kernels of an approach which enhances flexibility in policy formation. Flexibility itself is not a new concept. Yet, although many people pay lip service to strategic flexibility, there is no consensus of opinion which defines this capability or demonstrates how it should be used in the management of purposeful systems.

A cursory glance at the research into the notion of flexibility suggests a paucity of substantive contributions. Closer inspection, however, uncovers a significant body of research, albeit spread thinly over a wide range of disciplines such as military strategy (Liddell Hart 1954, Eccles 1965), business policy (Hart 1937, Eppink 1978, Ansoff 1980), economics (Stigler 1939, Koopmans 1964, Kreps 1979), decision analysis (Rosenhead 1972, Merkhofer 1977, Mandelbaum 1978), and technology management (Fuss 1977, Montenegro 1977, Collingridge 1980). Although these studies address specific elements of flexibility, how this abstract quality is to be put into practice successfully still remains somewhat elusive. This is in part not only because the conceptual foundations of flexibility are not well-developed (Mandelbaum 1978, Eppink 1981: personal communication), but also because there is little empirical

research on the need for flexibility and its incorporation into the policy formation process. With these limitations in mind, a two-pronged attempt was embarked upon for studying this concept. First, in order to examine the conceptual underpinnings of flexibility, an attempt was made to search for previous studies which investigate this and related issues. These concepts were subsequently refined by means of a "conceptual analysis" in order to generate a clearer impression. Second, we sought to observe how flexibility would be useful: first in a "technology-specific" setting and then in a corporate setting. This enabled us to see how strategic flexibility was viewed and realised.

The "First Time Computer User" study was undertaken during the early stages of the research; its mission was both to acquaint the researcher with the policy and decision making process and to ascertain the role of flexibility in such a setting.

The policy setting examined was the acquisition of electronic data processing (E.D.P.) systems by five U.K.-based manufacturing companies. Various phases of the acquisition process were observed, spanning from the early contemplation of the need to use E.D.P. systems through the implementation phase and on to consideration of system development and enhancement.

The corporate study was completed while the conceptual analysis was being conducted. Twenty one transnational corp-

orations, mainly U.K. based, participated in the study. Considerable interest was displayed toward the concept of strategic flexibility, a concern which received even more attention due to a deepening recession at the time of the study. Senior corporate strategists briefed the researcher on their companies' policy-making procedures and were then asked to focus on examples of situations where practices they adopted put them in a better position to cope with uncertainty. Explicit questions were asked regarding the importance of these practices in furnishing strategic flexibility in the second phase of the study in which a subset of the senior corporate strategists participated.

The methodology of the present study is set out in Chapter 2 which describes alternative methods for undertaking research of this type and briefly suggests the reasons for adopting our research strategy. Substantive issues are then discussed, setting out in more detail the rationale behind each of the three main components: the conceptual analysis, first-time computer user study and the corporate study. The means of gaining access to the companies participating in the two field studies is described along with data acquisition techniques.

Chapter 3 sets out the various diverse strands of research into aspects of our problem. The chapter is organized according to discipline. At the beginning of each section, the authors and the theme of their research are presented in tabu-

lar form, followed by a discussion of the salient features of their contributions.

Chapter 4 addresses the conceptual architecture of the notion of flexibility, drawing upon an analytical technique developed by philosophers. Related notions such as adaptability, resilience, and robustness are contrasted with flexibility in order to discover their logical relations. Following this, a critical evaluation of some of the hypotheses proposed by previous researchers is undertaken in order to discover any inherent paradoxes, contradictions, and misconceptions.

Chapter 5 describes the first field study: a technology focussed micro-decision problem was examined. The problem concerned small manufacturing companies in the U.K. acquiring electronic data processing (EDP) systems. Following the description of the process, the final section of the chapter outlines the main observations. These are presented in terms of attributes which give rise to strategic flexibility in this technology-specific setting.

Chapter 6 reports on the second field study which examined strategic flexibility in a corporate setting; 21 transnational corporations participated in the study. The mission of this macro-study was to discover if corporate strategists were concerned with strategic flexibility and if so, how it was achieved. This chapter describes specific practices adopted by the companies in order to promote strategic flexibility. Fol-

lowing these, the final section sets out the main observations of the second field study in terms of five general capabilities which are required, in varying proportions (depending upon a company's situation), to provide strategic flexibility.

Chapter 7 summarizes the main observations and major conclusions of the study. This is followed by a discussion of the limitations of the research and areas where, in the author's opinion, future research may be usefully focussed.



## CHAPTER 2

### Methodology

The differences between the natural and social sciences emerge clearly when one considers the epistemological and teleological issues involved in acquiring and analyzing information in order to make policy decisions. The dichotomy is particularly problematic in management which suffers more than other disciplines from the absence of an accepted methodological foundation. This chapter describes the methodology adopted in the present research in order to examine the use of strategic flexibility in policy formation.

The chapter is divided into two main sections; the first describes suitable research postures for examining this type of issue. These are categorized as "hypothesis testing", "state-of-the-art", and "theory generation" approaches. Their relative merits for our problem are also discussed; four main sections describe the procedure adopted for the present study. Following a brief exposition of the analysis of previous studies, we turn to the "conceptual analysis," which was undertaken to clarify the critical notions enmeshed in flexibility. Finally, the approaches adopted for conducting the two field studies are described from a methodological standpoint.

## 2.1 Research Posture

This study seeks a better understanding of the concept of flexibility with a view to making it functional in strategic decision making. Three methodological research postures can be used to enhance a fuller understanding of such a notion. These are:

1. "Hypothesis Testing", in order to falsify existing or conjectured theories,
2. "State-of-the-Art" survey, describing current practices,
3. "Theory Generation" leading to the development of testable hypotheses which may be refined by future research.

This section will discuss the relative merits of each posture in dealing with the problem at hand.

Such research may be descriptive or prescriptive in its intent and could proceed by either empirical or hermeneutical means. Information necessary for conducting the research could therefore be derived from a retrospective analysis of policy issues; it could also be focussed on future concerns.

Warneryd (1980) describes three approaches for investigating such an area:

1. Normative Approach
2. Behavioural Approach
3. Intervention Approach

The first demands analytical approaches required to solve a generic problem type. The second approach can be termed the "impartial observer" approach, whereby the data required to substantiate the hypotheses are derived from "snapshot observations". Interpreting this information is not easy and can lead to many criticisms, most of which centre around the notion that only a limited subset of the problem can be investigated and that the information must somehow be passed through the filter of bias and experience. The third approach requires the researcher's direct participation in the problem as a basis for conducting the investigation.

The strength of all these three approaches revolves around accepting the scientific method as an appropriate foundation for examining strategic decision making. However, as Miller, et al., point out:

This type of thinking, ...is wholly inappropriate in the field of decision making.... In science the only place for intuition is the design of an experiment; in the unavoidable personalistic realm of decision making, intuition must play a central role. (1980:77)

Most important decisions are usually one-of-a-kind. Thus, the use of a standardized framework for analyzing such decisions on a comparative basis is of questionable validity.

#### 2.1.1. Hypothesis Testing

Previous attempts to investigate the notion of flexibility have tended to proceed from specific assumptions which

motivate the quest for flexibility; Collingridge (1980) suggests that flexibility is essential to enable society to control the unwanted impacts of maturing technologies. This view is further grounded in the conjecture that the consequences of adopting or, more accurately, allowing innovations to diffuse are impossible to predict. Eppink (1978) sought to explore the notion of flexibility as a response to unanticipated events; Mandelbaum (1978) as a hedge against modelling unease. Merkhofer (1975) investigated the worth of postponing an irreversible commitment of resources until (the value of obtaining) further information would have no impact on the decision. On the other hand, Ansoff's (1965, 1975, 1980) quest for flexibility sprang from his insight that the magnitude and rapidity of changes likely to be experienced by "environment serving organizations" rendered inadequate the ex-post facto decision activation period for accommodating such events. The capability to respond to any number of changes, he conjectured, ought, therefore, to be preprogrammed into systems. Obviously, it would be impossible, costly, or both to install this capability for every imagined contingency; nonetheless, promoting flexibility engenders a willingness and ability to reposition which is difficult to quantify.

While transposing these conjectures into testable hypotheses would, in principle, be relatively straight-forward, it does not seem to this author that there is much value in em-

pirical research seeking to falsify or to find such hypotheses acceptable at appropriate levels of statistical significance. At this stage of development, we need to find out what flexibility is, why it is needed and how it is currently acquired; only then will we be in a position to say when, why, and how much should be acquired for a given system. The theory testing approach does not suit this purpose.<sup>1</sup>

#### 2.1.2 State-of-the-Art

A second posture advocated for studying purposeful behaviour is a review of the leading contemporary approaches and practices. Grinyer and Wooller (1978) successfully used this method in their research into corporate planning models. Where a specific technology is a major feature of the environment under consideration, this posture works effectively as illustrated by Alter's (1975) research, examining the use of decision aiding systems by policy makers.<sup>2</sup>

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<sup>1</sup>Further weight for this conclusion comes from Mintzberg (1975), who suggests that testing hypotheses in a relatively under-researched field has limited importance.

<sup>2</sup>Following this examination, he went on to propose specific guidelines in order to facilitate the effective implementation of such systems, giving due regard to the requirements and psychological characteristics of the procuring organization.

Policy's role is to prescribe the intentionality of an organization while unifying and reconciling all aspects of internal administration. This ought to be achieved by setting the boundaries wherein legitimate dispositions may be formed. (Shackle 1969). In such an activity within goal-directed systems, Nagel argues, questions about the value of an explanation:

...are not decided by reference to the logical source of the explanatory premises and can be answered only by examining the effective role an explanation plays in inquiry and the communication of ideas. (1961:422)

In this context, a "state-of-the-art" approach may be partially adopted in order to understand more fully those features of purposeful systems which allow them to be modified in responding to threats, grasping opportunities, or taking the initiative to create opportunities.

Nagel postulated two approaches for this task:

1. to analyze "quite similar systems" in order to extrapolate from these observations a system of inductive generalizations; or
2. to derive from previously established causal laws a body of deductions "concerning the mechanisms embodied in systems" (1968:94).

In two policy settings, the researcher had the opportunity to examine this problem at both micro and macro levels. A "state-of-the-art" approach was adopted only in so far as it

was necessary to become acquainted with the micro and macro policy environment. In the case of the former, a "technology-specific" decision setting was the window through which we examined the need for flexibility. In the macro-policy environment technological uncertainty was a major factor but it was tightly coupled to political, economic and social considerations. On the whole, strategic issues in these settings were specific and unique to each participating organization. In order to discuss salient features of the problem setting with those responsible for making decisions it was necessary to become familiar with the relevant issues. The nature of this approach corresponds to Bouchard's (1976) Type 4 "non-directive" interviews which then coalesced into Type 2 "open-ended but issue-specific" interviews, as suggested by Duncan (1979).

### 2.1.3 Theory Generation

This approach to research is by far the most interesting, though difficult to substantiate. Methodologically, one needs to progress from a given number of observations to the generic problem and pose an explanation. While the scientific method may be appropriate for closed systems, it is not clear how to proceed when studying interacting forms of life in purposeful systems. Habermas (1966) has suggested that epistemology may be either interest or knowledge-driven. Spender (1980) attempted to fuse both the positivist and phen-

omenological approaches in order to justify his research methodology.<sup>3</sup>

The present research does not seek to promote flexibility as a panacea for dealing with uncertainty or ignorance. Flexibility is merely one item in the repertoire of responses available to ease repositioning. A number of technological attributes are promoted as furnishing flexibility in the "first-time computer user situation" (which may or may not be applicable to other technologies). Following the study of policy formation in corporate settings, five capabilities are proposed as a means for instituting successfully strategic flexibility. The extent to which these hypotheses can be tested must await the endeavours of future researchers.

## 2.2 The Research Process

The study followed the traditional path, beginning with a rigorous review of the previous research. Then, in a slight departure from tradition, we analyzed the concept under consideration while undertaking the field studies. The various stages of the investigation described in this section are:

1. Analysis of Previous Research
2. Conceptual Analysis

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<sup>3</sup>His findings indicate that within an industry or business sector, a common recipe is used for managing business affairs, although the actors operate in independent companies.



### 3. First-time Computer User Study

### 4. Policy Formation in Corporate settings

Each section describes the process adopted for a specific task. In a collective sense, the approach appears to be novel but on close inspection, one sees that the underlying rationale was a variation of that proposed by Churchman (1968), Tomlinson (1977), and Checkland (1972) in the pursuit of problem-focussed research. In summary, the research programme adopted in this study was as follows:

- Select topic
- Develop preliminary research issues
- Select study procedures
- Select data acquisition techniques
- Gather and analyze data
- Structure analysis to yield observations

#### 2.2.1 Analysis of Previous Research

Since the notion of flexibility abounds in diverse disciplines, one of our initial tasks was pulling together the threads of previous studies. Sources varied from research papers, theses and articles to rather more obscure sources including personal communication with some researchers.

In the area of policy research, several attempts have been made to develop the concept of flexibility. The earliest and most comprehensive is in the field of military strategy, fol-



- Adaptability
- Elasticity
- Liquidity
- Plasticity
- Resilience
- Robustness
- Versatility

Secondly, we examined the use of the concept "in concreto" in order to identify some of its logical features. A further method involved wondering "what sort of questions could be appropriately asked about flexibility" (White 1975). By anchoring the analysis to the use of flexibility in propositions about policy formation or technological systems we discovered its polymorphic nature. The penultimate stage analyzed various hypotheses proposed by other researchers about its logical features.

### 2.2.3 First Time Computer User Study

Several concerns motivated previous research to adopt the notion of flexibility. However, a major deficiency of previous studies was that they began with too many or too complicated problems and attempted to solve them all. The tendency was to transform a number of symptoms rapidly and incompletely into a form which could be analyzed rigorously.

Our objective in this section is to sketch out an alternative approach which was adopted in this study. The "First-Time Computer User Study" was a situational analysis of the technology-focussed decision which sought to:

- i) Examine first-hand how policies are shaped within a dynamic environment at a manageable level of complexity
- ii) Investigate the role of experts in the decision-making process
- iii) Discover how a policy is modified to meet the requirements of evolving situations
- iv) Short-circuit the experience curve by utilizing the experience of managers well-versed in the requirements of a practical situation
- v) Examine the problems posed by the rapid change of technology

The strategic decision under consideration faces many companies: do we need a computer and if so, how do we get one? Our study tracked the policy from its embryonic form through its maturity in a number of companies. A striking feature of the decision-makers was their unfamiliarity with the technology, in stark contrast to their business acumen. However, this was an important factor in choosing this policy setting, for the decision, when made, would involve considerable uncertainties. Some of these uncertainties were associated with the

technology, others with the impact of automating existing functions (with subsequent disruption of the informal organic alliances); in the final analysis, the overall impact upon the business was one of fundamental uncertainty.

The decision was strategic for the participating companies, as argued by Mumford and Pettigrew in their study (1975) of computer system acquisition. In our sample, the investment by the participating companies represented a significant expenditure. Employing experts to assist at various phases of development was therefore worthwhile. Essential to this study was the process of examining the acquisition process from its conceptual inception through to its eventual implementation, in order to capture the motivating concern and the wisdom of hindsight i.e. "I would have done it this way had I known that...."

Five First Time Users (FTU's) participated in the study. Table 2.1 shows the manufacturing activity in which each company was involved. The firms varied in size: two were business units of large UK-based companies; the third was part of a US-based group; two were independent.

A number of manufacturers provided background information on the capabilities of appropriate computer systems and, in addition, a number of consultants from both small and large practices kindly gave the benefit of their experience to the researcher. Considerable assistance was afforded by the man-

Table 2.1 Principal Activities of the Participating Companies

Company A	Brake & Clutch Cable Manufacturer
Company B	Paper Products
Company C	Metal Smelting
Company D	Plastics and Chemical Manufacture
Company E	Metal Alloy Extrusion

\* \* \* \* \*

aging director of a systems house who spent many hours informing the researcher about the decision making process. Further help came from members of a special study group from the "British Computer Society" who advised the researcher throughout the study and sponsored the development of a checklist to assist the FTUs in their acquisition strategy.

The study was conducted on the basis of the following:

- Stage 1. Review pertinent literature
- Stage 2. Conduct preliminary discussion with experts in the field
- Stage 3. Interview First Time Computer Users (FTUs)
- Stage 4. Conduct further discussion with experts
- Stage 5. Develop the checklist to assist the FTUs during the acquisition process

Interviews with the "First-Time Users" were loosely focussed around the following questions:

1. Where did the motivation to acquire data processing technology originate?
2. How was responsibility for the decision delegated?
3. What time periods were involved?
4. How many alternatives were considered?
5. How was a choice made?
6. Who installed the system?
7. When was it integrated into daily operation?
8. What types of problems were not envisaged at the outset?
9. Why was a particular development path chosen?

The FTU study served to acquaint the researcher with a policy setting where the technology itself was marketed on the basis of its inherent flexibility. The trade literature indicates that flexibility, in relation to computer systems, is a much-vaunted property. This study attempted to isolate those aspects of the setting which were linked to the technology in order to identify those attributes which enhanced flexibility from the users' perspective.

#### 2.2.4 The "Corporate" Study

Numerous texts have propounded the usefulness of the case-study approach in policy research, but they tend to take for granted the legitimacy in moving from the general to the specific and vice versa in order to generate theory. For example, Popper (1963) assigns primal importance to problem solving as the motivation behind the genesis of theory. The available alternative, if we are to accept Popperian methodology, is an indirect approach. As Bismark is quoted as saying: "Fools say that they learn by experience. I prefer to profit by others' experience." Unlike those who practice management, a researcher investigating the situation in which policies are formed must seek access to the upper echelons of the pertinent organizational hierarchies. The opportunity to investigate such situations, directly or indirectly, is contingent upon the cooperation of senior officers of such organizations.

The need to examine at least a number of cases, implied that the research methodology had to accommodate situations that involved the close linking of many variables. The basic underlying hypotheses were:

- a) Technological change has a significant impact upon an organization's strategy
- b) Flexibility would be required in order to match successfully the organization's strategic response to changing technological possibilities.



Verifying these hypotheses is an impossible task. The one piece of dogma which the contingency school of strategy has removed is that standard solutions exist for classes of problem. A field study involving the participation of senior strategists from organizations with different technology portfolios, would help to clarify our problem. A more humble aim was that it would short-circuit the learning curve by gaining access to the senior executives and the body of wisdom gathered from their personal experience of "doing the job". Integrating the technological with the other perspectives inherent in policy formation also appeared to be critically important to the study.

A sample of thirty public and private organizations were selected in the first instance, and a request tendered to the Chairmen/Chief Executive Officers of such organizations (see appendix 1). Fifty-seven percent of the selected sample responded favourably to the request, seeking participation in the research. A number of chief executives expressed an interest in the project, yet in view of the economic climate, could not afford to divert any of their senior executives' attention from current concerns. Of the seventeen organizations which agreed to participate, two were nationalized industries, whereas the remainder were private-sector corporations with turnovers in excess of one billion Pounds. (See Chapter 6 for a description).

With possible cultural differences in mind, it was decided that including European and US companies in the sample would help identify such influences. Limited resources dictated narrowing the geographical target area and ultimately the sample was restricted to two regions: Belgium in Europe and California in the US where ten and twenty organizations respectively were approached; twenty percent of the companies approached responded positively.

A date for an interview was arranged once a respondent had been suggested,. From a methodological point of view, the interviews were broadly focussed on the following topics:

- i) The scope and impact of unanticipated events on the organization's policies,
- ii) Attitudes towards flexibility and its incorporation into the policy formation process

The researcher used a variety of archival sources in order to brief himself with the strategy and technology portfolio of each organization.

During the interviews, excessive adherence to the interview schedule was avoided, so as not to impose a rigid concept of flexibility which would merely reflect the researcher's perspective. In order to avoid constraining the discussions, tape recording and excessive note taking were avoided deliberately. Immediately following such interviews, a record of the discussion was taken, and where necessary, details were later

clarified. The primary objective of the study was to find out how senior executives viewed the concept of flexibility, and how strategic flexibility was taken into account during the process of policy formation.

Where practical, a second interview was arranged. A summary of the features of interest was sent to the respondent before this second stage and was subsequently discussed during this further round of interviews.

Practices taken to induce strategic flexibility were identified as a result of these interviews. The relationships among technological, economic and political features of strategy were found to be exceedingly complex, and not easily disentangled. On the basis of these findings, a number of capabilities which might expedite the use of flexibility in policy formation were proposed.

The justification for this research project, apart from that provided by the author, is eloquently suggested by one of the most recent investigations into the measurement of flexibility:

There is great need for research into flexibility as a basic strategic principle or attribute in large, complex decision problems, since research up to now has concentrated on precise model calculations. The importance of flexibility, what makes it possible and the means of obtaining it must be more widely understood. (Cunningham and Mandelbaum, 1979:27)

## CHAPTER 3

### THE SKEIN OF FLEXIBILITY: REVIEW OF PREVIOUS RESEARCH

This study investigates the problem of sketching out a means of formulating strategies which, allow whatever is being done to be done differently. This problem is difficult to conceptualize in any formal sense, for one cannot be aware of all the changes which affect a situation nor can one foresee those goals which will be desired in the future. "Certainty" is often mistaken for "certitude". Unexpected occurrences may generate either threats or opportunities. If systems are too rigid or unsteerable then the potential for responding to clarification of facts, emerging values, or new technology is forfeited. This danger is described in a remark of Wellington's.

They (Napoleon's Marshalls) planned their campaigns just as you might make a splendid piece of harness. It looks very well until it gets broken; and then you're done for. Now I made my campaigns of rope. If anything went wrong, I tied a knot and went on. (Shackle 1972)

Transposing the analogy of the rope to our problem is appealing; this chapter sets out to examine the various "knots" which have been designed to facilitate "doing things differently".

While successful repositioning is intuitively valued, a systems resource configuration which enables this is, often

considered to be more expensive than it would be if the future were known. This has led a number of economists to examine how anticipations about the future enframe preferences toward flexibility. This line of research began after the traumatic crises of the 1920s and the 1970s. The first section of this chapter reviews previous studies which can be broadly categorized as the "economics" literature.

A number of attempts have been made to apply the concept of flexibility in a "technology specific" perspective.<sup>4</sup> One notable exception is the work of Collingridge (1980), who attempts to harness flexibility to permit the social control of technology. His position rests upon the premise that decisions concerning technology are taken, of necessity, without due regard to the accompanying unintended consequences about which we have little knowledge and potentially fallacious beliefs. He views social control as directing technology to achieve what is wanted by most members of society while avoiding unwelcome consequences. The second section of this chapter discusses the significance of flexibility in risky decisions where technological uncertainties are present.

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<sup>4</sup>In this context, one ought to be aware that technology may be organically continuous or dynamically discontinuous. Indeed, the recent trend in strategic management recognizes the significance of technology in determining an organization's viable posture.(Porter 1981)

The problem of decision-making under conditions of uncertainty and risk is an established branch of operational research and systems analysis. In the last twenty years, decision analysis has made considerable advances in coping with uncertainty. It is hardly surprising, therefore, to find a number of attempts aimed at measuring flexibility by decision theorists. The third section of this review examines the contribution of these approaches to our understanding of the problem of flexibility.

"Strategic management" is an area which has only recently emerged in the academic literature and has started to gain academic credibility. The problem of flexibility is also significant in strategic management as a number of business strategists have shown. In section four of this chapter, we discuss the strategic management and business policy literature concerned with the notion of flexibility.

The formal study of strategy began in Prussia under the influence of Kantian rationality. The author's research in this area uncovered an early attempt at scenario planning by the Frenchman Comte de Guibert (1772). Before the dawn of the "Corporate Era", strategy was the exclusive preserve of Generals. It is, therefore, hardly surprising to find that the problem of flexibility is addressed in the field of military strategy. There is a remarkable similarity between strategy, policy, and statesmanship in the business and military environ-

ments. The fifth section of this review will, therefore, discuss the historical development of the notion of flexibility in the context of military strategy. It will not, however, discuss the current issues of nuclear deterrence and graduated response.

Section Six will investigate those studies which can be broadly categorized as "Management Science". Finally, section seven of the review examines those studies which can be referred to as the "Systems Management" literature. Each section is in two parts; the first sets out the authors, date of the work and its theme in a Table. The second part discusses the salient themes of the studies.

### 3.1 The "ECONOMICS" Literature

#### 3.1.1 Agriculture

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Table 3.1. Chronological list of significant contributors to the "economics" literature on flexibility: Agriculture.

<u>Researchers</u>	<u>Date</u>	<u>Theme</u>
Stiles	1922	Hedging to compensate for price oscillations
Timoshenko	1930	Impact of the business cycle on value of farm output
Nicholls	1940	Product concentration as a result of price volatility in cheese production cost changes
Cowden & Trelogan	1948	Operational flexibility in dairy manufacturing
French, Sammet & Bressler	1956	Response to major uncertainties
Collins	1956	Impact of technology on adjustability of crop production pattern
Carley & Cryer	1964	Changes in operational flexibility of dairy manufacturing plants 1944-1961
Kerchner	1966	Assessment of flexible dairy plants

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#### 3.1.1.1 Salient Themes

Stiles (1922) argued that as a response to anticipated changes in prices, a miller who typically negotiated contracts long before knowing the raw material's cost would secure against the risk of losses resulting from price fluctuations by opting for a much higher price than he would need if prices were known. Managing a number of mills was difficult because each miller would have a different attitude towards this risk. A common practice had evolved because a number of millers had decided upon a recipe to accommodate such uncertainty. When a further hierarchical level of management became involved in controlling a portfolio of mills, coordination became difficult. Stiles' early exposition of how retrospectively substantiated anticipations resulted in a prudent behaviour pattern was a precursor to the more theoretical treatment of this issue by Hart (1937) and Shackle (1938).

The significance of price fluctuations was investigated by Timoshenko (1930), who undertook an extensive statistical analysis of the impact of price fluctuations on the total value of crops at a farm. Flexibility was a significant factor because of the number of wholesale and retail stages through which a farmer's produce would pass to reach the consumer. Thus the lead time involved in price changes became increasingly short because of the product's constrained shelf life.

Timoshenko (1930) subsequently developed a measure of flexibility based upon the concept of elasticity.

The frequency of the change was not the only variable of significance to be considered; the magnitude of such changes or, as Nicholls suggested (1940), the amplitude and volatility of the price fluctuations were more important to the producer. Backman (1940) argued that in addition to these variables one ought to consider the nature of the changes. The extent to which these were "secular" or "cyclical" would determine the required type of flexibility.

Cowden and Trelogan (1948) pursued the analysis of flexibility in relation to dairy operations in a descriptive mode. The focal point of their study was the ability of dairy manufacturing plant to be readily adjustable to manufacture alternative products. This study was carried out for the U.S. Department of Agriculture. They contrasted American dairy product manufacturing facilities in two consecutive time periods. As Kerchner pointed out (1966:15), the study failed to discriminate between "effective" and "redundant" flexibility in that what they omitted to evaluate was the extra costs of these capabilities and their frequency of use.

Carley and Cryer (1964) extended Cowden and Trelogan's empirical study and found that the number of plants decreased by 37 percent, the average number of products had increased from 1.4 to 2.0 during the period between 1944 and 1961. A

major conclusion of this study concerned the dual benefit of flexibility both to the milk producers who may be paid higher prices and the managers who may respond adroitly to price changes in manufactured products.

Kerchner (1966) took up the theme and attempted to develop a micro-perspective based upon the following hypotheses:

H<sub>A</sub>: "In a flexible dairy manufacturing plant it is not profitable to shift production between two alternative product groups."

H<sub>B</sub>: "The net returns to specialised plant are greater than to a flexible dairy plant..."

This study was comprehensive in scope and executed. A retrospective analysis on the basis of accurately collated statistics underpinned the comparison of the benefits of specialisation against those of flexibility.

His findings were, however, less than conclusive. In certain economic circumstances, the specialized plant out-performed its flexible counterpart. Although this study emphatically stated the feasibility of an acceptable yield from a flexible plant (Kerchner 1966:154), Kerchner's second hypothesis was far too broad in scope to allow any reasonable substantiation. The underlying assumptions of the investigation are at the root of the ambiguity in his findings; though in fairness to Kerchner, he did state some assumptions with unusual clarity. These were as follows:

- i) Yearly processing costs remain constant
  - ii) The practicality of shifting production in concert with changing prices
  - iii) The continuity of price relationships
- (Kerchner 1966:157)

While these may seem reasonable to assume in the immediate post-War era, the volatility and discontinuities of the 1970s and 1980s do little to enhance the generality of his findings. Underlying all work on flexibility, as Kerchner wittily points out, is the fundamental assumption that if **flexibility is available it will be effectively utilized.**

The generic problem of flexibility was taken up in an earlier study by French, Sammet and Bressler (1956), with reference to the California pear industry. While Kerchner's study investigated only product switching, French, et al., examined three further dimensions of flexibility, namely,

- i) Responding to seasonal fluctuations in output,
- ii) Replacing fixed services with variable services,
- iii) Varying output in synchronization with oscillating demand

(French, Sammet & Bressler, 1956:577)

As we point out later, Stigler discussed some of the available strategies for dealing with these factors. Interestingly, a strategy discussed by French, et al. (ibid, p. 555) was the capability to segment a plant into a number of similar oper-

ating units which could be withdrawn from or added to operations without impinging upon the efficiency of others. The resulting marginal cost would therefore be constant; however, while the total cost curve would be linear, it is also discontinuous.<sup>5</sup>

In summary, the topic of flexibility has been given considerable attention in the field of agricultural economics. Most of these studies have examined the vulnerability of the system to rapid swings in prices, but the boundaries of these studies were drawn too narrowly for them to be relevant to our problem. The period in which they were being conducted witnessed major technological innovations; fertilizers, pesticides and mechanized aids have all had major impacts on the technology of agriculture.

Collins' study (1956) attempted to compensate for technological evolution in a comparative assessment of flexible strategies in the production of grain. In his dissertation, he presents the results of an examination of the profitability of the flexible use of resources in small grain producing firms. The methodology was rigorous. Collins gathered data on commodity prices and, by means of an econometric model, deduced the potentially optimal production schedule for a given, tech-

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<sup>5</sup>Parallels can be drawn between this situation and that discussed by Hart (1937). (See also Turvey, 1969 for a discussion of the impact of new technology on marginal cost).

nologically compensated resource configuration. He conjectured that the extent to which a firm was able to readjust its crop production pattern was determined mainly by technological conditions. The available crop alternatives, the speed with which various operations were performed and the quantity of resources at hand were all considered in determining the extent to which adjustments could be made to changes in prices.

Various time periods were carefully distinguished on the basis of technological considerations; about time period 1, which covered 1915 to 1927, Collins wrote:

The striking conclusion which has been found thus far is that the firm gains very little income-wise by shifting among the various profit maximising farm organizations compared with picking that solution which maximises net revenue for the mean price situation. (1956:88)

In time period 2, which covered 1928 to 1940, the optimal solution, as generated by a linear program (which, at the time must have been a significant computational endeavour), proved to be 10 percent lower in terms of economic returns than the flexible strategy. While Collins' findings suffer from the same fundamental limitation as beset Kerchner's later work, he clearly attempted to compensate for more significant causes of incomparability. Advances in management technology have now led to a situation where the individual farmer can run a linear program on a microcomputer, using either his own or respected experts' best guess on possible price scenarios as the foundation for developing a strategy.

The shortcomings of Kerchner's and Collins' studies concern the retrospective focus of the two investigations and the fundamental assumption thereof, that given the appropriate degree of flexibility, an optimally effective course of action would result. French, et. al. (1956), circumvent this line of criticism by pointing out the underlying uncertainties which motivate the quest for flexibility and, in a sense, show that anticipations play a crucial role, as demonstrated by Stiles (1922).

### 3.1.2. Economic Policy

Table 3.2. Chronological list of significant contributors to the literature on flexibility: Economic Policy

<u>Researcher</u>	<u>Date</u>	<u>Theme</u>
Means	1935	Stabilizing monetary policy
Bell	1936	Plant size
Kindleberger	1937	International trade
Mason	1938	Price inflexibility
Musgrave & Miller	1948	Budgeting flexibility
Vernon	1966	International trade
Sherman & Tollison	1972	Market performance
Wales	1977	Flexible functional forms
Berndt <u>et al.</u>	1977	Flexible functional forms
Berndt and Khaled	1979	Flexible functional forms

### 3.1.2.1 Salient Themes

Economic thought has shown only limited awareness of flexibility's value. Considerable attention has been devoted to the problems of a stable monetary policy (Means, 1935: Musgrave and Miller, 1948). Mason argued that flexibility requires a judgement of the probable consequences for relevant economic quantities to types of behaviour different from that under observation (1938:59). In contrast to many other authors (the present researcher excluded), he distinguished three groups of meaning associated with flexibility;<sup>6</sup> the appropriate measure is dependent upon the purpose of the analysis.

Taking a different tack, Bell (1936) related price flexibility to plant size and technology. A much later study of ten major industry sectors undertaken by Sherman and Tollison (1972) viewed flexibility in terms of the level of marginal cost relative to price. Production flexibility was perceived as the extent to which any variability in output would be reflected in instability of profits. Kindleberger (1937) and Vernon (1966) added an international perspective. The former examined how demand in a given country would change in situations where, for example, money incomes are unaltered yet real bility in the technology profile to the location of an indus-

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<sup>6</sup>These were that flexibility is; a) form of price behaviour, b) relationship between price and other economic variables, c) relationship between actual and desired price behaviour. income changes. Vernon related the issue of strategic flexi-



try. In determining the need for flexibility three factors were isolated:

- i) Timing of innovation
- ii) Effects of scale economies
- iii) Role of ignorance and uncertainty in influencing trade patterns

The third factor is of critical importance in both foreign policy and corporate trans-national positioning.

Other economists have turned inward and examined the concept of flexibility with reference to their own models. One such model is termed a "flexible functional form" and is designed to approximate various types of econometric phenomena. Berndt, et al. (1977) examine these in relation to Canadian consumer demand functions; Berndt and Khaled (1979) discuss the selection of a form with respect to the accuracy of estimating pertinent parameters. Wales (1977) attempted to assess the 'flexibility of flexible functional forms', only to conclude that such forms, while capable of a reasonable second order approximation to an arbitrary utility function, do not provide a good approximation over a range of observations. Wales' approach fails to justify the rationale underlying Mandelbaum's (1978) quest for a measure of flexibility which reflects a decision-maker's unease with a decision-aiding model.

### 3.1.3 Investment Theory

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Table 3.3. Chronological list of significant contributors to the literature on flexibility: Investment Theory

<u>Researcher</u>	<u>Date</u>	<u>Theme</u>
a) Preference Migration		
Marschak	1949	Role of Liquidity
Strotz	1955	Myopia
Tobin	1958	Liquidity
Stein	1964	Hedging
Day	1969	Flexible Utility
Peleg & Yaan	1973	Changing Tastes
Hammond	1976	Preference Migration
Kreps	1979	Preference for Flexibility
b) Liquidity and Portfolio Choice		
Orr	1967	Capital Flexibility
Goldman	1974	Demand for Money
Jones & Ostroy	1976	Liquidity
Goldman	1978	Portfolio Choice
Frazer	1980	Demand for Bonds

### 3.1.3.1 Salient Themes

Another branch of economics is concerned with questions of value surrounding changing tastes and preferences. The history of this topic is obscure because of its "back seat" position relative to quantitative economics. It was relegated to pillion position when 'machine age' thinking was at its peak. Stigler (1977) eventually grasped the significance of these issues yet, imponderably, did not relate it to the problems posed by his earlier paper (1939).

Before economics had become somewhat narrowly specialized, Clark (1891) identified five types of change which influenced the dynamics of social fabric. These were:

- a) changes in social wants
- b) changes in the mechanical processes of production
- c) alterations in the mode of organizing industry
- d) shifts in labour and capital
- e) increase or diminuiton of the amounts of labour and capital in existence

While many economists focussed attention on the last four, the fact that these factors hinged on the first was not so much overlooked as ignored. Mill long ago asserted:

In all branches of practical business there are cases in which individuals are bound to conform their practice to a pre-established rule, while there are others in which it is their task to find or construct the rule by which they are to govern their conduct" (1858:616).

It is interesting to note the weight given by economists to "adhesion to rules" at the expense of the "dynamic and creative". Questions of value are reasonably straightforward when the outcome is unidimensional in the financial realm. The expected payoff is then a suitable indicator of performance. However, decisions are rarely taken on the basis of perfect information. Marschak (1949) pointed out the significance of the mobility of resources under conditions of partial knowledge. A theme pursued by Tobin (1958) suggested that risk played a crucial role in formulating an individual's preference for holding readily transferable assets. Arriving at a description of risk diversifiers and risk plungers, Tobin prescribed a method for decision analysis which was to:

- a) Estimate subjective probability distributions of capital gain or loss from holding consuls,
- b) Evaluate prospective increase in wealth in terms of a cardinal utility function,
- c) Rank alternative prospects according to the expected value of utility.

While the theory was plausible for arriving at decisions in a purely financial dimension, investment decisions generally involve at least three or four equally significant dimensions. In addition to this potential limitation, a further cause for consternation concerns dynamic utility maximization. Strotz (1955) distinguished two significant durations for the assess-

ment of the relative weight to satisfaction derivable from a future act:

- 1) time distance of a future date from the present moment
- 2) calendar date of the future act of consumption.

In recognizing the possible dissonance between the utility ascribed at each time, Strotz coined the term "myopic utility" to be applied to a strategy of precommitment. To perform "consistent planning" one ought, he argued, to select persistently an action which will be best in the light of future deviations. The idea was later championed by Day (1969), who recognized the significance of changing tastes and attempted to explicate the concept of flexible utility by reference to Roy's safety first principle.<sup>7</sup> In a different approach, Peleg and Yaan (1973), sought to establish the existence of a consistent course of action when tastes were changing. Spurred by this idea, Hammond (1976) went on to explore this in some detail.

In a theoretical financial environment, Orr (1967) forged the notion of capital flexibility in the Stiglerian mould, though as we point out later (Chapter 4), Goldman's treatment of flexibility (1974) was more explicit. In a later paper,

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<sup>7</sup>Day bases his notion on the hypothesis that risk is identified with change and the greater the departure from the ways things are currently perceived the greater the perception of risk (1971:240).

Goldman (1978) examined the problem of portfolio choices with regard to the problem of flexibility. As we point out in Chapter 4, Frazer (1980) used Goldman's models to investigate holding mobile assets. An earlier paper by Jones and Ostroy (1976) had argued the synonymy of liquidity and flexibility. Kreps (1979) has since sketched out the formal treatment of flexibility in this context.

### 3.2 The Technology Literature

Table 3.4. Chronological list of significant contributors to the literature on flexibility: Technology.

<u>Researcher</u>	<u>Date</u>	<u>Theme</u>
Mitchell	1970	Computer systems
Hutchinson	1973	Flexible manufacturing systems
Chernya	1975	Electricity generation
Spur <u>et al.</u>	1976	Flexible manufacturing cells
Fuss	1977	Electricity generation
Montenegro	1977	Communications systems
Draaisma & Mol	1977	Feedstock Flexibility
Grinyer and Wooller	1978	Computer based models
Tilak	1978	Production flexibility
Frazer	1979	Compunications
Collingridge	1980	Control of technology
Schroeder, <u>et al.</u>	1981	Electricity generation
Guerico	1981	Feedstock flexibility
Sigismund	1982	Factory Automation
Gerwin	1982	Flexible manufacturing systems

### 3.2.1 Salient Themes

In the studies reviewed in the previous two sections, flexibility was sought as a response to uncertainty. Within a technological setting, flexibility impacts upon the diffusion of products, processes and management techniques. with associated after actions. Most efforts aimed at using flexibility in a technological context have been focussed on a particular technology. The notable exception is the work of Collingridge (1979, 1980), who attempts to apply more enlightened criteria in evaluating the social desirability of technologies.

Collingridge (1979) asserts that the underlying rationale for planning technology-intensive systems is based upon a misplaced confidence in the ability of experts to envision the consequences of implementing new technologies. He replaces this archaic foundation for decision-making with a fallibilist theory of value. This epistemological foundation has a "thoroughbred" philosophical pedigree which draws on the Popperian criterion of falsifiability and the deontic logic of Mill. From a practical perspective, Collingridge offers guidelines for selecting any potentially hazardous technology based on the following principles:

- 1) Monitorability
- 2) Error cost
- 3) Correction time
- 4) Cost of remedial action



Flexibility, he suggests, is negatively correlated to the "controlled error cost and gross response time" (1980:38). While Collingridge is arguing from sound principles on the basis of avoiding or ameliorating the hazardous after effects of technologies, it is not so easy to apply such a schema to the other side of the equation. As the old Chinese proverb says: risk is a dangerous opportunity. Many decisions require comparative risk assessments of alternatives. In a corporate setting, a new technology may generate a distinct competitive advantage and hence generate employment and wealth while facilitating the testing of the technology, thus enabling scientists to fathom the depths of any hidden dangers. In spite of this deficiency, Collingridge's prescriptive theses are a major contribution to our understanding of the concept of flexibility.

Other attempts to implement flexibility have been technology specific. Electricity generation is an area where the planning lead times and plant life cycles give sufficient cause for consternation about the ability to accommodate the many inherent uncertainties; indeed, uncertainty surrounds the current use of generating equipment, fuel feedstock prices, commissioning strategies for new stations, and proposed technology-mix for planned capacity expansion. At an operational level, there are problems in predicting peaks and troughs in demand which are contingent upon prevailing economic and cli-

matic conditions (Bunn 1982). Additionally, environmental issues such as acid precipitation, nuclear fuel reprocessing, waste disposal and thermal pollution collectively constitute a genuine need for flexibility. The extent to which these problems are soluble is an open question. Chernya argued that his data on the operational problems of thermal power stations showed:

...the very great importance and urgency of solving the problem of increasing the flexibility of the plant at power stations and the need for faster introduction into service of highly flexible units (1975:38).

Fuss (1977), on the other hand, viewed the issue of flexibility in a time perspective. Ex-ante flexibility was required in choosing new capacity which was dependent upon the relationships among technology, expected future relative price factors, and anticipated future demand. Fuss viewed ex-post flexibility, as being determined by the links among existing technology, current relative prices, and the prior ex-ante choice of technique. Such an approach was implemented, to a certain extent, by the Central Electricity Generating Board (The Electricity Council, May 1980, p. 34). A further strategy suggested by Collingridge (1980) was to build smaller units in order to reduce the lead time in responding to revisions in forecasted demand levels. (Also see Schroeder et al., 1981.)

While it is possible to view flexibility as a requirement if a system should "go wrong," some have argued that innova-

tions, especially in communications, have greatly enhanced capabilities because of the inherent technological flexibility. Writing about IBM's new communications technology, Frazer (1979) argued that high quality digital transmission facilities introduce significant system flexibility due to their portability, physical flexibility (reflected in ease of maintenance), interconnection capability, and ability to be tailored to user requirements (1979:337). This view may be interpreted as enlightened self-interest, yet this is unjustly critical of IBM's commitment to innovation.

Within the same technological setting, Montenegro (1977) set out an alternative to risk preference theory as a basis for planning telecommunication systems where future demand and technical capability were uncertain. Montenegro defines flexibility as that extra capacity built in a system to compensate for low probability growths not taken into consideration in the original estimates of the systems requirements (1977:61). This form of flexibility preference theory was grounded in the objective of maximizing flexibility and minimizing cost, which is achieved by maximizing the expected flexibility utility function. This, however, is a somewhat circular definition and is restricted in its applicability to situations where the cost of undercapacity warrants the added burden of unused overcapacity. As a general maxim of engineering practice, Montenegro's

stated dictum resembles that of increasing a discount rate a few points to take care of unanticipated uncertainties.

In a related setting, Grinyer and Wooller (1978) explored the flexibility of available corporate planning software along several dimensions. The attribute of flexibility was used as a decision criterion in selecting the best modelling system. Mitchell (1970) saw flexibility in a programming system as an aid to evolutionary development (1970:6A1). More precisely, he defined flexibility as:

...the ease with which the user of an interactive programming system can manipulate the objects of interest to him.... Thus, a system in which lines of programming text can be altered by the user would be deemed more flexible than one in which they cannot (1970:1C.5).<sup>8</sup>

The ability to make changes is the motivating force behind the development of flexible manufacturing systems. Based on the same fundamental technology, the shortening of product life cycles and the necessity of modification has preempted a fusion of data processing, artificial intelligence and robotics. Such systems are approaching the inflection point on the Gompertz curve of diffusion, heralding a metamorphosis of the mode of production (Sigismund 1982). Flexibility in this setting is operational in its truest sense, yet its successful adoption

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<sup>8</sup>He goes on to argue "efficient use of the human is achieved by flexibility in the system and the system can be more efficient if the user is more flexible (ibid)."

will yield a significant strategic advantage and promote social change of enormous proportions. The works of Hutchinson (1973), Spur (1976), and Gerwin (1982), discuss just how flexible such systems are. Tilak (1978) investigated the value of technological and resource flexibility in a production setting by means of a simulation model. His findings substantiated the view that flexibility is required both to ameliorate a threat and to exploit an opportunity, (since its value was highest at production levels exceeding 75% of capacity). Product switching and output variability are elements in corporate strategic flexibility and since this area is significant it would prove to be a topic worthy of singular attention.

This section has scanned some of the attempts directed at applying the concept of flexibility in a technological framework. Two studies by German authors were focussed on personnel flexibility in relation to the introduction of new technologies and products in the shipbuilding and publishing industries (Budczies, 1980; Schulte Hillen, 1980). Additionally, flexibility of ethylene production has been evaluated both with respect to process technologies (Draaisma and Mol 1977), and with respect to usable feedstock (Guerico, 1981). The underlying theme is that **flexibility enables appropriate adjustments to be made in order to balance a system more correctly with its environment.**

### 3.3. The Decision Analysis Literature

<u>Researchers</u>	<u>Date</u>	<u>Theme</u>
Tintner	1942	Risk and uncertainty
Lange	1944	Technological change
Klein & Meckling	1958	R & D portfolio
Marschak & Nelson	1962	Measurement of flexibility
Koopmans	1964	Preference migration
Rosenhead	1968/80	Robustness
White	1973/75	Robustness and Entropy
Merkhofer	1975	Decision flexibility
Bonder	1976	Versatility planning
Pye	1976	Entropy and robustness
Mandelbaum	1978	Hedge against model error
Keeney	1981	Technological value conflict

Table 3.5. Chronological list of significant contributors to the literature on flexibility: Decision Analysis.

### 3.3.1 Salient Themes

The most significant attempts to develop numerical indices for flexibility have emanated from decision analysts. The term is used advisedly to refer to those scholars who attempt to render explicit the logic of fusing fact and value in order to choose among strategic alternatives. The foundations of their discipline are to be found in economics, engineering, operational research, systems analysis and psychology. Tintner (1942), an economist, had been influenced by Hart's work (1937) and tackled the problem of substitution of one technology dominating an industry with its successor. His attempt was grounded in utility theory and probabilistic analysis which, though innovatory in the 1930s, became a hallmark of the "Cowles foundation" economists under Oskar Lange. Lange's (1944) attempt to investigate flexibility of prices also looked at the problem of changing dominant technologies.

Klein and Meckling (1958) examined the problem concerning the diffusion of technologies. They were concerned with the problem of deciding which research project ought to be developed out of the laboratory and into production. It was their belief that an engineer who made a deliberate attempt to incorporate some revisionary capability into his project could make better use of his later experiences when implementing the programme. As they suggest:

In order to maintain flexibility he (the engineer) commits resources to development only by stages, reviewing the state of his knowledge at each stage prior to commitments (1958:360).

While this posture has merit and includes some of the ingredients of Lindblom's incrementalism (1959), it will not serve as an approach for conceptualizing flexibility. There are points in most resource allocation decisions where exposure is a necessary complement of risk taking. Significant events, such as moving from a pilot plant or prototype phase to full production, involve substantial commitment; in these cases phasing resources may be counter-productive. Klein and Meckling's work, however, represented a major effort against the tide of optimization.

Marschak and Nelson (1962) set out to give an unambiguous and precise definition of flexibility. In so doing, they made several important advances in their valiant attempt. They evaluated flexibility according to the degrees of freedom available which allow the tuning of decision variables to appropriate conditions in future periods. In a sense, they pursued Klein and Meckling's goal--formalizing the ability to refine decisions as a result of experience; flexibility is therefore a response to uncertainty. Flexibility, they suggest, can be measured by the size of the choice set associated with alternative courses of action. The most flexible initial course of action is that which retains most of the future



options. It follows, therefore, that courses of action can be compared and ranked, ordinally at least, with respect to their flexibility. They conjecture that the more a decision-maker expects to learn in subsequent periods, the greater the value of flexibility. It transpires that flexibility, in their view, is a property of an initial action in a sequential decision process. Based upon such a conceptual foundation, Marschak and Nelson proceed to develop precise measures of flexibility based upon the assumption that a mythical decision-maker wishes to maximize expected pay-off.

Inasmuch as Marschak and Nelson recognized that their attempt only scratched the surface, it seems unjust to criticize such a courageous effort at harnessing the intuitive appeal of the concept of flexibility. Yet, they appear to confuse the property of flexibility with its measure and, more importantly, they isolate the actions of the decision-maker as being somehow in dependent of the future state of the world. Furthermore, the equivalence between learning and uncertainty is too tidy and fails to distinguish between what is "unknown" from that which is "unknowable" and that which is "unimagined" from that which is "unimaginable".

Koopmans (1964), by way of contrast, begins his quest for flexibility by explicitly recognizing the paucity of economic theory in dealing with constantly changing or dialectically evolving needs, wants, and aspirations. In addition, he hints

that technological change is reason enough for requiring flexibility. His main thesis is **that tastes evolve with experience.** Therefore, the sources of uncertainty which beset our mythical decision-maker are two-fold:

1. Unimaginable technological or resource possibilities,
2. The knowledge that choices in the future will be based upon new preferences.

Koopmans' main assertions grew from his realisation that flexibility is desirable in decisions because it is not possible to envision the preferences of the stakeholders especially those whose implications span long periods. These assertions are as follows:

1. Technology provides the potential for acquiring flexibility
2. A preference ordering can be used to rank sets of programmes according to the range of alternatives they give access to.
3. An opportunity A is more flexible than an opportunity B if all the choices in B are all present in A but in addition A has other choices not contained in B.

Koopmans proposes five postulates which may underlie the possible axiomatisation of the concept of flexible choice. Commenting on his fifth postulate, he states:

A chooser who adopts such a postulate is telling himself that one can never know how drastically one's preferences may have changed when the time of choice arrives" (1964:251).

The intuitive simplicity of this paper is stimulating yet it goes no further than to "take us to the well".

The concept of robustness was a statistical notion which Stone (1963) attempted to formalize. Gupta and Rosenhead, (1968) applied it to an investment decision and developed a measure of robustness which, broadly speaking, was equivalent to the fraction of good options to which a particular action would allow access. Later papers by Rosenhead (1980a, 1980b) suggest that robustness is synonymous with strategic flexibility. It is evident, as he admits, that the need for flexibility arises because we do not know what we will desire in the future. This is because we have only limited foreknowledge of technology and resource capabilities as well as our restricted comprehension of likely future value structures. How then can it be asserted that flexibility can be measured by the number of good options we can have access to if we do not know what will be "good" in future times? Even though the simplistic choice set measure of Marschak and Nelson lacks the depth to embrace the quality as well as the quantity of options, given the limitations of projecting the desirability and efficiency of a given course of action into the future, our ability to capture the universe of available scenarios must be even more suspect. Rosenhead places a high value on strategic flexibility, yet its measurement is not secured by his measure of robustness.

Merkhofer (1975), inverted the strategy, arguing that the value of flexibility is to be found by reference to the impact of information on a particular decision. This inversion is consistent with the works of Koopmans (1964) and Marschak and Nelson (1962). Significantly, the decision analytic paradigm enabled the value of flexibility and information to be assessed. By establishing the value of varying degrees of flexibility conditioned by perfect and imperfect information, the improvement in payoff or reduction of losses associated with postponing a decision can be assessed. This process could be used to locate characteristics of a decision environment which influence the choice of the type of flexibility.

In a later work, Merkhofer and Saade (1978) address the following questions:

- a) What is the cost of acquiring flexibility?
- b) How does the timing of information affect the significance of resolving uncertainty?
- c) What is the cost of making an erroneous decision?
- d) Why is it desirable to retain flexibility?

The answers to these questions were ascertained by using a simple gambling decision where the objective was to gauge accurately the distribution of outcomes resulting from tossing a drawing pin. The impact of over- and under-confidence in the estimation were considered. Notwithstanding the simplicity of the example, Merkhofer was able to conclude in his study that

flexibility has value when the receipt of significant information is expected prior to an irreversible commitment of resources, the value being dependent on the uncertainty surrounding a decision. Fluctuations in the values will accompany shifts in the cost of an erroneous decision and are negatively correlated with the costs of introducing flexibility.

While this tack represents a sound logical approach to decision-making under uncertainty, it is limited in its application. To some extent, this is due to sheer computational complexity; the ability to capture socio-economic, geopolitical, technological and ethical uncertainties is constrained by the bounds of imagination. Trading off values on a unidimensional scale to represent preferences, in some cases for future generations, captures only a small part of likely future values (if Koopmans argument is accepted). We are reminded of Hart's (1937) exposition of flexibility under conditions of certainty in which he asserts that a businessman is still justified in seeking flexibility even though feeling no uncertainty that he might be wrong.

The evaluation of flexibility using a Bayesian approach was extended by Pye (1978) who drew on Rosenhead's concept of robustness and on Mandelbaum (1978) concept using the concepts of Marschak and Nelson (1962), Rosenhead (1972) and Merkhofer (1975). Mandelbaum was motivated by a common problem facing O.R. practitioners, namely a decision-maker's uneasiness with a

model. Indeed we are uneasy with Pye's model because it can lead to bad decisions. Mandelbaum pulling together some of the strands of the multi-dimensionality of uncertainty which motivated the quest for flexibility, which were:

- i) The availability of actions
- ii) The genesis of new options
- iii) Unanticipated events
- iv) Changed preferences

Departing from convention, however, we must draw into the question the availability of information about current state and decision variables which are required for the type of quantification proposed by both Cunningham and Mandelbaum (1979) and Pye (1978). As the former conclude:

...research up to now has concentrated on precise model calculations. The importance of flexibility, what makes it possible and the means of obtaining it must be more widely understood (1979:27).

In this spirit, Bonder (1976) had earlier attempted to examine new ways of thinking about flexibility. As we point out in the sections on Military and Business Policy, attempts have been made to further our conceptual understanding of flexibility as a key strategic principle. Keeney (1981) used a utility-based approach to evaluate resilience of a variety of standards designed to contain potential hazards from advanced technological systems. These two contributions will be further elaborated in the sections on versatility policy and resilience.

### 3.4 Business Policy

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Table 3.6. Chronological list of significant contributors to the literature on flexibility: Business Policy

<u>Researcher</u>	<u>Date</u>	<u>Theme</u>
Hart	1937/40	Role of anticipations
Stigler	1939	Plant flexibility
Shackle	1953	Kaleidoscopic change
Cyert & March	1963	Theory of the firm
Meffert	1969	Organizational flexibility
Eppink	1978	Strategic flexibility
Krijnen	1979	Flexible firm
Ansoff	1980	Adaptive strategic positioning
Harrigan	1980	Entry and exit barriers
Kickert	1981	Organizational flexibility
Kylen	1981	Business response to ricochets

### 3.4.1 Salient Themes

Hart viewed flexibility as the law of response to uncertainty. During the years of his doctoral research, under Knight, he examined the role of anticipations in business planning. "Anticipations", he tells us, "include the expectation that anticipations will change." (1940:84)<sup>9</sup> He examined the many connections among the key variables of significance in steering a business enterprise through an ever-changing environment. Hart's work was, however, directed toward fusing the subjective elements of judgement with financial, technological and market contingencies.

In this context, Hart conducted a holistic analysis of flexibility which was elegant in its simplicity. Essentially, the concept of flexibility was used as a double-edged sword with one blade ameliorating the consequences of a change with negative implications, and the other enabling the timely exploitation of an opportunity. Stated with eloquence, his definition of flexibility suggests:

In setting out to do a particular thing in a particular way, we try to plan so that in case of need we can do it differently or do something else" (1940:25).

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<sup>9</sup>It took some time for this author to appreciate the semantics of this distinction; it was clarified by Mr. W. F. Hartman quoting from A.P. Herbert in a letter to the Financial Times (Jan. 24, 1981) "Any one who equated 'anticipate' with 'expect' must believe that John and Mary expected to be married meant the same as John and Mary anticipated marriage."



Hart contested the view that optimal plans could be generated pointing out that measures looking toward to flexibility were still reasonable to pursue despite a decision-maker feeling no uncertainty. However, Stigler (discussed later) extends the analysis of fluctuations under certainty (see footnote 16 Hart 1940:26). Stigler's analysis of productive flexibility comprised three main strategies in Hart's conception, which were:

- a) fixed costs changing proportionally to currently required services;
- b) plant better suited to prospective variations in output rather than adapted to constant output;
- c) buffer stocks of both raw materials and semi-finished goods.

In addition, capital sources were a further ingredient which under conditions of certainty could enhance flexibility if two generic strategies were adopted, namely:

- a) creating liquidity
- b) holding insurance

From a theoretical perspective, these observations were useful but not essential to his argument. From a conceptual perspective, his analysis of flexibility set out the fundamental *raison d'etre* for pursuing strategic flexibility as follows:

- 1) To make the most of later opportunities to improve estimates.

- 2) To make room for changes.
- 3) To postpone a decision until critical information is received (1940:55:60, 1937:386).

Underlying the quest for flexibility was the simple realization that:

...it is plain that entrepreneurs must know methods will change; and even more plain that they cannot believe they know just how they will change (1940:87).

Hart's contribution to this area was substantial although it lacked an empirical foundation. This limitation may be passed over by those intuitively cognizant of the critical importance of flexibility. His appeal to intuition fell on barren soil. Shackle briefly alludes to Hart's notion but even such a brilliant economist as he failed to grasp the significance of flexibility. Baumol (1959) and later Koopmans (1964) referred to his work. Perhaps the very generality of Hart's observations contributed to this shortcoming since one could not expect a statistical examination of his hypotheses. However, Hart's reliance on general business acumen, while helpful for those possessed of such an ability, does little to fire the imaginations of those who investigate flexibility in other systems.

In conclusion, Hart's treatise was grounded in the belief that situations could transform either as a result of changing physical possibilities (including technological, market and capital as well as material resources) or changing conceptions



of desirability. On the whole the latter was prompted by the former though not, by any means, exclusively so. Flexibility was thus necessary to match purpose with potential in a continuously evolving reality.

In contrast, Stigler's (1939) views were exclusively concerned with the operational time frame. Later in his writings, he examined the process of habit formation and preference development though the connection between this topic and his earlier work seemed to escape his attention. A flexible production system was defined, in much the same mould as Hart, as "one which operates with a tolerable efficiency over a considerable range of outputs" (1939).

Stigler's major assertions were that flexibility is not a free good; it is bought in order to coordinate plant and equipment to rates of required output so that the plant operates efficiently over the range of probable outputs. He carefully distinguished flexibility from adaptability, arguing that the greater the degree of adaptability, the less the need for flexibility. Adaptability was complete when any mix of variable quantities could be used to produce the optimal output. Flexibility was secured by having the plant consist of a number of homogenous units with the ability to transform fixed into variable costs or being able to combine physical elements of plant with varying amounts of other productive services.

Stigler's model was static and paid no attention to product or process obsolescence and, by his own admission, completely ignored portfolio-related issues. Merkhofer (1975) points out some of the consequences which follow from Stigler's decision rule, which stated that "flexibility will be added until accumulated marginal costs equals discounted marginal returns from savings due to that additional flexibility" (1939:131). Stigler's work on flexibility is often cited by economists who mention the problem of changing technology, (Turvey 1969, Baumol 1959, and Strangert 1977 Hashimoto 1982). Stigler's work, while more precise than Hart's, adds little to the conceptual foundations. It does point toward one direction in which flexibility may be quantified though, as Merkhofer (1975) demonstrates, it is erroneous.

With the exception of a few authors who briefly examined flexibility as a subsidiary issue, (such as Cyert and March's exposition [1963] of the use of organizational slack in the behavioural theory of the firm) the field has not been explored until recently. The kernels of some novel ways of putting flexibility into practice were germinated in Ansoff's seminal work on corporate strategy (1965). He briefly alluded to flexibility as providing a cushion for coping with discontinuities, achieved by "not having all of one's eggs in one basket". Later, he suggested that attention needed to be focussed on balancing product life cycles, short and long run profit-

ability, strategic resources, and power relations with exposure to discontinuities (1975:47). This was further developed into the elegant notion of strategic positioning (1980a).

Eppink (1978) was influenced by Ansoff's germane analysis and developed a conceptually elegant image of how one could visualize strategic flexibility. This was composed of three dimensions: types, components and aspects. He viewed flexibility as a "characteristic of an organization that makes it less vulnerable to unforeseen external change or puts it in a better position to respond successfully" (1978:42). In a sense, Eppink sees flexibility as "surprise management" though he argues (in a personal discussion) that it is not restricted to surprises. The concepts and framework he developed drew on many diverse sources. Empirically, he tested his framework by recourse to the strategies adopted by three corporations in response to the discontinuity precipitated by the oil embargo and subsequent price hike.<sup>10</sup>

His field work is interesting from our perspective. One of the key assumptions of Merkhofer's work (see Section 3.3) was that flexibility will be valued only if the decision-maker expects to receive some information which would influence his choice. In essence, this was refuted by Eppink's research since the executives in the oil company he studied had been

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<sup>10</sup>It would be interesting to reexamine his observations in the light of the 1978 oil price increase.

forewarned of the impending crisis. However, the scenario was seen as having a very low probability of occurrence, so low in fact that no measures were taken to provide a cushion. On being questioned on this point in connection with Hart's statement, op cit., Merkhofer (personal communication 1980) maintained that a decision-maker ought logically to place a value on flexibility if he thinks that he will receive information which would influence or alter his choice. Clearly there is a tension between logical and prudent behaviour.

Eppink's empirical findings were, by and large, consistent with previous work in the area and added substance to Hart's claims. The corporate study undertaken as part of this research found some corporations to have implemented a number of the practices which Eppink described as inducing strategic flexibility. Some of the implications for acquiring flexibility which he proposed, however, are confusing.

A case in point would be his reference to environmental scanning and monitoring. If, by his definition, flexibility is a property which partly facilitates a successful response to unexpected change, how can one use an early warning system to predict such a change? Since the likely signals of such events are likely to be faint and highly attenuated, the filter used to determine the significance and points of impact would have to be very delicate and highly sensitive. Eppink's framework and fieldwork made no attempt to justify the costs of flexibil-

ity in terms of its value, which is surprising considering how often he draws a parallel between flexibility and insurance. Notwithstanding these limitations, Eppink made a very valuable contribution to the study of strategic flexibility.

Harrigan (1980) relates immobility of resources to an overcrowded competitive environment. Strategic flexibility, she argues, will be enhanced by assisting marginal competitors to divest themselves of their interests in a potentially volatile business area. Kickert (1981) presents an argument to suggest that flexibility is a built-in capacity to control unforeseen situations. His conceptual framework contains some ideas worthy of further consideration. This notion that flexibility enhances controllability is reminiscent of Collingridge's (1980) but not as well elaborated.

### 3.5 Military Strategy.

Table 3.7. Chronological list of significant contributors to the literature on flexibility: Military strategy.

<u>Researcher</u>	<u>Date</u>	<u>Theme</u>
Sun Tzu	500 BC	Subtlety
Bourcet	1760	Divisional structure
Guibert	1772	Speed of response
Napoleon	1810	Star formation
Wellington	1810	Dynamic defense
Clausewitz	1830	Concentration & dispersion
Sherman	1860	"Horns of a dilemma"
Liddell Hart	1929	Indirect approach
Fuller	1932	Technology policy
Taylor	1959	Flexible response
Eccles	1965	Logistical flexibility
Horowitz	1970	Flexible Responsiveness
Jacobsen	1974	Flexible Responsiveness
Carter	1974	Flexible strategic options
Rathjens	1974	Flexible options
Martin	1977	Tactical Flexibility
Strangert	1977	Adaptive planning
Ritter	1978	Tactical flexibility
Bonder	1979	Versatility planning



### 3.5.1 Salient Themes

It took almost three-quarters of a century for two major innovations to be fused together with a third, contributed by Napoleon, to give the French forces a strategy which required the combined forces of many nations to resist and defeat. The three innovations were configuration, communication and convertability.

These were the ideas of Bourcet, Guibert, and Broglie, which Napoleon integrated into an army likened to a "fluid body, a loose grouping of divisions, which like blots of quicksilver would suddenly flow together and coagulate on striking an obstacle" (Liddell Hart 1954:213). Bourcet developed the divisional structure which broke up the "monolithic army structures into a flexible concert of swiftly moving groups manoeuvring on a wide front and eliminated long pauses for reorganization" (Makesy 1959). In a strategic sense, Bourcet anticipated the development of decision analysis when he suggested:

Every plan of campaign ought to have several branches and to have been so well thought out that one or other of the said branches cannot fail of success.

Guibert thought that tactics could be divided into two parts; one elementary and limited, the other compound and sublime (the science of generals). He performed experiments on the marching drills preferring to prepare soldiers for engagements rather than ceremonial or mindless exercises. He, too, may be thought of as an early pioneer of scenario planning.

Upon inspecting the appendices of his book on tactics (1772), one finds maps displaying appropriate tactics for a variety of terrain/disposition configurations. When Napoleon acquired control of the French army (which for obvious reasons had been stripped of its aristocratic commanders) his friends were seeded as divisional commanders. This resulted in a much reduced decision activation time. With a new divisional structure and a speed of manoeuver enhanced by increasing marching from 60/70 to 110 steps per minute Napoleon, for a while, was invincible.

Wellington employed flexibility to great effect both in defending Portugal and at later engagements, culminating in Waterloo. (See Howard 1959). Furthermore, the father of the science of strategy, von Clausewitz participated in the later engagements of the campaign and took exception to Wellington's tactics at Waterloo, almost precipitating defeat for the allies. Clausewitz thought that standing reserves should provide for surprise situations (1976).

Liddell Hart, a vehement opponent of the "Mahdi of the Masses", was a firm believer in strategic flexibility and scattered through his voluminous work on strategy and strategists (1929, 1944, 1954) one finds many an odd thought on strategic flexibility. In his study of Sherman (1929, 1959) he came to realize the value of flexibility relating it to the high degree of manoeuverability and intriguing system of sup-

plying troops which also served as an intelligence system. "Sherman had sought to find a solution in variability--the choice of a line leading to alternative objectives with the power to vary his course to gain whichever the enemy left open" (1959:383). Liddell Hart had realized that strategists could rarely foresee or provide for the case of mixed success or failure, and that their plans often suffered in execution as a result. He saw flexibility as a multidimensional quality:

mobility implies flexibility and the power to manoeuver and act with rapidity.... Plans, dispositions, and organization should all be flexible, adaptable to varying circumstances and to the alternative courses these may dictate. We should think of flexibility as the counterpart or auxiliary principle of mobility. It may even be said that flexibility, in its widest sense, is the main component of economy of force" (1944:181).

The main points of reference to strategic flexibility collectively suggest that it is not to be located in any formalized sense by specific qualities or attributes. Rather, flexibility matches or positions in accordance with the situation confronted so as to allow things to be done differently should the need arise. Liddell Hart's conception was not restricted to a tactical or strategic level, and he thought of flexibility as a fundamental guiding principle:

History shows that the unswerving pursuit of any one objective is almost certain to be barren of any result. Variability of objectives like elasticity of disposition is necessary to fulfill an essential principle of war--flexibility (1944:243).

By shortening the chain of command and increasing the power of manoeuver through a flexible organizational structure, he argued, the decision activation time could be reduced to allow adjustments to be made to varying circumstances or to concentrate resources at the decisive point (1954:291).

A friend of Liddell Hart, J. F. C. Fuller concentrated on technological capability (1932, 1961) and expanded this theme. Eccles had a broader view arguing:

...the intellectual concept of strategy as involving comprehensive control naturally leads to the intellectual concept of flexibility (1959:25).

Eccles was aware that flexibility required the juxtaposition of many characteristics which could be destroyed or rendered rigid by one major inflexible characteristic (1959:116). He pointed out that it in no way implied indecision but rather avoidance of premature commitments, particularly at the early stages of an operation. All types of flexibility, he suggested (1959:129), require a clear understanding of objectives, appropriate delegation of authority, adequate information and intelligence, provision of adequate reserves, and alternative, well thought out strategic and tactical plans.

Returning to the theme of strategic flexibility, Maxwell Taylor (1959, 1972) appealed for alternatives to the M.A.D. policy of nuclear deterrence. The strategy of flexible response was to provide the capacity to react across the entire spectrum of possible challenges (1959:64). In essence, it

means that for every potential enemy action there should be an appropriate response, employing sufficient force to defeat the enemy but no more than is necessary. Many have argued the pros and cons of the current thinking on strategic flexibility. In this section, we have drawn on theoretical approaches based on the thoughts of military strategists, deliberately avoiding, it is hoped, contemporary issues (Jacobsen 1974, Rathjens 1974, Martin 1977). Recent articles suggest that running a corporation may have similarities at a conceptual level to military strategy. Widmer (1980) argues that there is a readiness to view corporate strategy in military terms. Some military strategists saw the parallels. Clausewitz writing to Gneisenau 17 June 1811 remarked:

Battle is money and property, strategy is commerce, it is only through the former that the latter become significant. (Quoted in Hahlway 1966:647).

### 3.6 Management Science

Table 3.8. Chronological list of significant contributors to the literature on flexibility: Management Science

<u>Researcher</u>	<u>Date</u>	<u>Theme</u>
Putney	1968	Flexible costing
Friend & Jessop	1969	Flexibility
Meffert	1969	Business flexibility
Tries	1973	Flexibility in production systems
Friedman & Reklaitis	1975	Linear programs
Tomlinson	1976	Organizational adaptivity
Van Der Vet	1977	Linear programs
Ackoff	1977	Flexible organization
Eppink and Derkinderen	1979	General management
Bonder	1979	Plea to O.R.
Fumas & Whinston	1979	Contracting theory
Krijnen	1979	Flexible firm
Park & Thuesen	1979	Flexible budgeting
Faludi	1973	Flexible planning
Wilkins	1980	Financial flexibility
Dorward and Wiedemann	1981	Robustness

### 3.6.1. Salient Themes

Friend and Jessop (1969) investigated the problem of planning in the context of local government in the U.K. from a theoretical perspective. Their work is of interest first, because it was a fine application of operational research to problem solving, and second, because of the unique way in which they distinguished between various types of uncertainties. This theme is taken up by Hickling (1978: personal interview) who further applies the concept of flexibility to strategic choice, again in the context of local government planning under the auspices of the Institute for Operational Research at Coventry. Rosenhead (1980) takes up the theme which had been extended by Faludi (1973) in a study of Dutch architectural planning. The latter refers to how a hospital's design can respond to changing budgetary requirements or adapt to varying demands for health care.

In Germany, a considerable volume of literature grew during the 1960s on the subject of flexibility (Reibel, 1954; Clasen 1966; Jacob, 1967; Jochum, 1969; Laux, 1969). The aims of these authors were loosely related to the idea that a business plan ought to be flexible both during the capital injection and the production phases in order to respond to the contingencies of the day. Among these writers, Meffert (1969) is worthy of individual attention because he developed a very sophisticated framework based upon comprehensive research. The

underlying notion was the separation of flexibility in policy formation from its means of achievement. The distinction is, (in the original German), between "Zielsetzungsflexibilität" and "Zielerreichungsflexibilität" (1969:787, 788); literally the two terms mean "flexibility of objective formation" and "flexibility of objective realization" respectively.<sup>11</sup>

Building upon the work of Meffert, Tries (1973) further develops the idea of flexibility within a decision analytic paradigm. He views flexibility as a property which allows for "necessary adjustments" to be made at the next conditional branch of the tree. Unfortunately Tries sees the need to assess flexibility in terms of "concrete calculation statements about the optimal flexibility of whole systems or individual subsystems." He attempted to do this with a linear program applied to a farmer's desire to manage changing prices optimally.

Friedman and Reklaitis (1975) and Van der Vet (1977) also attempt to measure flexibility of the variables in an objective function by virtue of their tolerance in an optimal solution to a linear program. Flexibility is measured by the distance or amount by which a variable can change its value from that in the optimal tableau and leave the solution unchanged. Such an approach is very useful for operational or tactical problems

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<sup>11</sup> Translated from the original German. The present author is solely responsible for any imperfection in the translation.



but has little bearing on the problem of the varying of the objectives themselves to meet new situations or changed circumstances.

The weightier contributions in this area come from Ackoff (1977) who suggests a variation of the matrix organizational structure to cope with environmental novelty and Tomlinson (1976:535) who asserts:

The effective survival of an organization, the ability to meet its prime objectives in a changing environment, is defined as organizational adaptivity. It includes what we would more commonly describe as flexibility.

Eppink and Derkinderen (1979) argue that it is better to be almost right than precisely wrong in one's vision of the future, which "Business Week" compared to piercing a future fog. Bonder (1979) suggests that the concept of versatility (synonymous with flexibility) is worthy of replacing optimality as a goal of many O.R. studies. Bonder (1979) expresses a concern to change the metaphysical and epistemological basis of management science away from clinical imprecision to a posture which perceives uncertainty in Knightian terms as a situation not where the probabilities of outcomes are unknown (risk) but where the very outcomes themselves are not known.

Putney (1968) attempted to bring in a finer degree of precision to accounting principles which were found wanting in the case of a multi-resource, multi-product system. Hart (1940) observed the inadequacy of available techniques for

evaluating the precise marginal cost of a product in such circumstances where there was non-linearity in mix. One hidden problem in deciding the appropriateness of flexible costing is that conditions of variable production mix and factor consumption fail to display little variation in aggregate costs. Second, costs based upon traditional analysis may indicate insignificant variation when, indeed, these variations may be significant for many management decisions, particularly short run planning and control decisions (1968:39). At a more strategic level, Park and Thuesen (1979) demonstrate the application of Baumol's minimum variance measure in cushioning a project budget from likely changes. In a similar vein, Fumas and Whinston (1979) examine the application of the concept of flexibility to contracting theory.

Dorward and Wiedemann suggest that robustness can be defined as "the degree of flexibility that a decision maker retains with regard to future decisions after the initial decision has been made" (1981:188). There, flexibility is viewed much as Hart viewed it, under conditions of certainty with capital rationing; for example, providing insurance against catastrophe and liquidity to, as they say, "put itself in the way of potential discoveries (1981:188). The measure of robustness they propose adds little to Rosenhead et al's. (1972) conception. A probabilistic framework, which thankfully does not require the probability of an unforeseen event to be

specified, is soldered on to the traditional robustness measure. The flux they omitted is the decision-maker's preference structure and attitude to risk. Reiterating the limitations of robustness as a measure of flexibility may reduce the temptation to measure the fraction of good options that are accessible following an initial action. These criticisms were cogently expressed by White (1972), responded to by Rosenhead et al. (1972) and restated by Mandelbaum (1978) as follows:

1. Unforeseen states cannot be measured in terms of uncertainty (see Bonder 1976 for a vehement vindication of this point)
2. If an initial action is not uniformly robust for all imagined states, how should one proceed to measure flexibility?
3. What level of performance is chosen as good? Good for whom? How does this remain the same through time?
4. Discount factors attached to robustness scores are an unsatisfactory method for dealing with preference migration.
5. Future states upon which the R score is computed may not be independent.

For the above reasons, the method set out by Dorward and Wiedemann (1981) is perhaps applicable to tactical decisions but certainly not to strategic problems, as they appear to

claim. A more fruitful approach to robustness was suggested by Hashimoto (1982) and is discussed in section 3.7.1.

### 3.7 Systems Management

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Table 3.9 Chronological list of significant contributors to the literature on flexibility: Systems Management.

<u>Researcher</u>	<u>Date</u>	<u>Theme</u>
Holling	1973	Resilience
Matlas and Fiering	1977	Resilience
Hashimoto	1980/82	Resilience, Robustness
Keeney	1981	Resilience

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#### 3.7.1 Salient Themes

Holling (1973) used the concept of resilience to describe an ecological system's ability to remain viable when subjected to a variety of shocks. Inspired in part by Koopmans (1964), Holling extended the mathematical foundations of resilience with Grumm (1976) at IIASA. Hashimoto, who also was at IIASA, investigated the application of resilience to plan-

ning water resource systems (1980). Fiering (1982) also attempted to quantify resilience in the context of water resource systems management.

Hashimoto argued (1982a) that "engineers and planners need to develop appropriate quantitative risk criteria that describe undesirable events that individuals may experience as a consequence of particular investment or operating policy decisions" (1980a:20). System performance was to be evaluated in terms of:

1. The incidence of system failure
2. The speed of recovery
3. The implications of failure

These three indicators of risk were formally defined as reliability, resiliency, and vulnerability. A companion paper sought to develop robustness as a foundation for project designs and operating policies which were flexible, in that adaptation to a wide range of "demand conditions" could be met without incurring significant transformation costs. He argues that "this definition of robustness corresponds to Stigler's concept of economic flexibility" (1982b:21). Fiering adopts a different approach, arguing:

We should require that our designs reflect awareness of potential surprise whether mechanical, statistical or institutional, and that they be able to respond to these surprises even if the capability to do so compromises some of the conventional benefits (1982:27).

Matlas and Fiering (1977) gave precise definitions of systems' resilience and robustness. Resilience was introduced to avoid the selection of a rigid and brittle solution intolerant of system perturbations. The transformability and generality of this work is questionable since the negative undertone is only one side of the risk equation. Nowhere do the authors discuss the creative capability of making things better than currently available. Despite this shortcoming, the concepts of resilience and robustness defined here are clearly linked to that of flexibility.

Keeney (1981) also addresses the issue of resilience. In the context of setting standards, he evaluates the ability of different types of standards to meet changes in technology or public values. He suggests trading-off the relative legal value of one attribute vis-a-vis another as situations evolve. "Such a standard is more resilient when applied to circumstances where the alternatives are routinely changing as is the case with alternatives dependent on advanced technology" (1981:27).

On the surface, flexibility appears to be a much talked about, but under-researched issue. On closer inspection, we have demonstrated that considerable attention has been focussed on the notion in general. The chapter has set out some of the more noteworthy contributions from a variety of disciplines. Little consensus has emerged because most attempts to examine

the concept of flexibility have been subsidiary to some other theme. On piecing together this diverse research, it became apparent that considerable ambiguity and confusion surrounded the notion. Consequently little would be gained from an attempt to put the concept into practice until there is a clearer impression of the conceptual foundations of flexibility in general and strategic flexibility in particular.

## CHAPTER 4

### CONCEPTUAL ANALYSIS

It was suggested in Chapter 2 that the notion of flexibility would be clarified by mapping the relations with related concepts. Philosophers such as Austin and Ryle in the Wittgensteinian tradition of linguistic analysis developed a technique of this sort, called conceptual analysis, which assists the examination of the logical features of a concept by highlighting the family resemblances between the various uses of the concept in question; this, as Waisman argued, "...is that which makes us denote them by one word" (1945).

Section 1 sets out the various concepts related to flexibility, some of which have been held to be synonymous or in some senses interchangeable with flexibility. The strength of these resemblances can vary, leading in some cases to ambiguities which ought to be avoided. Section 2 thus attempts to provide a semantic assessment of flexibility using research in hitherto unrelated disciplines. Four core meanings are presented, any one of which in certain circumstances may denote flexibility. Clearly, some hold a stronger accord with the problem under our consideration, yet the grounds, if they exist at all, for excluding any of the other senses of flexibility are far from obvious. Section 3 examines some of the



suppositions regarding flexibility which recur in various attempts to operationalize flexibility. This section aims to locate any paradoxes or contradictions embraced by the embedded hypotheses in order to clear the ground of such misunderstandings.

Flexibility in policy formation refers to developing or encouraging a capability which will allow things to be done differently in evolving circumstances. Chapters five and six investigate the incorporation of flexibility in the policy-making process; first, in relation to the acquisition of electronic data processing systems by First-Time Computer Users and, second, in large, highly technological organizations in order to discover empirically those practices which are adopted to provide flexibility. The purpose of this chapter is to investigate the architecture of flexibility.

#### 4.1 **RELATED CONCEPTS**

##### 4.1.1 Adaptability

Adaptability can be defined in terms of adjustment to the conditions of the changed environment. Rosen (1975) views adaptability as a polymorphous concept which has, at its core, the notion of a capability which embraces the end point and purpose of modification. Interestingly, for our point of view, he distinguishes between control in the sense of modification to changing circumstances and anticipatory control. This dis-

inction is crucial in drawing the boundaries between flexibility and adaptability.

In an organizational setting, the concept of adaptability implies a recognition of the environmental changes (internal or external) which motivate repositioning. It is in this area that the concepts of flexibility and adaptability become confused. As Eppink (1978) suggests, adaptability may be used to describe the ability to respond to foreseen changes, whereas flexibility is the ability to respond to unforeseen changes. In practice, however, the delineation may be fuzzy.

An earlier paper by Stigler (1939) pronounced, in unequivocal terms, that flexibility was not synonymous with adaptability. The former, he argues, provided only approximations for change, whereas the latter actually allowed for modifications to a plant to make it optimal for the desired output level. Again, the distinction does not mean that the terms are unrelated, for:

This line of reasoning indicates that flexibility and adaptability differ, but, on the other hand, there is a prima facie case for the proposition that the greater the adaptability, the less the need for flexibility.  
(1939:315)

Flexibility provides the capability to adapt where circumstances dictating modification to policy variables can, at best, be only partially anticipated. Furthermore, where the time required to generate a response is greater than that

required by the change to exert a full impact upon the system, policy must create the capacity for flexible response a priori. Where the range of future variations and perturbations is predictable and when unanticipated or counter-expected changes take a long time to unfold, then the notion of adaptability correctly describes those practices taken to mould a system to its environment. In the case of discontinuities or unforeseen changes (as is the case with many innovations) where, additionally, the speed of transformation is too rapid to allow the development of an appropriate response, then flexibility is the name of the property which facilitates successful repositioning.

To return to theoretical economics, Orr takes up the distinction originally developed by Stigler and suggests the following:

Adaptability is the attribute of a capital structure that permits a firm to operate within a larger (or smaller) quantity of variable inputs and thus obtain significant increases (reductions) in output: the smaller the unit cost changes incurred from this kind of output change, the more adaptable capital is.... Both adaptability and divisibility lead to flexibility. (1967:172)

Orr, in contrast to Stigler, sees adaptability as a component of flexibility. In other words, adaptability is necessary but not sufficient to provide flexibility. In a strategic issue where, as Clausewitz long ago recognized, everything must be guessed and presumed (1976), adaptability must be comple-

mented by the will to respond as well as the necessary means to respond. He saw a standing reserve, for example, as providing this capability, stressing that it must be used at the correct time to have value. Hart (1940) suggested that the possession of a number of homogeneous machines provided more flexibility than one large machine capable of the same output by virtue of the variability of use, or as Orr calls it, divisibility. Hart points out that this generalization may not be valid because the costs and value of flexibility are monotonically rising functions in only a few special situations.

#### 4.1.2 Elasticity

The OED defines elastic as "spontaneously resuming normal bulk or shape following contraction, dilation or distortion." Applying this to the realm of policy, we can suggest that elasticity overlaps with flexibility in the context of return to a normal state. Imagine a policy which mismatches a system to its environment because of temporary discontinuities, yet which functions well once these have been passed. In such circumstances we could describe the flexibility exhibited by the policy as elastic. However, the ability to exhibit such a quality is not simply contingent upon the possibility of changing posture but also on the strains and expenses incurred.

This situation occurred during the inter-War years when the strategic problem, according to Ansoff (1978b), shifted from

a production to a marketing orientation. A number of economists at the time investigated the ability of food production to respond to fluctuating prices. In an early study, Timoshenko (1930) proposed a measure of flexibility related to that of elasticity. Bell (1976) took up the issue and related the inflexibility of prices to the technology of the production process, particularly in relation to the size of plant.

The debate was extended by Means (1935) and later by Nicholls (1940), who concentrated on food prices. Backman argued that "the extent to which reductions in cost are reflected in lowering of prices would indicate its flexibility" (1940:579). Mason also clearly recognized that flexibility was a normative concept, related to elasticity in as much as its application "requires judgement of the probable consequences for relevant economic quantities to types of price behaviour different from the one actually under consideration" (1938:63). The economist Lange (1944) attempted to clarify the notion in an early Cowles Foundation Monograph which may have provided the stimulus for later work on the concept.<sup>12</sup>

Commenting on a more strategic setting, Liddell Hart often refers to elasticity of aim as necessary for overcoming uncer-

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<sup>12</sup>A.G. Hart, who had conducted his doctoral research under F. Knight, had a spell at the Cowles Foundation at the same time as T.C. Koopmans was a research fellow (later Director of Research). Dr. Lange was the Director of the Foundation at this time. See Hart (1937) and Koopmans (1964).

tainty in policy decisions. In describing Sherman's application of the strategy of the indirect approach, Liddell Hart postulated:

Sherman had sought to find a solution in variability or elasticity - the choice of a line leading to alternative objectives with the power to vary his course. (1959:383)

In an earlier work, Liddell Hart had also suggested:

Variability of objectives like elasticity of dispositions is necessary to fulfill an essential principle...flexibility. (1944)

#### 4.1.3 Liquidity

Economists have used the concept of liquidity in a variety of contexts. An asset is liquid if it can be easily converted into some alternative form of wealth with little or no penalty incurred during transformation. In its most general application, liquidity is applied to money which, under normal economic conditions, is one of the most readily convertible forms of holding assets. In times of inflation (as in recent years), one clearly pays a penalty for holding money in very liquid forms (Ross and Kami: 1973) and so it is prudent to spread one's assets over a bundle of commodities, some of which yield a return fixed at the time of purchase in consideration for retaining it over a fixed period. Other commodities, such as precious metals, may yield an uncertain return, depending upon prevailing market conditions at the time of disposal. In choosing a bundle of such assets, it will be important to

consider just how quickly these assets could be converted should the purchaser's requirements change. Thus during and after acquisition, if the desired future pattern of consumption is uncertain, the purchaser will seek to balance yield required for consumption or enjoyment against interest or changing future value, while at the same time paying attention to the cost of converting from one asset type to that amenable to current consumption. The role of liquidity in such a problem (where information is incomplete), is of paramount importance and is thus a critical parameter in portfolio selection (Marschak 1949).

Some economists treat liquidity as a property of a single choice, rather like the way flexibility is seen by some as a property of an initial decision in a sequential decision process. However, the approach proposed by Hicks suggests that:

Liquidity is not a property of a single choice; it is a matter of a sequence of choices ... it is not sufficient in liquidity theory, to make a single dichotomy between the known and the unknown. There is a further category of things which are unknown, but will become known with time. (1974:38/9)

Refining epistemological categories is important from the perspective of the current research. The concept of utility maximisation was questioned by Strotz (1955) in providing a criteria which accurately reflected behaviour. For example, a person may prefer to have a "deliberate regimenting" (ibid) of

future consumption even if this involves a cost; a person may change from being a spendthrift, having been converted to the virtues of thriftiness. Strotz, in criticising a strategy of precommitment, argues:

Today it will be rational for a man to jettison his "optimal" plan of yesterday, not because his tastes have changed in any unexpected way, nor because his knowledge of the future is different, but because he is a different person with a new discount function. (1955:1)

To be consistent with such eventualities, one ought, Strotz suggests, to select an action which will be best in the light of future disobediences. Thus the concept of myopic choice was born.

Later, Goldman (1974) related the concepts of liquidity and flexibility, which Jones and Ostroy (1976) in turn elaborated further. The former defined flexibility as the capacity of a portfolio to furnish a variety of consumption plans. In a later work, he confined the role of liquidity to that of "a penalty or transaction cost associated with realizing an asset prior to maturity" (1978:265). Two other roles of liquidity, the ease with which an asset could be disposed in the market place and the uncertainty of yields associated with an asset, were suppressed in order to build his model. Frazer (1980) extended this notion although he diverted from the central plank of the earlier work and interpreted the results of his model as follows:



- i) The individual will always choose initially to hold some of the highest yielding asset, despite the possibility that future circumstances might arise which face its premature redemption at the penal rate.
- ii) The individual will never adopt a "wait and see" attitude.
- iii) No bounded solution exists which suggests intermediate yielding assets being held in positive amounts. (1980:3/4)

Frazer's results appear to be at odds with reality since individuals do adopt a "wait and see" attitude, as Quinn (1980) clearly illustrates.

Liquidity as a concept refers to the ease of conversion. Mandelbaum (1978) takes Jones and Ostroy's position, (1976) which views flexibility as the ease of transition from one time period to a desired position in the next period. This idea is incorporated into the "counting of options" measure of flexibility developed in his thesis.

#### 4.1.4 Plasticity

"Pliant," "supple," and "capable of being moulded" are all parts of the meaning of plasticity. The term was used by Nagel to describe the manner in which a goal-directed system assumes changing postures according to variations in the environment. Drawing on an analogy to organic systems, he suggests that plasticity can be measured in the following fashion:

Suppose that the variations in the environmental state variables "F" assumed to be

compensated by further changes in the system S, so as to preserve S in some G-state, all fall into the class  $K_f'$ . If an appropriate measure for the magnitude of this class could be devised, the degree of plasticity of "S" with respect to the maintenance of some G-state in relation to "F" could then be defined as equal to the measure  $K_f'$ . (1961:417)

Nagel's argument is interesting from a methodological perspective; in the same paper, he suggests that there can be two sources of information about the range of environmental information to which a system can initiate adaptive responses:

- i) by way of inductive extrapolations from empirical observations of systems with some family resemblance
- ii) as the deductive outcome of an examination of tested and verified relationships inherent in the system under consideration.

This pattern was observed in the "First-Time Computer User" study during the feasibility phase (see Chapter 5) when information about the suitability of applications was gauged by both an internal examination of the company and an assessment of similar applications in comparable companies. From this point of view, the concept of plasticity resembles that of flexibility in that they both denote some form of malleability. However, there are clearly situations where the possession of plasticity on its own does not give rise to flexibility. Plasticity refers only to the ability to maintain a state, whereas flexibility, in addition, embraces the ability to influence successfully a transition to other states.

#### 4.1.5 Resilience

Working from the basic notion suggested by Holling (1973, 1978), Grumm (1976, 1981) defines resilience as the ability of a system to absorb sudden and external changes. In a more general sense, the OED defines the term as: "having or showing elasticity or buoyancy or recuperative power." In the first instance, the concept of resilience was applied to an ecological system undergoing changes such as those imposed by the construction of a hydro-electric dam. When the flow of the river is diverted or stopped, the basin of the reservoir radically alters the environment. Resilience in this setting could refer to the ability of natural species to recover to their existing population levels.

Separating the system of interest from the environment in which it functions, one can distinguish between shocks and discontinuities affecting the system in terms of the speed of impact; i.e. some changes will be sudden or rapid while others may be facilitated by slow or "adiabatic" changes.<sup>13</sup> In this respect flexibility and resilience are being used synonymously.

The notions of flexibility and resilience are similar in that both refer to the ability to respond to changes; yet they differ in that the former refers to the capability to effect a modification whereas the latter concerns the ability to absorb or accommodate changes.

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<sup>13</sup>) Literally occurring without heat; see Grumm 1976, p. 2.

#### 4.1.6 Robustness

A concept bearing a close family resemblance to flexibility is the notion of "robustness." The OED defines robust as "not slender or delicate or weakly" or, in a different connotation, "vigorous", whereas Roget's Thesaurus lists it with terms for "degree of power". However, its relationship to flexibility does not stem from the literal but from a modified or technical sense in which robustness refers to the ability to gain the highest proportion of good or lowest proportion of undesirable strategies within an "action space."

A cursory examination of the literature revealed that Stone (1963) suggested its first use (in a sense not too far removed from that given above); however the most developed application of the concept has been that of Rosenhead (1968, 1972). A number of later articles (1978, 1980) up-date Rosenhead's early attempts to formulate the notion and also discuss its relationship with flexibility.

Two definitions of robustness are offered with varying viewpoints:

- i) the quality of robustness which is operationalized as the fraction of all known desirable system states which would be facilitated by a particular decision (Rosenhead 1980: 214);
- ii) the analytical technique which "emphasises the need, under conditions of uncertainty, to take early decisions in a sequence in such a way as to preserve many future options which currently seem attractive". (Rosenhead 1978: 110)

Rosenhead's approach was prescriptive, implying that the decision strategy with a high (though not necessarily the largest) robustness score ought to be adopted as rational. In this respect it approaches utility theory and could indeed be adopted within a Bayesian framework.<sup>14</sup>

Rosenhead applied the quantification of robustness to sequential investment decisions of factory location with some success. A further application was concerned with planning health care facilities. In a refinement of the methodology the link between robustness and flexibility was elaborated, and illustrated by an application to a decision involving curriculum selection with a view to maintaining flexibility in career paths.

Rosenhead introduced a hierarchical segregation within the focus of robustness analysis. Whereas the ranking decisions in the factory location exercise were tactical in nature, the thrust of robustness analysis is, we are later informed, strategic in its flexibility which is defined as:

The ability to take a variety of subsequent decisions which define different resource configurations for the system as a whole.  
Rosenhead (1980:332)

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<sup>14</sup>Building upon Stone's early work, Schenkerman (1978) attempted to do this but did not aim to transform the robustness approach as developed by Rosenhead et al; rather his work sought to expound a "worst case" robustness - equivalent to the minimum expected pay off in the space. However, this approach was negative in outlook. Pye's attempt (1978) to place robustness in the "decision analytic" paradigm is discussed later.

In contrast, tactical flexibility, it is argued, resides in the capability of a combination of resources to operate in a number of modes. The critical issue encountered in practice, is the determination of system boundaries in order to differentiate strategic from tactical concerns.

Since this research is concerned with flexibility in policy formation, the problem of separating issues of strategic significance from those of a tactical nature was not as critical. Rosenhead has not considered that flexibility may arise in the interaction of strategic and tactical considerations although in a different setting Beaufre argues:

There must be continuous osmosis between policy and strategy; policy directs and lays down the framework within which strategy must search for its solutions; strategy assists policy in drawing up its diagnosis by use of its meticulous method and by its knowledge of strategic practicalities. (1967:31)

Although robustness may provide a measure of strategic flexibility, it does not suggest the measure of uncertainty which surrounds the consequences of such decisions.

Pye extended the initial measure of robustness and attempted to fuse it with flexibility. Robustness here was defined as "the useful flexibility maintained by a decision" (1978: 215) yet later, in the same paper, it was described as combining flexibility and value. Pye suggested three methods for trading off flexibility and value and thus evaluating the

most robust move as that which retains maximum flexibility, subject to the conditions that:

- i) the decision-maker believes on the basis of his current estimates of value that there is zero probability of his choosing a sequence of moves which is unsatisfactory at any stage;
- ii) the decision-maker's estimate of the probability that he will choose a future sequence of moves is dependent in an appropriate manner on his estimate of value;
- iii) the probability of choosing a sequence of moves is dependent on its value, provided that value is greater than a prescribed satisfaction level; (sic Schenkerman) otherwise the probability that it will be chosen will be zero. (1978:220-223)

Pye is suggesting that flexibility is to be measured by the number of future options kept open (1978: 218); this is a probabilistic technique which assumes that the decision-maker will choose to act. To arrive at his measures of robustness, Pye suggests that his criteria of flexibility ought to be combined with one of value. This creates a mild confusion, because a technique which measures the likelihood of the decision-maker choosing a particular path along a multi-branched decision tree but which lacks a notion of outcome evaluation can barely be charitably extended to enable the construction of a more realistic model.

It seems that Pye has confused the measure with that which it measures. If, as Rosenhead suggests (rightly, in our opinion), the most robust of decisions within a rigid plan does not

preserve flexibility for meeting future uncertainties, how then can robustness be concerned with both flexibility and the notion of "value"? Furthermore, it seems inconceivable that such an exposition of flexibility, based explicitly on a measure of the uncertainty of the decision-maker's future moves, could possibly be commensurate with Koopmans' preference mutation rationale for preserving flexibility, as is claimed.<sup>15</sup> How is it possible to satisfy Koopmans' postulate and at the same time propose an explicit definition of uncertainty--which by definition cannot be known?

As Rosenhead, reinterpreting Hart, states:

We know we do not even know what it is we will want in ten years' time. (1978:103)

How, then, can we use Pye's methodology to attach figures which merely extrapolate our present preference structures for evaluating uncertain outcomes? The spirit of robustness seems to suggest that a strategic alternative, if robust, will remain viable even if a "kaleidoscopic" shift occurs either in value structures (thereby altering preferences) or in future technological resources. Flexibility is the inherent capability to modify a policy to accommodate and adapt successfully to such changes, whereas robustness refers only to the ability to endure such changes.

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<sup>15</sup>The concept of myopic choice as developed by Strotz (1955), adds further support to this supposition.



#### 4.1.7 Versatility

Of all the notions examined in this chapter, "versatility" bears the closest resemblance to flexibility. The OED defines "versatile" as "turning readily from one subject or occupation to another" as well as "capable of dealing with many subjects", while Roget's Thesaurus lists "versatile" alongside "changeable" and "skillful." Bonder has developed this notion within the context of strategic decision making, where the concepts of flexibility and versatility are synonymous. Bonder eloquently, though not formally, defined versatility planning as:

The provision of analytic support to decision-makers in choosing among alternative systems which explicitly consider the variations of the effectiveness of alternatives with potential future events and examines the trade-offs among the costs, effectiveness and flexibility or versatility of an alternative to respond to these future events. (1976:25)

This conception of flexibility acknowledges that a significant portion of these "potential future events" are predictable by such means as probabilistic scenario techniques and can thus be used to affect a strategy-scenario mix evaluation. However, such an exercise will fail to generate some features of the future. We know that we cannot know these features; furthermore, even if we recognize the weak signals heralding the future they are unlikely to possess the substance we need to effect a comparison of strategy alternatives.

This leads us to reject one of Bonder's hypotheses which, however, is not a central plank of his argument about the nature of versatility. Two preferable hypotheses are:

- a) Versatility is sought as a hedge against state changes
- b) Versatility is optimal for an infinite sequence of decisions. (1976)

There are circumstances where (a) can be a limiting case of (b), as Taylor (1959) suggests in his exposition of the notion of a flexible response. The main thrust of versatility or flexibility is simply stated in the second hypothesis.

Strategic issues which embrace technology portfolios with life cycles typically spanning two or three decades operate in a dynamic environment. Whereas other researchers consider that flexibility or versatility retain options in a sequential decision process, Bonder argues that this view is misplaced because:

...decisions are made continually throughout the life of the system as the environment in which it operates changes over time, and the "final" decision is made only when the system is abolished. (1980 Personal Communication)

Thus the successful adoption of both flexibility and versatility hinges on the following notions:

- i) the uncertainty surrounding the future environment
- ii) the potential adaptability of the system to reposition in the light of future contingencies.

Therefore, while it agrees with hypothesis (b), which seeks to abolish the tension between flexibility and optimality, hypothesis (a) must be seriously reconsidered. However, the notions of flexibility and versatility are synonymous. Clearly the problem toward which versatility analysis was addressed is also similar to that in this dissertation, albeit in a different policy environment.

#### 4.2 A SEMANTIC ASSESSMENT OF FLEXIBILITY

##### 4.2.1 The ability to bend

Implicit in the notion of flexibility is the idea that functioning will continue in unenvisaged circumstances. We can imagine, further, a number of ways in which the quality of flexibility is displayed: A ruler, for example is flexible when it can be twisted or doubled over without snapping; Piping is often referred to as flexible when it can be bent or otherwise manipulated to fit physical contours.

A number of papers examined the notion of flexibility in space-craft, where flexibility referred to the degrees of freedom in, for example, remote controlled manipulators which pick up material or repair the craft. Here flexibility was not so much ability to bend as sensitivity of touch, ability to manoeuvre large, heavy objects, and capacity to move the grip in through greatest possible angle. This use of the concept obviously implies more than simply the ability to bend; in a

sense it refers to the system's tolerance in dealing with a range of situations. In policy formation, this type of flexibility can be conceived as a form of "pliability" to meet extenuating circumstances. For agricultural systems, as indicated by French et al. (1956), flexibility would expedite adjustment to seasonal variations.

A similar strategic posture has been introduced into electricity generation in the U.K., where demand undergoes seasonal variation and is also subject to longer term trends. Flexibility of the type under consideration is, it is argued, impregnated by:

The designation of a class of plant that is decommissioned and maintained. This option has similar economic advantages to complete decommissioning. Should demand increase, this plant can be reactivated given due notice. (Electricity Council, May 1980, s. 180, p. 35.)

This serves to stretch the boundaries over which existing capacity can be utilized, while incurring the lowest possible penalty cost of retaining surplus capacity. Flexibility in the sense of being physically malleable can thus be directed to the limits of applicability.

#### 4.2.2 Yielding to pressure

A second way in which flexibility can be considered is similar to but not synonymous with the first; flexibility is defined as "yielding to pressure". Most commonly, this inter-

pretation was used in connection with exchange rates and wage negotiations. The former case occurs as a result of international pressures to hold or sell the currency of one nation in preference to others. The exchange rate system permits the Sterling to establish an equilibrium value in accordance with prevailing international pressures. Thus, in the face of political uncertainty due to U.S., French, and German elections, as well as the petro-currency status of Sterling, the relative political stability in Britain, and falling rate of inflation in the U.K., Sterling was very strong in November 1980. When the international uncertainty resolved after elections, and a glut of oil existed on the world market, then Sterling began to adjust in value relative to other currencies (the U.S. dollar in particular). Flexible exchange rates are those whose value varies according to buying or selling pressures.

In the other case, flexibility stems from yielding to pressure exerted on entrenched positions. Another example which springs to mind when speaking of flexibility is an electricity supply system, which provides peak generating capacity by utilizing off-peak cheap supplies of base load capacity. Two systems facilitate inducing flexibility: pumped hydro generating units and night storage space heaters. Two of the hydro units are currently under construction in the U.K. at Dinorwic in Wales and Craigroyston in Scotland. The system is elegant in its simplicity: water is pumped up through channels

connecting two reservoirs when spare base load capacity is available; conversely, where peak demand exceeds on-line capacity, water is forced through turbines by gravity as it passes from the upper to lower reservoir. Off-peak night storage units simply hold heat in bricks, warmed up during the period when demand is lowest. Flexibility in this sense refers to some response triggered by a shift in environmental conditions.

#### 4.2.3 Susceptibility of modification

A third sense of flexibility refers to "the ability to effect alterations." The three examples which follow illustrate this sense of flexibility which, as will be seen in the first example, bears a close resemblance to liquidity.

An investment portfolio (i.e. bonds, stocks and shares, cash, jewellery, etc.) is flexible if, in the event of consumption or, in accordance with variations of market conditions which affect the value of some or all the components of the portfolio, the mix of investments can be altered without incurring a penalty cost. (See discussion of liquidity, Section 4.1.3 and Goldman 1978). In drawing a parallel with this situation, many have argued that the costs of flexibility are to be evaluated within the context of insurable risks, as is the case with bonds redeemed or sold before a specified date; but the parallel is only applicable to a small part of the picture, as indeed it is to only that part of the portfolio

where changes in value can be known (probabilistically in some cases). Other components in a portfolio may include items whose precise value is set higher by the holder than by contemporaries, as was the case when Shell acquired Bellridge Inc., a decision based on a forecast of oil price which was well above that specified by leading experts. The forecast was based on a role-playing exercise (Personal interview 10.9.80).

In an investment, business or technological portfolio, flexibility is achieved not through individual properties of the various components but in the overall configuration of the portfolio (i.e. the balance between high-risk/high-yield/low-transferability on the one hand, and low-risk/low-yield/high-transferability on the other). In multiple-business-unit organizations, the board of directors is not so much concerned with the individual business units as with the balance of the overall portfolio in the light of threats and opportunities facing the organization, and the strengths and weaknesses of the firm.

The second example, currently one of the problems in the computer industry, has a technological flavour: a software package is called flexible if it can be easily tailored to meet the specific requirements of the application in question. Flexibility may be exhibited in this context in a number of ways. At its basic level, it refers to the package's level of generality, i.e. the variety of ways its format possesses for

performing the particular function and the ease with which the package may be modified to meet individual user requirements. A data base management system, for example, is a software package designed to facilitate the storage of information about various aspects of the user's operation. In the case of a software package, Grinyer & Wooller identified the following types of flexibility:

- Structure - where individual modules of the suite could be rearranged according to the requirement of the situation
- Logic - where changes in the order of operations could be made without reprogramming
- Input
  - i) information in various units of measurement may be inserted at different parts of the user environment
  - ii) format of the input does not need to conform to a prespecified style
  - iii) data may be continuously input
- Output
  - i) user can specify format and content for reports
  - ii) user can specify priority order of report printing and production. (Grinyer & Wooller 1978)



The value of being easily adapted, in terms of:

- i) installation and modification to user's requirements
- ii) appropriateness within the other suites of programmes utilized
- iii) capacity to modify as requirements change

all impinge on the flexibility of a package and hence an information system. Mitchell (1970) labelled an interactive computer system as flexible if it allows users with varying levels of skill in operating computer systems to meet their individual requirements. (In Chapter 5, these phenomena are examined within the first-time user context.)

The third illustration concerns the ability to vary the outputs from an ethylene catalytic-cracker by changing prices and demand. The various fractions converted can be altered by using a more expensive catalyst. This catalyst permits more variations in the output, yet avoids expensive conversion costs and downtime (Draaisma & Mol 1977). Recently a large chemical company investing in a new ethylene cracker reversed the process by acquiring a system which allowed the use of both oil and natural gas as feedstocks, thus taking advantage of any relative price differential that may arise. (The cost of this extra capability amounted to between 12-14% of the total project cost.)<sup>16</sup>

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<sup>16</sup>The substitution of LNG (Liquified Natural Gas) for ethylene is discussed by Guerico (1981).

The sense in which flexibility is employed in the three preceeding examples refers to the "corrigibility" of the various technologies and the range of situations to which the general technology could adequately be applied.

#### 4.2.4 Capacity for ready adaptation to new situations

The fourth sense of flexibility to be examined is "capacity for ready adaptation to new situations". As argued already, a policy may position a system badly in relation to its environment because new situations emerge, i.e. unexpected changes in the environment. Two examples will demonstrate this concept of flexibility.

The first example illustrates the way in which a complex technological system is planned so as to accommodate variations in demand. Montenegro (1977) defined flexibility as:

...extra capacity that is built into the systems to take care of low probability growths which are not accommodated for in the original estimates of the system's requirements. (1977:60 and 61)

His study seems to indicate that in planning telecommunications systems, designers leave some margin to take care of unexpected growth. The designer makes an estimate of the system's requirements and then increases it by an amount he decides upon intuitively. In other cases, in accordance with accepted practice in engineering some extra capacity is added to the equipment, on the basis of the original estimate. Such practices

are common except in situations where the last 1% capacity increase over a threshold point is very expensive because the capacity does not increase in a linear fashion.<sup>17</sup>

A more complicated issue of flexibility arises out of changing technological possibilities caused by communication/computer innovations and convergences which are likely to precipitate a kaleidoscopic shift in the potential of systems which use this technology. Frazer identifies four attributes emanating from novel features of technological convergences which will bring about flexibility:

- i) Portability resulting from the small size of terminals made possible by Large and Very Large Scale Integration fabrication technologies.
- ii) Customizing of functions that were previously immutable. This replaces hardware functions with programmed functions tailored to meet specific user requirements in call interception and forwarding as well as in conference calls.
- iii) Mobility arising from compact size and easy maintenance.

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<sup>17</sup>The ability to use a Lagrangian multiplier for scaling up an estimate is circumscribed by the size of the increment at the specified output level.

- iv) Compatibility ensuing from the ability to inter-connect such systems.<sup>18</sup> (Frazer 1979)

These features show that there are many types of flexibility, determined by the needs and ends which a particular technology serves and, in turn, prescribed by policy. In the above list, changing needs might include expansion, transition to a new environment, or installation of novel features.

#### 4.3 SUPPOSITIONS REGARDING FLEXIBILITY

Chapter 3 elaborated on various suppositions suggested by previous researchers about the concept of flexibility. A review of these suppositions will highlight paradoxes and contradictions in these hypotheses.

##### 4.3.1 Flexibility is synonymous with adaptability

Stigler (1939) first suggested the similarities between these notions in what Hart described as a static model of production planning. He drew a distinction on the basis of the relationship between technology, variable services and fixed plant.<sup>19</sup> A plant, he suggested, exhibits complete adaptability if it facilitates the use of the "best" technology in using the

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<sup>18</sup>For a discussion of these attributes see Chapter 5; A paper by Branscomb (1979) sets out the limits of physical and social constraints associated with this technology.

<sup>19</sup>Hart discusses Stigler's 1939 paper in footnote 16, page 26 (1940)

desired combination of variable services with fixed plant. Flexibility, on the other hand, permits one to approximate using the best technology. Generally speaking, it will not be practical to build in or even attain complete adaptability (though we are informed that agricultural land is close to being perfectly adaptable). Thus flexibility is to be sought when output is expected to vary beyond a range of production frontiers.

Eppink (1978) distinguishes between the two in terms of the ability to foresee the fluctuations which necessitate repositioning. This line of argument is sound in some specific contexts, but, as Eppink has suggested, even in cases where a situation requiring attention is seen as likely to arise, flexibility could still be required to deal with it successfully. While adaptability may sometimes provide this cushion, there is good reason to suppose that the unexpectedness of a situation demanding a response does not serve to distinguish a flexible from an adaptable posture. Rather, as Stigler points out in his example, flexibility allows an approximation to the best technology, i.e. constantly evolving short-term stop gap solutions, whereas adaptability implies a permanence brought about by careful assessment and subsequent repositioning.

Since the time of Stigler's 1939 paper, however, the nature of the strategic problem has been transformed, as Ansoff sagaciously demonstrated (1979). The tranquil environment of

the post-War era has been replaced by a volatile and rapidly changing one. This is most evident in high technology sectors where the lead times between innovation, diffusion, and market saturation have been drastically reduced. The turbulence is compounded by economic, demographic and socio-political issues which collectively dictate that the concept of adaptation to a new but permanent state of affairs is redundant. Because of unremitting changes, only flexibility will enable organizations to match purpose and potential in a partially unpredictable future environment.

#### 4.3.2 Flexibility is synonymous with hedging

The balance of opinion is finely poised on this hypothesis. Some researchers have likened flexibility to the hedging maxim: "don't put all your eggs in one basket" (Ansoff 1965), whereas others have argued that flexibility increases one's chances of making a better decision by allowing one to tune into future conditions when and as they materialize (Merkhofer and Saade 1978). The OED sets forth two senses of hedge; the first, when used as a noun, refers to the compensating transactions one engages in to secure oneself against loss on a speculative venture; the second, intransitive sense refers to avoiding total commitment. These two senses have very different implications.

Those who hold that flexibility is equivalent to hedging argue from various standpoints. The most explicit support for this view comes from Mandelbaum (1978), as set out in Chapter 3. To recapitulate, Cunningham and Mandelbaum envision flexibility as a vehicle to hedge against modelling unease:

In more common situations ... the decision maker is so uncertain about future events, states and available actions that no formal model can be constructed. (1979:25)

In their subsequent quantification of flexibility, they argue that flexibility is the "paramount if not the only concern" in such situations. The prescribed form of behaviour in such circumstances is to adopt a posture which maximizes flexibility, using a measure appropriate to the situation. Clearly, they were somewhat uneasy about their model of flexibility and so to avoid this uncertainty, they proposed the alternative view. Can it be allowed both ways?

Other researchers point out that the extra costs incurred in inducing flexibility ought to be regarded as an insurance premium (Eppink 1978, Rosenhead 1980). In the main, however, this explanation refers to limiting cases, where the possibility of events occurring (and thus necessitating a shift of posture) can be accurately gauged. (This is how an insurance premium is calculated; See Hart 1937). The flexibility approach as Ansoff prescribes:

...is to be used whenever the environmental challenge cannot be predicted with sufficient accuracy and far enough ahead of time

to allow the firm to make a timely response  
by using its historical response mechanisms.  
(1980: 9)

The probability of a loss and the magnitude of the loss determine the premium one must pay to insure against it. If we are to accept Ansoff's view regarding the circumstances in which a flexible posture is intuitively appropriate, then it would seem that the basis for deriving the premium, and thus the hedging strategies, is simply not there. If it were, then there would be no need for flexibility in the first place. Merkhofer resolved this paradox with cogency and precision:

The difference (between flexible and hedging strategies) is that hedges and compromises are options that make the worst outcome a little better at the expense of making the best outcome a little worse. A flexible strategy justifies the cost of keeping options open by the expectation that additional information will permit the decision to be made more effectively later.  
(Merkhofer and Saade 1978:2)

The difference is crucial: hedges involve a negative approach, while the flexible response copes with various unavoidable uncertainties about the future. The weight of opinion seems to reject the OED's first sense of hedging as paradoxical or at least contrary to the spirit of flexibility. If we are to use the notion of "hedging" at all it should be in the second sense, as adopted by Merkhofer and Saade (1978).



#### 4.3.3 Flexibility is lost when irrevocable commitment is made to a specific option

It has been argued that flexibility is lost when one decides to embrace an alternative which requires an irreversible allocation of resources (Henry 1974, Merkhofer 1975). Intuitively, this line is appealing since irreversibility seems diametrically opposed to flexibility, as depicted by Henry's example in an ecological setting. However, one must seriously question whether allocating resources to a discrete alternative eliminates flexibility.

A flexible (in the intra-option sense) strategy is still possible when irreversible commitments are made. Indeed, in situations which dictate such a commitment, lasting perhaps 30 years or more, the quest for flexibility will take high priority. The case of military planning demonstrates this point.

#### 4.3.4 Flexibility facilitates a successful reaction to surprises.

The ability to endure changes was suggested as a characteristic of flexibility by Klein and Meckling (1958); Eppink (1978) also invoked the concept of a "surprise" in his definition of flexibility. Surprises are by definition not predictable and so Ansoff's rationale *op cit.* embraces surprises as a limiting case. It seems imprudent, however, to place too great an emphasis on surprises as the sole motivation in the quest

for flexibility. Military strategists have suggested that in implementing plans, only "partial" success or failure is normally encountered, rather than either extreme. Thus, to base plans on "either/or" contingencies may be an over simplification, leading to faulty diagnosis of a situation and hence poor prognosis. In wartime conditions, this problem is acute because uncertainties become concentrated. As Clausewitz remarked, in war things do not turn out as we expect:

A general in time of war is constantly bombarded with reports both true and false; by errors arising from fear or negligence or hastiness; by disobedience born of right or wrong interpretations, of ill will, of a proper or mistaken sense of duty, of laziness or of exhaustion; and by accidents nobody could have foreseen. (1976:193)

Note that Clausewitz leaves the surprises to the end of the list; the other factors all demand consideration in deriving the need for flexibility. This is nowhere better illustrated than in modern organizations embracing new technology. Mumford and Pettigrew (1975) referred to the Luddite syndrome, in which functions were altered or labour displaced by capital. This is hardly a surprising situation; it is a constant theme accompanying major labour-saving innovations throughout history.

To locate a definition of flexibility at only situational extremes is not only wrong but misdirected. In technology, for example, it is rarely difficult to predict innovations, because the size and complexity of modern inventions (see Rescher 1977)

usually dictate a large research effort and imminent success is easily noticed. Thus, while predicting its occurrence is rarely problematic, difficulties arise in determining the scope, significance and likely timing of impact. Some inventions, such as the float glass process developed by Pilkingtons, the anti-asthma drug "Intal" developed by Fisons, and Polaroid's self-developing picture are cases which illustrate "surprise" and represent a major driving force behind the acquisition of flexibility; these events do not occur in a vacuum and to be in a position to change direction requires co-ordinating many (apparently) unrelated capabilities. With this said, it is perfectly legitimate to suggest that flexibility not only provides a cushion against the impact of detrimental change but also facilitates capitalizing on advantageous surprises. Suggesting that the sole reasons for acquiring flexibility revolves around surprises is simply invalid. (Liddell Hart noted: "men easily miss what is right under their eye, ...concealment can often be found in the obvious and that in some cases the most direct approach can become the least this "expected". [1954:224])

#### 4.3.5 Flexibility assists tolerable efficiency in production over a required range of outputs.

Engineering literature most frequently defines flexibility as it arises in association with this hypothesis. Its origins

may be traced to Stigler (1939) and it receives its most rigorous examination in Tilak's study (1978). He was not as concerned with the conceptual underpinnings of flexibility as with the ability to use machines in various combinations, tested for effectiveness and efficiency in a job shop. The hypothesis was tested independently of changing demand (an exogenous variable in the model), raw materials, or underlying technology of the production process.

The thrust of Tilak's study was to investigate various scheduling heuristics and, by way of implication (the scheduling is determined by demand for throughput), to show strengths and weaknesses of the current hypothesis. Two aims of his research were:

- i) to test various rules which attempt to capitalize upon flexibility and thus enhance performance by increasing use of facilities reducing delays in job-completion and lowering inventory levels
- ii) estimate cost-saving resulting from various levels of flexibility.

Two types of flexibility were defined; the first being technological, i.e. the capability to alter the sequence for processing a job, and second, resources, i.e. the capability of workers to function in more than one type of work centre.<sup>20</sup>

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<sup>20</sup>Turvey takes up this point and suggests that a change in technology will have the effect of increasing existing marginal costs relative to the new possibilities. (1969:282)

Tilak developed a simulation model to test his hypotheses. His conclusions confirm that efficiency is in fact augmented by both technological and resource flexibility, although the benefits were not uniformly distributed. Both types of flexibility tended to enhance performance at high levels of output, but benefits were negligible (and did not justify cost) unless output fluctuated significantly to levels in excess of 75% capacity.

While these results applied to job-shop scheduling, their significance also holds for the hypothesis currently under consideration. The implication, which ostensibly confirms Stigler's conjecture, is that where the variation in load fluctuation is considerable and clustered around higher levels of output, the benefits of a high degree of interchangeability would be considerable (as in the sweat-shop illustration used by Stigler). We must take care in applying these results to differing technologies, such as those which (for technical reasons) cannot be smaller than a certain size, e.g. nuclear reactors. Nonetheless, Tilak's findings still agreed well with those observed in the "First-Time User" study with respect to size, divisibility, workforce versatility and ability to vary workload through rescheduling.<sup>21</sup>

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<sup>21</sup>The early work of French et al. also suggests that flexibility in scale of operation was an important consideration in the efficiency of plant operations, (1956, p. 577 quoted in Kerchner 1966, p. 3)

That this supposition recurs in many of the classical works suggests that, in a technological context, it is fundamental to providing strategic flexibility. This view was reinforced during the corporate study when a senior executive stated that a prime consideration in planning a new plant was the ability to vary production between a factor of two to five because it was impossible to forecast the potential market for a new product.

4.3.6 Flexibility permits the best technology for sub-optimum output levels to be approximated at the cost of not using the best technology for the optimum output level

This hypothesis is also derived from Stigler's work (1939) and presents difficulties for analytical purposes, both by way of its intuitive appeal and its implicit tautological evaluation of the "best technology" as being that which allows production at an optimum level. At best, and this is how Hart (1940:26) interpreted it, Stigler's concept provides for fluctuations under conditions of certainty. One objection levelled at Stigler is that, allowing for market certainty, a range of output can be sold depending upon price; what happens if some new invention or modification can be created, rendering the previous best technology obsolete?

Ansoff (1979), in analyzing the transformation of the strategic problems facing environment-serving organizations,

suggests that the era when Stigler was undertaking his study was characterized by high volume/low cost facilities in which production technology was the strategic issue - epitomised by Henry Ford's famous dictum "Give 'em any car so long as it is black". The strategic problem is rarely static, and as Barnard (1938) cautions all, the strategic issue is that which causes a new system to arise once current policies are realized. In Ansoff's analysis, the strategic problem transformed to a market orientation in the 1950s and has shifted at least once more since then. In Stigler's time, the name of the game was getting as many widgets out of the gates as cheaply as possible; hence his equating the best technology with an optimum production level. Hart (1940), however, was not convinced and argued that:

This policy of flexibility will of course yield worse results than immediate decision based upon following a "hunch" as to the final market situation if the hunch happens to be correct. But if it is not correct - flexibility will yield much better results.

The point being made is that when production is either above or below the scale to which the plant can be adapted, then less specialized machinery (which could produce over a broader range without incurring the high gross outlays) would be less adapted to the specific range of production possibilities but more flexible over a broad range and probably less expensive. (For example, a racing car can go faster on a smooth surface when correctly tuned, but if the grade octane

rating of the petrol drops or if the car has to negotiate badly-maintained country roads, a less exotic and thus cheaper vehicle would probably reach the destination before the racing car.)

4.3.7 Flexibility instills the capability to incorporate or respond usefully to relevant information which will not be available until some further date

Hart (1937) conceived this supposition, wherein he argues that flexibility is preserved when decisions can be postponed until more information helps resolve uncertainty. This proposition assumes implicitly that a decision can be delayed; Hart qualified this by suggesting that a business plan can alleviate the pressures of a premature commitment to a precise production schedule. Such a plan tends to incur extra costs, such as storage, when there is uncertainty about the quantity of output demanded at a price. However, should (the source of) uncertainty emanate from buying in of raw materials (either in terms of cost or availability) then inventories can be maintained at a high level. Both of these postures involve bearing extra costs in the hope that the revenue accruing from the relatively less uncommitted production schedule will compensate for this burden. By the same token, processes which facilitate product switching or allow materials to be shifted from one product to another will furnish flexibility in choice and volume of production.



This theme is resurrected by Marschak and Nelson (1962), who view flexibility as a property which encourages attuning a course of action to what is learned during the course of implementation and operation in a probabilistic context, i.e. the probability distribution is conditionally refined in the light of sample observations (combined using a Bayesian rule). As Mandelbaum (1978) suggests, the flaw in their line of reasoning stems from dislocating the evaluation of flexibility from the maximum expected pay-off. However, by suggesting that the outcome of the flexible option is not equivalent to what would be the best result if everything were certain, we are left wondering whether a flexible posture could give rise to a pay-off in excess of the maximum expected value (as is hinted when the notion of learning is introduced).

Taking a slightly tangential, but nonetheless important tack, Koopmans (1964), in sympathy with Hart's original intention, pursues a line of thought leading to the rhetorical question:

Wouldn't he (the decision-maker) wish to retain flexibility so that he could respond in the future to newly perceived currents of taste and desire? (1964:246)

Within Hart's conception of anticipation "was the expectation that anticipations will change" (1940:84), thus probabilistic phenomena as well as evaluative criteria will change. These issues were captured by Merkhofer, (1975) who related the value of flexibility not simply to the resolution of uncer-

tainty, as Mandelbaum mistakenly intimates, but also to the value of the course of action.

Keeney (1981) adopted this framework in a technological setting by using decision analysis to evaluate the future availability of freedom of action. He evaluates the impact of a modification on an existing technology on both the technological tradeoff curves between the various attributes of the decision space, and the utility curves of the various interest groups affected by or influencing the policy decision. This greatly clarifies the issues involved and suggests a structure within which decision-making is assisted.

The stumbling block of the information acquisition posture adopted in this hypothesis lies in the assumption that the learning which occurs is relevant to the alternative under consideration. Stated simply, the uncertainties of today may not concern us in the future. A rather amusing story from "Punch" around the turn of the century, illustrates this with force and vivacity. Punch produced a report suggesting that the centre of London would, in a decade or so, become devoid of pedestrians due to the alarming side-effects of the growth of horse-drawn cabs and their like. Such was the concern of the time that, even in this bastion of British self-effacement, the matter was not treated in a light-hearted fashion: fifteen years was the upper limit set on the ability of London's sewerage system to cope with the "emission" problem of the time.

The motor-car emerged to a sigh of relief to alleviate the cause of anxiety.

This anecdote warns against expecting the future to resemble the past. Information has to be relevant. As Ansoff (1978) remarks, a capability for response must be installed early because when changes do occur, there is rarely time to reposition. This precludes visualizing the precise form of such changes before making a response. The reaction cycle response time is greater than the impact cycle time of events, or put another way, the changes in the various environments which affect organizations (internal, transactional and external) happen so quickly that there is not enough time to modify policy and to reposition the direction. Thus, while in a theoretical sense the expected value of information ought to be calculated for both perfect and imperfect information (see Miller 1974, Tani 1975) the nature of situations can shift drastically thus pulling the grounds for rationality from under the feet of policy analysis. In conclusion, although learning and ability to respond to strong and weak signals of new information are necessary for flexibility, they are not sufficient for determining the will to embrace the fluidity of choice. Policy must install the capability to respond to a wide variety of possible signals even before it can know the nature of these signals.

#### 4.3.8 Flexibility is aided by holding stocks over and above that level necessitated by normal variations

The concept of carrying spare capacity is often invoked as a panacea for inducing flexibility; in this context we can trace its origins to Hart (1937, 1940), though Clausewitz stated that in military policy it was an essential condition of strategy that reserves should be held according to the degree of strategic uncertainty (1976:210). The strategic reserve served two roles: firstly, to prolong and renew action, and secondly, to counter unforeseen threats. The first was a tactical role, whereas the second was strategic. Most analysts of business or technology policy fail to grasp this dual significance. Having insurance (i.e. high stock and inventory levels) is only relevant when the risk can be insured against. This prompted Hart to suggest that liquidity "is thus a partial substitute for insurance; and for many types of losses, against which insurance is not purchaseable, it is the only protection" (1940:69). Cyert and March (1963) transpose this into a broader organizational context, and, as Eppink (1978:35) points out, invoke the concept of "organizational slack" to serve as a buffer between the organization and the discontinuities in the environment.

Holding slack is like hedging, and so fits in with Clausewitz's first role for reserves. In the strategic sense, coping with the unknown also entails carrying the cost of unused

resources in "normal operating conditions". Flexibility does not necessarily entail carrying such extra cost; indeed, the concept of buffers resembles the notion of resilience more than flexibility. Empirically, some strategists who participated in the corporate study viewed having reserves suspiciously and did not think it was a factor in inducing strategic flexibility. Indeed, in his historical analysis of strategy, Liddell Hart marvelled at Sherman's flexibility. His policy, which had no reserves or buffer stocks, was yet flexible through the resultant unbridled mobility of his forces (1954, 1959).

4.3.9 Flexibility is measurable by the size of the choice set of each contingency; the most flexible course is that with the largest number of options.

None of the five categories of flexibility seem suitable as a basis for such a hypothesis. Yet, both Koopmans (1964) and Mandelbaum (1978) are tempted into the trap of counting available options. Further, Rosenhead (1972) measures flexibility by recourse, to the fraction of "good actions" brought on by one particular option out of the total constellation of available actions. <sup>22</sup>

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<sup>22</sup>Koopmans' principles are pointing towards the same direction but, in view of the brevity of his account, it would be unjust to criticize on the basis of the "hints" he puts forward as possible measurement criteria. Koopmans was later the driving force behind the development of the resilience concept at IIASA.

The distinctions among various temporal dimensions underlying this hypothesis are also questionable since projects rarely conform to regular and sequential periods. Often, as is common in technological ventures such as plant construction, commissioning and total life cycle can be up to 20 or 30 years (including the planning cycle). Notwithstanding the problems which Koopmans cogently expressed, (i.e. the transformation of desires and the subsequent impact upon volition), the probability of projecting performance data correctly over such a period must be viewed skeptically. (Here we are leaving aside the problems inherent in predicting the modifications which unanticipated hazards may require or which changing environmental conditions may precipitate.)

Merkhofer's approach (1975) does not suffer from this problem, because it works backwards from evaluating information acquisition in late time periods to give a means which measures the value of postponing a decision until such a signal is received. As information is seldom perfect, the impacts of "under- and over-confidence" are modelled by way of the spread of a distribution. This, however, is not the same approach as that implied by the above hypothesis.

Such a hypothesis seems to beg the question: If flexibility is to be desired because the future is unknown and because of the fallibility of our reasoning (which enables us to predict events that necessitate strategic repositioning), the very

need for flexibility would disappear if outcomes could all be known in advance. The raison d'etre for seeking flexibility arises from potential surprises inherent in the behaviour of dynamic systems. We may employ probabilistic techniques (using the best available information) to provide the logical foundations for decision-making, to identify areas where future information signals might be critical and by using sensitivity analysis, to highlight areas where small shifts in value are likely to have significant impacts on outcomes. These, however, do not eradicate the need for flexibility, even in a deterministic system. As Hart (1940:50) comments:

Measures looking toward flexibility may be rational even though the entrepreneur feels no uncertainty.

4.3.10 The more flexible a policy, the greater the value of information gathering

This proposition is almost tautological since for flexibility to be needed, some perturbation around a fixed point or some unexpected shift in parameters has to occur or be anticipated. In such circumstances, learning occurs both about the change-prompting phenomena and about the impact of such changes. The resultant information will be valuable if there is room for modification in the way things are done. Logically this inevitably leads to the proposition which inverts supposition 4.3.10: where no information is expected which would

render modifications necessary, then flexibility would not be of value. To be consistent with the axioms of rational behaviour, this inversion must hold good (Merkhofer 1980 personal communication).

This question has been a source of consternation to a number of previous writers on the subject. In the "decision-analytic" paradigm, the value of information has a precise role in prescribing choice (Miller 1974). The expected value of (perfect) information was invoked by Marschak and Nelson (1962) in their suggestions for ranking alternatives ordinally by way of relative flexibility. Merkhofer (1975) adopted a different approach, using the EVPI concept, and modified the concept of flexibility into one of "degrees"; thus the value of postponing a decision was estimated on the basis of two factors:

- i) The flexibility of an alternative (partial or total)
- ii) The value of information (perfect or incomplete).

While this level of refinement complicated the analytical procedures, particularly those involved in the sensitivity analysis, the added realism and congruence to the problematique imply that if no information is expected which will enable the decision-maker to refine his choice, then the strategic importance of the decision will dictate the relevance of this corollary. (This is in agreement with Merkhofer 1980: Personal Communication). The potential failing of judgement is thus correlated to the cost of making an error. Given the justifi-



cation for the initial quest for flexibility, the conceptual issue is: how can one maintain that in circumstances of "subjective certainty," relinquishing flexibility is justified?

Indeed, Hart (1940) is the only researcher to propose that flexibility has value even if the participating stakeholders feel no uncertainty. In choosing an option with flexibility, where the cost is negligible, the decision maker is exercising discretion since he may be defective in his judgement.

As Ansoff suggests, the nature of the strategic problem shifts and, through inertia or lack of recognition, in some cases the cycle time needed to make appropriate modifications may be greater than the time taken for the strategic problem to have changed once again (Ansoff 1980). Thus, while in the domain of theory it is reasonable to propose a relationship between information and flexibility, the capacity to utilize the information depends upon the inherent or latent flexibility. However, in practice the problems of directing an organization require that flexibility be sought because we do not know the effects of learning in their totality, as we do not know, by definition, what sort of surprises may ensue to necessitate a shift in direction.

Therefore flexibility, Liddell Hart suggests, enables an organization to increase its effectiveness by allowing it to adjust to various circumstances and by concentrating its effort on decisive points (1950: 291).

#### 4.3.11 Flexibility has an opportunity cost

Extending the analogy of insurable risks, many authors have evaluated the cost of acquiring flexibility by the premium paid for insurance. This recurring theme has been taken up in consort with the equally prevalent notion of hedging. Merkhofer and Saade (1978) was justified in rejecting the latter notion and, in the same way, a parallel argument can be suggested to limit the former. Thus we can clear the ground for a reasoned appraisal of this conjecture around which the efficiency and effectiveness of flexibility is to be woven.

Taking the traditional economic definition of opportunity cost as that which is foregone by commitment, the costs of flexibility can be related to that which could have been acquired instead of flexibility. The tendency has been to generalize and argue that flexibility always has a cost, as in Stigler's plant, which was only adaptable within limits. However, such generalizations are vacuous; Stigler's (1939) recipe for acquiring flexibility (up to the point where its marginal cost is equal to the marginal revenue) would have been sensible to use, were it not for the problem of apportioning costs.

The foregoing analysis has demonstrated the implicit complexity of the notion of flexibility. This is due in part to its inherently polymorphous nature as we discovered. Additionally, some of the assertions made by previous researchers

have been contradictory and lead to paradoxes. Strategic flexibility is a quality or property in the management of purposeful systems which facilitates repositioning by virtue of timely modifications made operable by action before the nature of the initiating event is known. It is provided typically by virtue of a number of situationally specific features which do not, of necessity, provide flexibility in other situations. In order to arrive at a clearer impression of the need for strategic flexibility and how it can be provided, we need to turn away from abstract considerations and examine situations facing contemporary policy-makers.

## CHAPTER 5

### THE "FIRST TIME COMPUTER USER" STUDY

The thrust of the present research is directed towards policy formation with respect to technological issues. Examining a microcosmic environment which captures the decisions' strategic significance is of paramount importance because it enhances our understanding of the underlying forces and relationships. The situation facing "First-Time Users" (FTU) of computer technology provided an appropriate setting for such an investigation. This "policy setting" encompassed many of the factors inherent in large scale technologies, yet at a level of variety and complexity which facilitated a grasp of the relevant issues.

Conducting a field study is a complicated exercise; there are difficulties in acquiring data within an appropriate framework as well as problems of access to policy makers. The policy setting of this study concerned the acquisition procedures adopted by small manufacturing companies when they first procured electronic data processing (EDP) capabilities. The multiple learning curves (Nolan 1976) to be confronted by the FTU provided a practical setting for investigating an important aspect of "flexibility" elaborated by previous research; namely that a policy is flexible if it permits the incorporation of

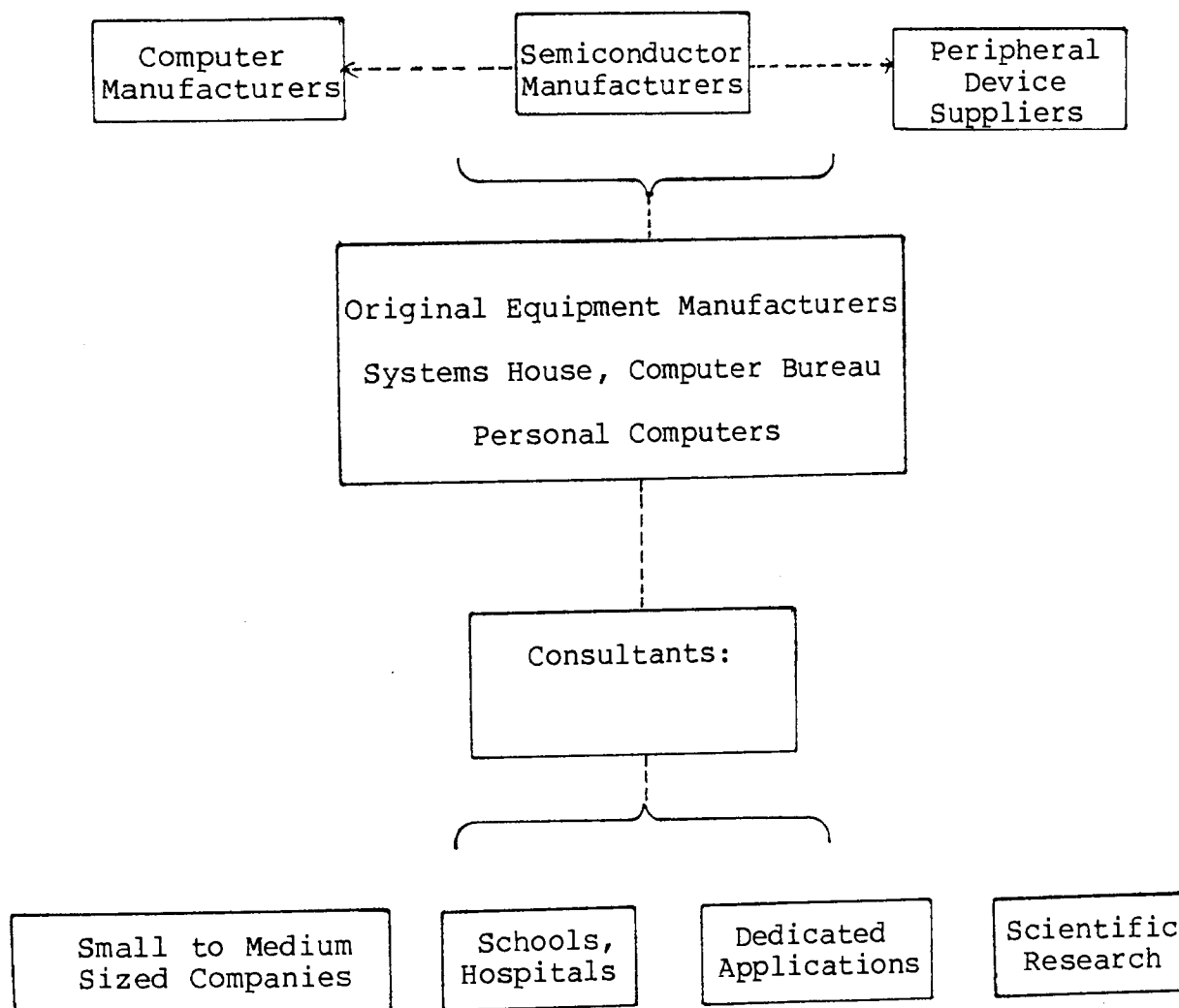
information which becomes available only after a project's initiation. This is highlighted in the case of the FTU because of policy makers' unfamiliarity with the technology and the rapidly changing nature of the technology.

Although the scale of investment in the cases examined was relatively small (30-100,000 Pounds), the economic conditions at the time of the study were about to deteriorate and the available technology was likely to change as a result of improvement in microprocessor design and manufacture. The subsequent change in technology has been dramatic in hardware; the constraint then, as now, lies in the available software and skilled personnel to develop and put into operation useful applications of such systems (Branscomb 1979).

### 5.1 Methodology

The "FTU" study required access to policy makers within organizations representing the various stakeholders, depicted in Figure 5.1. Five manufacturing companies whose characteristics are set out in Table 2.1 agreed to participate in the study. In addition, two consultancy practices with specialized data processing departments, two software houses, two bureaus and a national support agency provided assistance and valuable advice.

Figure 5.1. The First-Time User Environment



# CHARACTERISTICS OF THE PARTICIPATING COMPANIES

Company					
Characteristics	A	B	C	D	E
1. Nature of business	Paper Products	Metal Smelting	Cable Production	Explosive Manufacture	Plastic Extrusion
2. Location	Watford	London	Lichfield	Stroud	Birmingham
3. Position of Interviewee	Data Processing Manager	Group Data Processing Director	Data Processing Manager	1 Finance Director 2 DP Manager	Chief Accountant
4. System Acquired	Data Saab	Digital Equipment	I.B.M.	Data Saab	I.B.M.
5. Scale of Investment					
6. Investigated Phase	Company Analysis/ Feasibility Study, Invitation to Tender	Choosing a System/ Development	Implementation/ Operation	Implementation	Development

The five participating companies were at various stages in the "acquisition" process. These were:

- i) considering computerization (involving company analysis, feasibility and invitation to tender)
- ii) evaluating alternative configurations
- ii) implementing the configuration
- iv) switching from manual to automated mode of operation and subsequent assessment
- v) integration and development.

The "Stage approach" to the analysis of EDP system acquisition with multiple learning curves has been articulated by Nolan (1977, 1981) and Zani (1970). For this study, the investigated companies covered a wide range of the acquisition spectrum, spanning the early period involving company analysis and feasibility study, the "choice" stage, and finally, contemplation of further applications. This variation of perspective traced the acquisition process from its inception to its operationalization. The other four companies were not examined with the same temporal extension. This approach enabled the researcher to take account of the perspective of the "software house" supplying systems on a turn-key basis to two of the participating companies, which facilitated a comparison of problems from the point of view of the "user" and the "vendor". An evaluation of the effectiveness of the system was not in-



cluded; however, the auditing of facilities, which was an integral part of the post-implementation checks, was observed.

Further assistance was enlisted from the British Computer Society's "Specialist Group for New and Potential Users". Members of this group included consultants, manufacturers, academics and first-time users. The officers of the study group suggested that the practical findings of the research could be summarized as a "checklist" which could assist first-time users.

Bouchard's (1976) types II and IV interview archetypes were used to generate the required information (described in Chapter 2). A number of problems were encountered during the course of the study, ranging from difficulties associated with interpreting data, to time constraints (on the part of executives), and expenses incurred by the researcher. Moreover, it was not possible to canvass the views of all the relevant members of each participating organization. Additional difficulties included the researcher's unfamiliarity with the companies, their environments, and technologies. Reporting information of a confidential nature also posed a problem. These difficulties should be borne in mind while assessing the practical contributions and usefulness of the study. The experience gained in terms of research design, interview technique and collation of information provided ample justification for undertaking the FTU study.

## 5.2 The Anatomy of the Policy Process

In accordance with Nolan's schema (1976), the policy process may be divided into discrete stages. However, diverging from Nolan's classification, this study found seven distinct phases of policy formation within the initiation stage spelled out by Nolan. Turner (1977) also discusses the acquisition process on the basis of a number of discrete stages, thus lending support to the validity of the "segmented policy formation focus".

Firms participating in the study were at various stages of completion in the acquisition process and provided an empirical viewpoint of the various phases. These seven phases were:

- i) Company Analysis
- ii) Feasibility Study
- iii) Invitation to Tender
- iv) Choosing a Configuration
- v) Implementation
- vi) Operation and Audit
- vii) Development

A variety of options is available to first-time users (FTU) in the acquisition of EDP. These include:

- i) purchasing a configuration from a manufacturer or Original Equipment Manufacturer (OEM)
- ii) leasing a system from one of the above

- iii) acquiring a configuration on a turn-key basis  
from a systems or software house
- iv) using a computer bureau to provide processing  
capability
- v) combinations of the above

To an outsider, this choice seems to embody the real policy issue in the acquisition process; yet in the opinion of the participating consultants and companies which had progressed beyond the choice phase, the critical issues were located in the "company analysis" phase since a configuration is only valuable if it solves the appropriate problems. A decision about the relative merits of various configurations is sound only if the problems are clearly perceived on the basis of a comprehensive appraisal of the firm and its direction. Many FTUs remarked on this with hindsight. The following sections will describe the various phases of the policy formation process in the investigated companies and other similar studies.

#### 5.2.1 Company Analysis

Perceiving a particular deficiency is likely to prompt a firm to evaluate the soundness of its existing methods. The problem may be one of resources such as insufficient capacity to meet demand or an unacceptable standard of performance. For example, it may take a firm three weeks to process an order while its competitors need only ten days to process an order

through their system. A firm may have a relatively small number of clients so that its transactions are high value/low volume; in this case, the firm may wish to ensure that it has appropriate levels of inventory in order to minimize delays in fulfilling client requirements. A myriad of reasons and objectives can prompt the evaluation of existing methods.

Application areas within manufacturing companies were broadly divided into four categories:

- i) Planning and Control
- ii) Marketing and Administration
- iii) Engineering
- iv) Factory and Plant Operations

The initial stimulus in three of the companies (I, II and IV) resulted from a reappraisal of their accounting functions (embracing administrative, operational and control procedures). Diagnosing the problems was considered to be critical at this stage as the obvious danger lay in confusing the symptoms of a problem with the problem itself. This phase comprised an evaluation of the company and its method of operation by considering factors such as the nature of its transactions, their progress through the company, their duration, associated processes, required resources and services, size and growth of clients, and an overall focus on the sources and uses of information. Such an appraisal involved evaluating current methods and procedures, examining the nature and type of documentation

required for various reports, estimating how often such reports were needed and how frequently the requirements changed.

Following a comprehensive reappraisal, Company I developed a better understanding of the need for change. Indeed, it learned that long-standing deficiencies could be eradicated simply by re-routing the information flow without recourse to an expensive solution. With hindsight, this company derived substantial intangible benefits from the "analysis" performed by a task force. Their job was to investigate the problems without recommending a specific solution and to point out the expected benefits likely to result from particular improvements, regardless of the type of system adopted. Having identified specific areas for further examination, the task force reported back to the managing director (who instigated the appraisal on the recommendation of his finance director who was the chairman of the task force). The decision was made to seek external advice to investigate the potential for EDP within the company. Companies II and V, which were at later phases in the process, thought that, were they to repeat the process, this stage would be given more attention. A more thorough analysis of their company and its method of operation, they believed, would have revealed issues which if identified at that stage would have allowed them to specify more accurately their EDP requirements.

Company I, having established the need for change, investigated likely areas for revision. During this process, the longer-term aspirations of the company were made more explicit. Thus, in accordance with these objectives, a number of policy alternatives were generated aimed at resolving current problems and preparing the company for future environments.

#### 5.2.2 Feasibility Study

At this stage, Company I contracted a systems analyst. Based on the company analysis, his brief was to:

- i) conduct a departmental overview
- ii) document existing procedures and work flow
- iii) assess the effectiveness of existing systems
- iv) establish the operating costs of existing systems
- v) develop a comprehensive outline of the most promising improvements

The task involved appraising the information system and its role in the co-ordination of production, marketing, purchasing and personnel functions. The ensuing analysis was performed in three parallel stages:

- i) developing a familiarity with EDP-technology and the various means by which it could be acquired;
- ii) visiting other companies where EDP facilities had been installed; appraising applications

which the company might wish to emulate. Wherever possible, user groups were approached in order to benefit from the experience of others who had undergone a similar process;

- iii) formulating company analysis and suggestions of possible solutions to the problems identified.

The feasibility study was iterative, lasting a number of months. During this period, the analyst attended vendor demonstrations and visited a number of user groups. A gradual awareness of some of the hazards and pitfalls emerged from discussions with other companies which had had similar experience. In addition, alternative possibilities, costs, and sources of supply became apparent after examining the range of available services.

The systems analyst subsequently prepared a report for the finance director, which was reviewed by the task force before its eventual submission to the managing director. The specialized terminology of the computer world was not clear to the managing director, necessitating a "translation" of parts of the report so that the EDP technology could be related to the problems identified by the task force.

A revised report was prepared which partially overcame these difficulties. After considering the relevant issues, the task force assembled for a meeting with the managing director and various suggestions were put forward. The consensus was

that the benefits of EDP technology were substantial, as were the risks inherent in its acquisition. In order to assess the effectiveness and efficiency of EDP in meeting the requirements identified in the feasibility study, an "invitation to tender" was made to various parties supplying the required configurations. On the basis of discussions with user-groups and other companies, the systems analyst suggested that a specification of the system might be drawn up so that the suppliers could all address the same problems. The systems analyst was to draw up a systems specification on the basis of the following:

- i) overview of the company
- ii) description of existing systems and equipment
- iii) specification of inputs, reports generated, file contents and anomaly handling
- iv) performance measures
- v) access restrictions
- vi) timing of critical activities
- vii) audit functions

By formalizing the procedures adopted within the firm, the systems specification provided a vehicle for comparing various options. It served as a basis for further discussions in which problems to be solved and benefits provided by a computer were weighed against the direct and indirect costs incurred. In a situation such as that facing Company I, where experience of computers was restricted to the payroll which had been handled



by a bureau, the only conceivable way of discerning among the various configurations was by reference to the job which they had to perform. However, this was not the way to realize the best potential of EDP technology, as Company I realized later.

Company I was followed throughout the acquisition process which extended over 18 months. The area of interest was initially focussed on the first two phases of the process, although lessons learned during subsequent stages will be incorporated where appropriate. The systems' specification was the culmination of a feasibility study performed by an in-house systems analyst and the "invitation to tender" was subsequently based upon this specification.

#### 5.2.3 Invitation To Tender

A tender is a comprehensive document setting out features of the proposed configuration, its associated cost, and a description of how it will perform the desired functions. An invitation to tender is sent to those companies considered likely to cater for the company's specific requirements. There are no hard and fast rules on the number of companies which are invited to tender. Some were eliminated during the "feasibility study" and a list of about a dozen companies was drawn up, based on user group experience, supplier' reputation, or competitive pricing.

In accordance with their consultant's advice, Company I had decided to specify a standard format on the basis of which tenders should be submitted, enabling them to compare and contrast those proffered on a systematic basis. Such a comprehensive approach is rarely adopted. A consultant who advised the researcher pointed out that inappropriate configurations can result from the lack of a structure in which to frame the tender. The FTUs participating in the study all reported difficulties in framing the tender since they did not understand EDP technology well enough to specify their requirements. Their inexperience prompted them to seek external expert advice.

The salient features of the tender were considered to be:

1. cost of    i) hardware  
              ii) software
2. commissioning and delivery dates
3. project management
4. training
5. documentation
6. maintenance
7. breakdown and security

A feature which Company I did not include in its request was the ability to modify the configuration in the light of changing requirements. The director of the participating software house commented that a nightmare he often confronted was the FTU who constantly changed his requirements as the capability of the technology gradually became apparent.

An acquisition strategy (which developed user awareness of the capabilities), concentrating on a single application using a microcomputer or a bureau, was often advocated to avoid this problem. However, this occasionally led some FTUs to rely heavily on a bureau, in some cases spending hundreds of thousands of Pounds on such services, when an in-house system would have been far more cost-effective.

#### 5.2.4 Choosing a System

Section 5.2.3 discussed how various system suppliers were asked to suggest a solution to the problems outlined in the systems brief. The level of effort devoted to the analysis of client requirements varied considerably, thus adding a further complication to the policy-forming process. Some manufacturers expend considerable resources on a comprehensive requirements appraisal for their prospective clients. The sales personnel who are initially contacted often draw up a preliminary evaluation of user requirements. However, as considerable bonuses may be at stake, an over-zealous sales agent may give the client more than is really justified by the situation. In order to overcome this problem, some companies, such as IBM, review all their sales staff's user specifications and, in the event of an over-ambitious specification, deduct commission by graduated amounts.

An invitation to tender often involves an appraisal of the client's requirements by the vendor's systems analyst, who, will later be charged with commissioning the system if his tender is accepted. Psychological factors played a significant role in those companies studied; for example, the ability of the vendor's analysts to work amicably with staff members became a critical variable in the selection procedure.

In comparing the various proposals, (which could have taken up to a couple of months to prepare) the companies undertook an initial scanning of a dozen or so tenders which were quoted. The extent to which each proposal met the objectives of the following criteria served to isolate the most promising contenders:

- i) total cost
- ii) operations
- iii) timing
- iv) capacity

Additional factors, such as the degree of confidence in the companies submitting tenders, the level of effort applied to the analysis of requirements, satisfaction with a similar configuration by other users in a comparable situation, and the ability to accommodate changing requirements, all played varying roles during the screening process and were used to filter the tenders down to a short-list of two to five contenders.

Company I had been using a bureau for limited applications such as company payroll (and thus was not in the strictest sense a first-time user). Yet it eliminated the possibility of extending its reliance on this service, although specialist services which were only required sporadically, such as financial modelling (where investment in software was large), could still be contracted. Thus the options facing the companies were:

1. bureau service with off-site/on site data preparation;
2. bureau service using remote job entry;
3. in-house system of time sharing/batch capability (mini-computer system);
4. in-house network of micro-computers convertible to intelligent-terminals for interaction with leased mainframe (bureau) capacity for specialist services.

The bureau solution was found to be the least preferred option among the companies. However, the consultant from the bureau service, suggested that the image of bureau had been unduly tarnished, in part by users who had developed an over-reliance on bureau services (often as a result of complacency), when an in-house system would have been more cost-effective. Once a short-list was developed, further discussions with the remaining suppliers, focussed on areas of concern.

The financial director of Company V, who was in charge of overseeing the final selection and whose recommendations would influence the board's final decision, was not familiar with EDP technology. Hence the company decided to enlist external expertise to supplement the ability of the in-house accountant charged with the task of analysing the tenders. The consultant used formal evaluation techniques and also undertook to acquaint the decision-makers with these techniques. The financial director, an accountant by training, favoured using "discounted cash flow projection" as selection criteria. These, however, did not capture the intangible factors mentioned previously, such as the ability of the employees to work alongside the vendor's staff during conversion and installation. A multi-attribute utility approach was therefore adopted, although for ease of understanding, it was called a "weighted score approach". This approach was developed by Keeney (1975) and extended by Maier and Van der Weide (1977). In the situation at hand, the approach involved breaking down the attributes or components of a configuration into their various categories as shown in Table 5.2.

Each tender was evaluated systematically. The set of factors and alternatives were then ranked in terms of the various measures of effectiveness ascribed to each attribute. The process was iterative, with alternatives being progressively rejected. The method was found to be useful because that it

Table 5.2. Attributes Used to Compare Alternative Hardware Configurations.

HARDWARE PERFORMANCE

- i) Benchmark Test
- ii) Memory Capacity
- iii) Back-Up Store (accessibility and transfer speed)
- iv) Peripherals - speed, reliability and interchangeability

HARDWARE FEATURES

- i) Quoted Downtime
- ii) Available Production Time
- iii) Maintenance Services
- iv) Guarantees for Breakdown (time for engineer to get on-site)
- v) Standby and Back-Up Facilities

HARDWARE GROWTH

- i) Ability to Expand the Memory (user secondary)
- ii) Growth Within a Family of Machines Ensuring Software Compatibility
- iii) Cost of Changes
- iv) Manufacturer's Innovation Potential

focussed attention on comparative issues within each alternative, rather than comparing each as a total package. The analysis revealed two alternatives which appeared to meet the specific objectives noted earlier.

In order to choose between the two final options, representatives of the tendering companies were invited to a meeting to present their case and to be informed about how their tenders ranked in the evaluation. The choice was made two weeks after the meeting on the basis of newly-negotiated pricing, support, and training agreements.

#### 5.2.5 Implementation

Implementation began by careful planning, regular progress meetings and the freezing of the system's specification. Sometimes special facilities are necessitated by machine requirements (e.g. air conditioning) or other idiosyncracies of the site. The planning of "implementation" phase focussed on the following areas:

- i) file conversion and creation
- ii) data entry
- iii) pilot running
- iv) staffing
- v) documentation

The above functions required individual attention; some were started before the equipment was delivered. Existing



records and data had to be converted to match the style and format of the automated system. In some cases the information could be transferred directly, whereas in others, existing files had to be transcribed into new forms. At this stage, it was helpful to evaluate the existing staff and determine who could be trained for the EDP function. The analyst from the supplier began to modify the packages to suit the company's style and re-checked the specifications for new programmes or routines to link software packages.

Delivery of the hardware caused some excitement and within a couple of days, demonstrations were given to management and other users. The analysts checked out the equipment to ensure that all was in sound working order. The operating system was subsequently checked and debugged. The task of data preparation had been partially completed for the sales and purchase ledger, which were given first priority for conversion. The package for this function was modified by a programmer (from the vendor) followed by the tedious task of inputting the data.

This process was repeated for each application on the priority basis established previously, with progress meetings held bi-weekly to ensure tight coordination. As users became more familiar with the system, the initial unease and subsequent disdain for the extra workload subsided, and people began to "play" with the system. From time to time abnormalities

arose which had to be logged and resolved; gradually a procedure was developed for these occurrences.

As the various applications were prepared and tested, the cut-over from performing the tasks manually had to be integrated with the normal operations of the company. Demand for the company's products regularly slackened during the summer months by approximately 20 percent, so it was decided to make the transition during this period. Six to seven months were needed to develop the appropriate data bases to enable the various systems to become functional. Each was carefully tested and reviewed to ensure that the objectives set out in the systems specification were being met. Occasionally, the analyst became frustrated when the finance director, who would request modifications not included in the agreed specification as he had gradually come to realize the potential of EDP. Where possible, the analyst would accommodate these requests, but gradually it became apparent that a programmer would have to be recruited to establish this capability on an "in-house" basis.

Throughout this period, staff were being trained on-site, on courses provided by the vendor. Modifications to existing software packages were incorporated into the user manuals and documentation for virgin software was also developed. Comprehensive documentation was provided by the analyst and the company, including the following:

- i) company analysis
- ii) operating procedures
- iii) systems specification
- iv) programme manuals
- v) user manuals

In addition to progress meetings, target dates were set to review and accept the following:

- i) system specification
- ii) programmes
- iii) systems and systems coordination
- iv) equipment

With one or two exceptions, all went according to plan and everything was prepared for switching to the automated system.

#### 5.2.6 Operation

Company IV had gone through the installation phase and was in the process of assessing various methods to switch the system over from the manual to the automated system. Files had been created, data entered and the programmes checked. Some of the applications could not be prepared until the switch-over had been achieved, but these were of low priority. Unfortunately, there were no quiet periods to provide a breathing space for making the necessary transition. The following five methods of changeover were being considered:

- i) direct cut-over
- ii) parallel operation

- iii) pilot testing
- iv) restricted parallel operation
- v) phasing in

The first method was considered to be inappropriate since the psychological shocks of an immediate switch-over would stretch the user's ability to cope with a completely new system. The data processing manager had once experienced a direct cut-over in a company where staff were flexible and well-trained, and had the luxury of a three-month slack period to adjust. The strains and problems which he had encountered during that experience led him to urge that it should be completely ruled out.

Method two involved running the two systems simultaneously and was considered to possess two main advantages:

- i) the new system could be fully tested under actual conditions without endangering the firm's operation;
- ii) the accuracy and integrity of critically important files could be confirmed.

Parallel operation entailed running the new system side by side with the old one, comparing results, and investigating variances until a clear pattern of consistency and accuracy emerged.

Method three would have involved testing each application with dummy records and switching-over when verified. Histori-

cal data from the company's records was available and this information could have been conveniently used to analyze the veracity of the system. It was difficult, however, to see how all the applications could be divided and tested separately, although this was to be advocated where possible.

Restricted parallel operation was considered to be appropriate for the sales and purchase ledgers which were segmented alphabetically into sections. It was decided to run A-F in parallel in the first month, and G-M the next month if A-F had been made securely operational. This approach was not suitable for some applications, such as vehicle scheduling, which depended on some of the other systems. The sales ledger was to be cut-over first, followed by automatic invoicing (integrated initially with the sales ledger using dummy stock records) and finally the complete system switched-over when stock was automatic. Phasing-in to everyday use was advocated for those applications requiring the automation of other applications, to provide the necessary information for running them.

A combination of the last three methods was adopted because the first was considered unsuitable and the second placed too high a burden on the staff. A project management committee, consisting of the data processing manager, chief accountant and production manager, over-saw the transition, setting up control procedures for input and correction of data, assigning responsibility for initiating trial runs, and labelling

the diskettes. Contingency plans were developed to cope with system failures and were displayed prominently to ensure that an enthusiastic amateur did not meddle!

Daily, weekly, and monthly work schedules were allocated and running times were specified. It was considered good practice to have an operations log (which could be used later during the audit) showing the length of a job and the problems experienced. Consideration was given to the filing and distribution of output on the assumption that as users became more familiar with the new system, they would require only exceptions to the norm to be printed on reports, rather than all information.

During an early period of operation, a user had made only one copy of the weekly petty cash payments onto a diskette, which he had also forgotten to label. Inadvertently, another user picked up this diskette, thinking it was blank and reinitialized it for another job. When he returned to print out the petty cash payments, intending to load the data onto the general ledger, he could not locate his diskette. Since it was the only record of transactions, it was now impossible to recover that information. The matter caused a reassessment of security. (If, for example, the same thing had occurred with weekly times sheets, the wages would not have been made up!) The project management committee decided that copies of files of critical importance must be made and kept in the bank so

that the information would not be lost in the event of fire or some other disaster. Furthermore, duplicate copies of information were to be held for the period of its useful life. In order to retain the integrity of the system, access to some information was to be restricted.

The systems analyst from the supplying company visited the site upon request to deal with problems as they arose. Occasionally, a programme would not run or a job would be only partially completed; sometimes file amendments were made incorrectly. In these cases, the analyst came out to the site to take remedial action and, where possible, demonstrate the diagnostic procedures and subsequent correction. It was suggested that the firm, which was gradually coming to rely almost totally on EDP for some operations, should attempt to locate a company with similar facilities in the vicinity, in order to establish a reciprocal arrangement whereby in the event of a system malfunctioning, critical jobs could be run on the other's system. The firm supplying the configuration had installed a similar configuration in a neighbouring firm and so such an arrangement was readily established.

Once the novelty had worn off and the system became embedded in the firm's day-to-day activities, the managing director, who had initially been skeptical, appreciated the benefits of the system and decided that an evaluation of its associated costs and benefits would be in order so that tighter control

could be imposed on supplies and computer time (this had become scarce as demand had increased). The objective of this post-implementation audit was to assess the efficiency and security of the system. After 15 weeks of full operation, the managing director requested an audit to ascertain of the following:

- i) The degree to which the original specification of user requirements had been met.
- ii) The variance of project cost from expected forecast cost.
- iii) The concordance with time schedules.
- iv) The variance from the original system specification.
- v) The adherence to security requirements.

These required the evaluation of individual applications. Unfortunately, information about the non-logged features of some applications, essential for a comprehensive audit, was not available. However, it was possible to investigate each user department and to confirm that specified needs of the department were being met. In addition, each application was audited to ensure that the intended benefits (in terms of cost and time savings) were being realized. Depending upon their magnitude, where variances were noted, the analyst was summoned to explain. The initial estimate of system development and implementation, however, had proven to be reasonably accurate, to the amazement of all concerned, although the finance director



was skeptical about whether the intangible benefits included in the selection methodology had been realized. A sample of customers was subsequently approached and questioned about any noticeable changes in levels of services. While one or two did not notice any improvement, a considerable proportion of the clients reported that order turn-around time had been significantly reduced, by up to 30 percent.

The area of consternation for both the finance director and the managing director was the integrity of the information and the vulnerability of the system to breakdown or fraudulent use. A senior systems analyst from the supplying firm discussed security features with the two directors in order to allay their fears and to sketch out a strategy to deal with these troublesome and sensitive issues.

The audit proved to be a valuable exercise because it brought out common concern and highlighted the system's potential. A number of suggestions were put forward regarding other areas of the company's operations which might benefit from EDP although it was also suggested that such developments be postponed until the staff were fully competent in operating the system. According to Nolan (1981), this is where the second learning curve begins. A set of procedures was introduced to establish good processing practices, including the following:

- i) clear and concise labelling
- ii) storing variable names

- iii) logging activity dates
- iv) disciplined editing, so that each data element and every record meets its specification
- v) maintaining changes in performance
- vi) noting changes in performance
- vii) regular file audits.

By establishing such practices, the steering committee hoped to avoid unnecessary breakdowns or delays. It was considered that the expansion of the system, should it be necessary, would be motivated by new applications and not by inefficient overloading.

#### 5.2.7 Development

The level of sophistication and coverage of EDP applications tends to expand with the development of new technologies, such as fibre-optics, new techniques for software development and high level languages, such as Pascal and ADA, or packages such as VisiCalc. Recently, communication has been significantly enhanced by the development of satellite technology, delivery vehicles and network software, such as Ethernet and Telenet. While such capabilities are beyond the requirements currently envisaged by the FTU, the potential is enormous.

For First-Time Users, the inspiration to further develop the configuration originates from a variety of sources. In the present study these were found to take the following forms:

- i) to expand core storage
- ii) to increase secondary storage
- iii) to expand range and variety of
  - a. VDUs
  - b. printers
  - c. network facilities
- iv) to upgrade operating system
- v) to develop new applications
- vi) to develop in-house software production capability
- vii) to integrate data and word processing.

The consultants' presentation of a systematic method for developing new capabilities began by undertaking an "Applications Analysis" which fell into two categories: first, a review of current applications and suggestions for revision and/or fine tuning, and second, the specification of new assignments.

The first part was considered essential in that the systems specification drawn up initially by the FTU would now be modified due to the user's experience in operating their configuration and resolving problems. As the users became better acquainted with the system, they developed practices to increase efficiency. Furthermore, as the initial benefits were realized, other applications were envisaged, based on a working knowledge of EDP's potential. In Company V, a standard format was adopted on the basis of which suggestions regarding new assignments were solicited from within the firm. The cost of development was estimated on the following basis:

- i) labour time
  - a. systems analysis
  - b. programming
  - c. programme and system testing
  - d. data preparation
  - e. project management
- ii) materials
  - a. additional hardware
  - b. additional file storage
  - c. consumable materials
- iii) other resources
  - a. computer time (running)
  - b. computer time (development and testing)

Two FTUS in the study were at this final stage of the process and each was investigated from a different vantage point. The first, Company V, was considering renewing the system because the configuration initially installed, ran entirely on batch mode and was approaching the end of its life cycle. The second company was investigated from the perspective of the software house, whose managing director was involved in discussions with a client regarding the possibilities of enhancing the system previously installed in his company. He envisioned applications such as international document-transfer and data capturing to update their existing data base.

In the first case, the change was financially motivated; a huge investment had been made in software and systems reorganization during the installation of the first configuration. However, because the firm sought to retain the systems and software currently in use, the range of alternative systems was severely circumscribed. The manufacturer of the equipment had

designed the most up-to-date equipment to transfer software and data bases from the earlier generation of equipment; the choice was, however, limited to that particular manufacturer's equipment.

The dilemma facing the policy-makers was acute; on the one hand a major investment programme could be undertaken to transcribe the software into another high level language which could easily be modified to run on other manufacturers' computers; on the other hand, the original manufacturer could be retained at a lower initial cost but at the risk of becoming even more locked into a single development path. It became clear that the two development strategies were mutually exclusive. There was, however, a hybrid solution involving less investment than a major transcription effort, but more substantial than remaining with the original manufacturer.

The policy adopted was made simpler because new applications under consideration were not available from the manufacturer of the equipment currently installed. However, the problem had simultaneously become more complex by the move into production control, linking plant and equipment to the data processing capacity provided by this same manufacturer. Thus, if it were decided to install an automated production system, the new system would have to be compatible with existing EDP capability.

Resolving the problem required three consultants' reports and numerous meetings with suppliers and an in-house task force drawn from the various functions. A solution was found by upgrading the existing system into an interactive/batch mode of operation with a minimum investment in software. Where size permitted, selected applications were configured on new hardware supplied by a different company but in a language which could easily be run on the existing system. The decision to adopt automated production methods which were being developed by the manufacturer of the first configuration was thus left open.

Case two, involved a different problem since the systems currently in operation were all functioning satisfactorily and the configuration was only one-third of the way through its scheduled life cycle. The company marketed its products internationally and, by virtue of its product segmentation strategy, a potential existed for precise matching of client requirements and the sourcing of inputs. An additional requirement was specified for the transmission and modification of contracts to various overseas locations during negotiations. In contrast to the previous case, the initial systems had been developed on a configuration manufactured by the company with the largest share of the market. Many smaller suppliers sought to emulate this equipment by manufacturing what is known as plug compatible machines (P.C.M.), computers which can be linked to IBM

equipment. The managing director of the software house who installed the system was invited to suggest alternatives to deal with these additional applications.

The problem facing the software house was not one of providing the capability, but rather of providing extra capabilities over and above their competitors (who had the edge on price). From the user's perspective, the choice was simple, since a decision had to be made either to pay the penalty of remaining faithful to the original manufacturer or to switch to a cheaper source offering the same services. The director of the software house was fully aware of the situation and respected the skills which the DP manager had acquired. Thus, the most viable strategy was to offer the benefit of his analyst's experience to the DP manager during the ensuing feasibility study so that the data base of the installed products and other related systems could be linked to the newly designed capabilities in the best possible manner. Additional memory storage was added to hold the data base and a facsimile machine was leased to provide the required communications until interactive telecommunications was developed by the original manufacturer (which because of its research was ahead of its competitors).

It became obvious as this phase was examined that earlier decisions had constrained development options. At one end of the continuum, the strategy was to acquire a system at minimum

cost which could be discarded at the end of its life cycle, while at the other extreme lay the option of remaining loyal to a manufacturer and upgrading the system within a family of configurations. None of the sites visited fell into either of these extremes; however, reliably informed sources discussed a number of situations where companies were spending in excess of 100,000 Pounds on bureau services, which approximates the use/discard posture.

This study has attempted to observe the policy-making process in a setting where technological uncertainties played a major role. Such a situation was intensified by the decision makers' unfamiliarity with the technology and its use in improving the performance of their businesses. In a sense, we have partially adopted Glaser and Strauss' (1967) approach in order to identify the basic problems from a practical viewpoint.

Section 5.3 will outline the attributes of the technology which promote strategic flexibility and which need to be considered at the various phases of the policy formation process to avoid some of the problems identified in this study.



### 5.3 Attributes of Strategic Flexibility

This chapter described the study of a "technology-specific" policy issue. Our sample size was small and observation techniques were rudimentary. The policy making process was traced from the "embryonic" stage, where a need was identified through to the "mature" stage where specific action had been taken to develop the system further. The bulk of this chapter has concentrated on describing the vagaries of the computer acquisition process. The ramifications of such a process could exert a significant impact on the companies concerned and influence their competitive position. This section will discuss the various attributes of strategic flexibility which coalesced during the study.<sup>23</sup>

Five such attributes which relate to the technology under consideration are discussed; since the study was undertaken in 1978-80, considerable technological advances have been made. For example, two years ago a DEC Vax Computer required 38 printed circuit boards for its processing unit whereas now it requires only 5 and uses the same power as a light bulb. (Personal interview 1982: Wilf Corrigan, Chairman LSI-Logic Inc.) Notwithstanding these developments, there are still consider-

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<sup>23</sup>We make no pretence of any statistical rigour surrounding these attributes and thus no claim of transferability to other technological settings.

able diffusion problems for those wishing to use this technology to improve their business performance.

It must be stressed that these attributes of flexibility serve a dual purpose. One is to enable the users of small business computer systems to make modifications as they learn more about the potential of such systems and as their business and their environment change. Secondly, the manufacturers and other stakeholders in the business of supplying systems, require considerable flexibility to cope with the radical technological and market changes which occur with somewhat alarming rapidity. This section deals exclusively with the former, although the significance of the second role is also recognized and addressed more fully in Chapter 7 in the section discussing ideas for future research.

#### 5.3.1 Compatibility

Compatibility is a relational attribute. In this section two types of compatibility are discussed:

- Procedural compatibility
- Configurational compatibility

In order to achieve the requisite amount of compatibility, a trade-off should be made between levels of compatibility and cost (both tangible and intangible). Each type of compatibility exerts different impacts on the various phases of the acquisition process.

#### 5.3.1.1. Procedural Compatibility

Accounting systems would typically be the application area which would be first considered for automation. Such departments invariably wield a great deal of power in small businesses. It is hardly surprising that the "we've always done it this way" syndrome can be heard in such departments but the tendency to dismiss this apparently parochial attitude out of hand needs to be closely inspected. Often in such a vital function, informal ways of doing things evolve over the years; some of these practices are indeed helpful, even though others are less useful.

Attention should be focussed on the compatibility of such systems with existing procedures when the various systems specifications are being devised. In general, the most up-to-date methods of accounting, stock control and material requirements planning are incorporated in "Electronic Data Processing" (EDP) systems. Applying new techniques can be quite traumatic especially when the change is imposed as a fait accompli.

Other factors are also important when considering procedural compatibility. The information system is the basis for decision making and hence defines the lines of communication and authority. A clear understanding of the links between these is required so as not to perturb unduly the status quo. However, this represents a difficult challenge. The person updating the information system is given considerable power.

This is initially manifested during training meetings with systems analyst and other staff. Secondly, the decision-making system will be affected by the user's ability to access and process the relevant information. Finally, the lines of communication will invariably need to be altered when a configuration is installed. This can entail a redistribution of power within the company. All these factors must be taken into account. Nolan (1982) suggests that a steering committee of 5-10 persons should be set up to coordinate and control the acquisition process.

#### 5.3.1.2. Configurational Compatibility

This attribute is technological in nature and refers to the ability to connect a number of disparate systems. It is required to facilitate communications data transfer and to increase processing capabilities. As work stations become more powerful and autonomous, it can be extremely difficult to ensure that the systems can be continually reconfigured around the desired application.

Consider the decision to make a major investment in new production equipment. This machinery may have a sophisticated computer-aided function and may even be computer-controlled. Now imagine, if you will, the process leading to its acquisition. In the first instance, one needs to prove that a substantial advantage will result from its acquisition. Making the case will involve an extensive analysis of existing production

facilities examining various costs, down time speed of tool change, energy costs, output variability, optimum job size, etc. Customer records must then be examined in order to estimate the demand which the new machine could satisfy. All of these considerations are dependent upon having the resources to pay for the investment. Thus, the accountants will have to estimate the present value, payback period and rates of return in order to satisfy the financiers that the loan will be repaid and to obtain the lowest cost of borrowing. Clearly, the management of the company responsible for such a decision will need to collect information from a variety of sources and be able to process and verify findings with company specialists. Internal compatibility is thus essential for strategic decision making so that management can access and process vital information relevant to the germane strategic issues.

Additionally, the hardware of the system ought to conform to industry standards to ensure that if (as in the above example) new equipment becomes available, the desirable level of interconnection can be achieved. This holds for communications, word processing, data processing, computer aided design, computer aided manufacture and office automation.

Software is a major source of incompatibility problems, which can occur both at the operating system level, constraining inter-computer communications, and at the applications area, limiting interpackage data transfer. Languages such as

APL and ADA have been developed to facilitate this but the problem of machine transferability still exists.

#### 5.3.2. Expandability

As we have pointed out, the first-time computer user has only a vague idea of the type and quality of hardware to use for contemplated applications. During the feasibility study a systems specification is outlined which relates the perceived computing needs of the company to a hardware requirement. This systems specification is the basis for the rest of the process. The FTU is continuously learning about the technology and its potential applications, therefore, this systems specification can create rigidity during the implementation phase.

The sources of rigidity are not unidimensional; yet their effect is to constrain new applications being incorporated at an early stage. Memory, processing power, number of parts, and software can all be constraining features when further enhancements are considered. One way to achieve flexibility in such circumstances is to select a kernel system which is incrementally expandable along some or all of these dimensions.

On the software side, the most significant qualities which allows reconfigurability and enhancement are discussed in Section 5.3.5. In expanding applications, the most important aspect of the software is the data base management system. An

efficient data-base management package will have the ability to expand applications which are already embedded.

Many manufacturers offer a family of systems to facilitate flexible expansion as the user's requirements evolve. The most important feature of this concept relates to software. As the cost of computational power declines rapidly, the largest cost component is the systems software. In the past, the user could find that in order to expand to the next level in a family of systems, the original software would need to be completely replaced. Most of the manufacturers have the foresight to recognize the need to retain software and build into their latest product the ability to run software designed for previous models.

Companies such as IBM set the industry standards. IBM has a commitment to ensure the expansion of systems with a minimum of inconvenience for all their equipment, even when resold. It is hardly surprising, therefore, to find that the exchange value of an IBM computer is rather higher than for those without such a commitment.<sup>24</sup> In such circumstances, the ability of the FTU to expand his configuration is considerably enhanced in two critical ways: first, the software development needed to tailor packages to meet unique requirements and virgin applica-

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<sup>24</sup>This point is more applicable to mainframes than it is to micro-computers.

tions can be retained. Second, the hardware can be changed without having to write off the initial investment.

### 5.3.3. Maintainability and Supportability

The "trial-and-error" learning method is nowhere better illustrated than in computer technology. In order to become familiar with operating procedures, first-time users have to undergo a substantial learning process.<sup>25</sup> Furthermore, the technology itself is temperamental and notoriously subject to "going down." As critical parts of the business became vulnerably dependent upon EDP facilities, it is vital for "machine down time" to be kept to a minimum. Maintainability is a characteristic of both the machine and the manufacturer. Machine design plays an important role in the way in which, for example, faults are diagnosed and recovery procedures enabled. Manufacturers' response time to machine failure is also important in determining how long a dead machine remains idle. This is generally expressed in concrete terms by two measures:

- the time taken to return a telephone call for assistance
- the time taken by support staff to get on-site to effect repairs

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<sup>25</sup>Nolan (1982) suggests that these problems are not only restricted to FTUs but can also present major strategic problems for large corporations.



At the beginning of the acquisition process the unsuspecting FTU may not grasp the importance of a vendor's claim for a rapid "turnaround time." Often a vendor will offer back-up systems so that vital operations, such as the payroll, will not be unduly delayed. These services are generally provided by manufacturers whose systems are more expensive. Thus a trade-off needs to be made between "higher initial cost" and "machine up-time." (This is partly a function of user familiarity and hence diagnostic capability.) A related characteristic of significance is a manufacturer's commitment to support its old equipment. This can affect the FTUs willingness to acquire a particular manufacturer's equipment.

Supportability is extremely important in the early stages especially during the cut-over from manual to automated mode of operation. In a sense it can amount to "hand-holding" during this critical period. In practical terms it amounts to the supplier training the user and being readily available to advise during the "teething problem" period when a system is being bedded-in. Later it is important when system development is contemplated to ensure new applications software can be efficiently grafted on to existing packages and programs.

#### 5.3.4. Upgradeability

Early choice of a configuration can affect the range of later upgrading options. As the rate of innovation continues unabated, improvements are constantly being made both in hardware and software. In addition, as a company begins to use more and more computing power, it strives for a better and more cost-effective provision of services to its users. As a number of studies have demonstrated (Booz-Allen & Hamilton 1981; Porter 1981), the ability to use computer technology efficiently can have a tremendous impact upon a company's profitability and competitive position. Therefore, the ease with which a configuration can be upgraded is important in securing flexibility.

Upgrading a configuration takes two forms which usually though by no means always, occur simultaneously. The first involves the incorporation of a more powerful central processing unit. The second involves a new operating system which allows existing jobs to be processed more efficiently and facilitates new applications. Unfortunately, this process does not simply involve plugging in new pieces of equipment.

A degree of logistical flexibility is required to implement the upgrade. The most critical features include a high level of user feedback which permits the rapid detection of "bugs" during implementation. Additionally, the transition should be made during periods when the work load and critical

applications are not at their peak. The development of hardware and software which enable a system to take advantage of technological improvements is the manufacturer's responsibility. This is discussed in greater detail in Section 5.3.6.

#### 5.3.5 Modularity and Portability

These two attributes, closely coupled, are features of both hardware and software which allow quick and efficient redeployment. Broadly speaking, "modularity" refers to the size of a self-contained but integral part of a system. "Portability" is the ease with which a modules can be reconfigured into another system.

From an applications perspective, these attributes are complementary. New applications will often require software development. More often than not, a high proportion of the necessary code required for a new application is present in existing software. If the relevant sections of code can be extracted and cemented together in the new application, then new applications can be rapidly developed avoiding considerable duplication of effort. Hardware also needs to have the ability to be unplugged and switched around as requirements evolve. The ease and speed by which these tasks may be performed are dependent upon the modularity and portability of the systems.

#### 5.3.6. Potential for Innovation

Seldom has a technology witnessed such dramatic cost reductions and improvements in performance as the computer technology. Branscomb (1979) spells these out with eloquent simplicity. It is clear that the FTU will not require "state-of-the-art" technology conforming to the most rigorous military reliability specification. However, these advances in technology can have a considerable bearing both on the cost of a system and the length of time it can be used before becoming technologically obsolete.

The potential for innovation is a twin-edged sword. On the one hand, a manufacturer may have a vested interest in ignoring an innovation because of its impact, whereas another manufacturer, (such as IBM) may be committed to providing its clients with the most up-to-date technology. On the other hand, innovations may be generated by small firms such as those making disk drives (e.g. Seagate, Shuggart). In order to be able to take advantage of developments, the choice of a configuration must be made with an eye on the future.

This attribute is often overlooked, mainly because of the inability in comprehending the significance of technology strategy rather than the difficulty in foreseeing new developments. In manufacturing companies, linking EDP with novel production equipment is becoming the "decisive point" for strategy. The main difficulty is the inability to identify areas where the

potential for innovation is great and to select a configuration which allows the innovation to be rapidly and effectively incorporated.

#### 5.3.7. Procurement Options

There are essentially three options available for the FTU: outright purchase, leasing and rental. Tradeoffs have to be made between these three options. The optimum choice is determined by the length of time that a system will be kept and this will also reflect its cost.

The speed of change in the industry can have dramatic impacts upon price. This makes the trade-off slightly more complex. As Itel found out, much to Lloyd's displeasure, "when IBM sneezes the whole industry can catch a cold."

When considering these acquisition options, the FTU is usually unaware of the dynamics of the industry. It is here that unbiased expert advice is helpful. Unfortunately there are no absolute guidelines. An FTU may wait 6 months before acquiring a system in the hope of price reductions. The reductions may then occur in the seventh month. Clearly the types of available finance options affect the cost of the system and hence its value to the company. This too is a major concern in achieving flexibility.

## CHAPTER 6

### FLEXIBILITY IN POLICY FORMATION: A CORPORATE PERSPECTIVE

Chapter 5 set out to examine a strategic decision taken by a number of small manufacturing companies. The decision was observed in its formative stages, followed through its implementation and finally to the stage where the companies were considering further development. Decision-makers were easily identifiable and their objectives were clearly articulated. Although the decision-makers did not explicitly adopt considerations of flexibility, a number of attributes were identified as influencing effective response to change.

This chapter summarises the second investigation undertaken to clarify the use of flexibility in corporate policy formation. Whereas the "first-time user" situation involved a homogeneous decision, the complex corporate strategy environment is mainly comprised of heterogeneous technologies within a diversified portfolio. Notwithstanding the differences between the two environments, both exhibited common features pertinent to the investigation of the operationalization of flexibility. From this perspective, the first-time user study examined the micro factors in strategic decision-making, whereas the corporate study was primarily concerned with the macro issues. A

number of attributes of the technology were identified in the "first-time user" study; similarly, a number of capabilities were observed in the study of corporate policy formation which will be discussed at the conclusion of this chapter.

In reviewing previous studies, it was noted that the successful practical application of the notion of flexibility had yet to be observed in a strategic decision setting. Applying it to a generic problem was conceptually confusing because of its inherently polymorphous nature. While the "first-time user" study limited this problem by bounding the area to a specific decision-technology case, the complications of steering large organizations provided an opportunity for examining the policy formation process in all its splendour. Any attempt to capture the complex nature of these issues must of necessity select some small part of the universe to examine, and in an area where many have tread before, the task can be reduced to testing hypotheses generated by others. However, the operationalization of flexibility still eludes us and the approach adopted in this study was grounded in the idea that, to paraphrase Aristotle, what has been learned about it has been learned by doing. Thus by short-circuiting the experience curve and using instead an unsystematic, unstructured, widely focussed study of corporate strategic decision-making, some insight may emerge.

### 6.1 Objectives of the Study

The objectives of the study were as follows:

- i) To find out whether appropriate regard is given to flexibility in decision making; if it is not, what are the underlying reasons for this omission?
- ii) To determine the obstacles in translating into practical terms the notion of flexibility and suggest how these could be ameliorated.
- iii) To ascertain the scope for paying greater heed to enhancing flexibility in policy formation.

In order to fulfill these objectives, it was necessary to gain access to senior corporate management at a level which integrated technology and strategy within the policy-making framework. The problems associated with conducting the study were compounded since a variety of decision-aiding techniques and contrasting technologies may obscure the perception of major sources of uncertainty. Further caution was required because variations in organizational characteristics may influence the specific manifestation of the problem of flexibility; thus this study did not systematically address the task of separating the generic from the specific issues.

As its focus, the study examined how decisions are made in the light of a capricious future. In such circumstances the means by which uncertainty is accommodated play a crucial role.



As the time horizon and technological complexity of such decisions increase, so the uncertainties are compounded.

## 6.2 Characteristics of the Sample of Companies

Three geographical regions were selected for the study, on the following basis:

- i) Proximity
- ii) Technological development/sophistication
- iii) Ease of communication

The UK was the target area for the first wave of the study and thirty organizations within technologically dynamic business sectors were selected from the Times list of "Top 100 UK Companies". The second part focussed on another geographical region, the West Coast of the USA, where 16 organizations were selected from the Financial Times International Directory of Companies, on the basis of their distinctive competence and strategic thrust in technologically dynamic industries. During the third and final wave of the study, a sample of Belgian companies was selected. (See Table 6.1)

In all cases, a letter to the Chairman or Chief Executive Officers of these organizations (see Appendix 1) briefly explained the nature of the research problem while requesting the cooperation of their concerns. Of the 54 organizations which were initially contacted, 25 (i.e. 48%) responded positively to

the request, and of these, 21 companies actively participated. Table 6.1 sets out the response rate in the selected regions.

\* \* \* \* \*

Table 6.1. Response Rate of Companies Contracted at the Outset of the Study

	Total Contacted	Negative Responses	Positive Responses
UK	30	12	18
US	16	12	4
Belgium	8	5	3
Total	54	29	25

\* \* \* \* \*

The responses varied from:

- i) a polite refusal to participate on the grounds of policy or because of time constraints placed on executives to,
- ii) a request for more information,
- iii) the name of a person who would assist the search for the appropriate executive within the organization, or
- iv) a letter directly from the respondent within the organization.

After contact was established, meetings were arranged with the appropriate persons in the various organizations. Table 6.2 sets out the position of the respondents and the number and duration of interviews.

The various approaches to strategy formulation in business embrace a variety of techniques ranging from "portfolio-based" to "decision analytic". In the last decade, there have been a number of attempts to examine the notion of flexibility; two concentrated on the decision analytic measurement of flexibility, while the third investigated the role of flexibility in responding to a crisis (Merkhofer 1975, Mandelbaum 1978, Eppink 1978). Montenegro (1977) and Fuss (1977) directed the notion toward technological decisions, but their analyses were limited to one technology, the former to tele-communications system expansion, the latter to electricity generating systems. The perspective in this study emanates from the idea that the future can only be partially predicted from present relationships; variables which may exert a significant influence on policy may not be recognized either because they do not yet exist or because the early signs of influence are too highly attenuated. Ansoff suggests that a capacity for flexible response must be preprogrammed within policies before the occurrence of events which necessitate such responses. In this spirit, the present investigation was directed toward identifying practices used to promote flexibility.

Table 6.2. Position of Respondents, Number and Duration of Interviews

<u>COMPANY</u>	<u>POSITION OF RESPONDENT</u>	<u>NUMBER OF INTERVIEWS</u>	<u>LENGTH OF INTERVIEWS</u>
BP	Deputy Manager Group Plan	2	1.5, 3 hrs
Bank of America	VP Strategic Planning	1	1.5 hr
CEGB	Regional Planning Manager	1	3 hrs
CGDR	Financial Executive (Belgium)	2	1, 3 hrs
Chloride	Economist, Business Strategy	1	2.5 hrs
Dalgety	Director Group Strategy	2	1.5, 2.5 hr
Ford UK	Correspondence		
GEC	Associate Director	2	1.5 hr
IBM	Director Management Systems	2	3, 2 hrs
ICI	General Mgr/Corporate Planning	1	1 hr
Lucas	Group Strategic Planning Mgr.	5	9 hrs
NCB	Dir/Board Central Plan. Unit	2	1 hr each
Pacific Gas & Electric	Corporate Planning Analyst	1	1.5 hr
Pilk-ington	Head Group Planning and Government Liaison	1	3.5 hrs
Plessey	Director Strategic Planning	1	3 hrs
Racal	Director Technical Services	1	3.5 hr
Reed	Group Strategic Planning Dir.	1	1 hr
Shell	Head Strategic Analysis Unit Business Environment, TA	2 2	1 hr each 1, 3.5 hr
Socal	Gen. Mgr/Corp. Planning/Dev.	1	1 hr
Southern Pacific	Assistant Vice President	1	1.5 hr
Thorn EMI	Group Economist	1	1 hr

The attempt to discover whether this attitude was promoted within an organization's strategic positioning across its business portfolio necessitated adopting open-ended questions for each organization. This practice seems prudent given the diversity of technology portfolios in the participating organizations. The complex nexus of factors which form the strategic and policy issues for each organization were so disparate that no standardized format was considered to be adequate.

Two approaches were considered initially:

- i) Adopting individually designed interview formats.
- ii) Using a schedule with two parts; the first common to all organizations, the second with questions specifically geared to an individual organization.

Eventually this study employed the second posture, whereby an interview schedule was prepared to explore the research questions. (See Appendix 2a). In addition a more focussed series of questions was developed in accordance with the situational setting, history, and technology portfolio of the organization (See Appendix 2b).

Archival sources revealed pertinent strategic reorientations, providing a useful way to examine ex-post considerations of flexibility. This involved exhaustive searches through research abstracts, newspaper articles, case studies and professional papers. Company reports were another source of pertinent material.

The findings of the first round of interviews were categorized into a list of practices which the organizations adopted to promote strategic flexibility, and this list was then sent to the respondents to solicit their evaluation of its cogency and usefulness. The response was encouraging. The list of practices was modified on the basis of this second round of interviews. This round focussed more specifically on strategic flexibility, and the relevant issues were discussed with a somewhat sharper focus. On the basis of these discussions, a number of capabilities emerged which underscored the strategies adopted to provide flexibility in policy formation; these are discussed at the conclusion of this Chapter.

### 6.3 Findings of the Study

The findings of the investigation emerge from the practices adopted by the participating organizations to cope with what was seen as a capricious future. A complete synthesis of these practices would not be possible or practical, owing to the individual characteristics of each organization, but a partial synthesis may uncover the relationship between the empirical observations and the expressed aims of the study.

Following this partial synthesis, the ensuing section will describe these empirical findings in terms of the practices used to promote flexibility. In some instances this flexibility was explicit, as, for example, in the case of IBM and Shell,

where considerations of flexibility play a crucial role in policy formulation. In other cases the researcher was justified in ascribing the "intention of promoting" flexibility after the list of practices was shown to the participants and modified. The practices, when subsequently categorized, were derived through an appraisal of the information generated during the meetings.

#### 6.3.1 Impact of Unanticipated Events

A surprise can occur either when something completely novel spontaneously affects a situation or when the probability of an event occurring is poorly assessed. Discovery of new technologies typifies the former case; the transition of ideas from the research and development stages to full-scale production is an example of the latter. Strategies set over periods of twenty to thirty years are particularly vulnerable to such "surprises." All the participating organizations were concerned about evaluating surprises of the first type by continually scanning areas for developments. In Pacific Gas and Electric Company, the respondent's task was monitoring social trends which were likely to influence the technologies that the corporation could use to provide energy.

The examination of economic, political, social and technological trends has been formalized by means of 'scenarios' and 'cross impact analysis'. A variety of alternative futures are

projected to allow 'strategy-scenario' combinations to be examined, in terms of their potential consequences. The scenario approach is well-developed and many of the companies used external consultants to assist in their generation. Two of the companies, Shell and Reed International, had developed comprehensive in-house systems for generating and assessing scenarios (Chandler, Financial Times, 21.7.1980).<sup>26</sup>

The consensus among the participants was that truly unexpected and hence unanticipated occurrences, especially in technology, seldom occur. Those occurrences which caused major strategic disruption were often anticipated; they caused problems because not enough attention was paid to their impact. The Oil Crisis is a regularly-cited illustration of an event which requires flexibility (Eppink 1978). One of the respondents suggested that even if the oil majors had been forewarned of the Oil Crisis, enabling them to divest themselves of vulnerable interests and divert resources into alternative energy supplies, the resulting portfolio would most probably have been composed of coal, nuclear power and natural gas; excluding the latter, the two substitutes for oil would hardly have proven to be an efficient reallocation of resources. (Source: personal interviews, December 1980, USA).

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<sup>26</sup>Mandel (1982) provides a comprehensive guide to implementing the scenario approach in a corporate setting.



To take an example from a purely technological setting, one company had recognized the potential of an incremental innovation to a product which it estimated would capture some 75% of the "Original Equipment Manufacturer" market by a specified date: 1985. Due to the production facilities, the existing plant could not be modified or easily converted to produce the new product. Having recognized a strategic threat, the company had to generate an appropriate response. The lead times involved in coming up with an appropriate plan were critically affected by the impact of other policy constraints and for a variety of reasons, the ensuing response took three years to be orchestrated.

The respondents stressed emphatically that the problem was not confined to recognizing changes significant for strategy. In some situations, where the organization could not be repositioned, the person conveying the news was often ostracised. Detecting weak signals of change is easy with hindsight; monitoring and scanning exercises are likely to increase perceptiveness but the information is useless unless linked to those with power to change the enterprise's direction (see Quinn 1980). Developing capabilities to enhance reaction postures was considered a priority especially when likely changes could not be envisioned let alone predicted.

### 6.3.2 Attitudes towards flexibility

A synthesis of the findings can do little more than point out salient features which emerge more clearly after the empirical findings have been presented. The first thing to note is that the attitude of the respondents toward flexibility varied considerably. IBM and Shell, for example, considered flexibility to be a major factor in policy formation. The former had developed a practice which promoted flexibility in a policy of non-redundancy. The ability to close down mature production capability was critical in a highly volatile industry with only months between innovation and diffusion. Planning product life cycles carefully and introducing new products without dislocating present product segmentation required a fluidity of production capability. An added advantage was that deploying personnel from, for example, production to field service engineer, in situations where mobility was restricted, would mean that people who had been involved in the manufacture of equipment would maintain it. This made for smooth transfer of information and reduced training costs; it also would be useful for designing new products. The policy of non-redundancy gave rise to other significant benefits.

The concept of flexibility ranked high within the 'Strategic Analysis Unit' in Royal Dutch Shell. The 'Committee of Managing Directors' sought to blend the various interests of the Group into a coherent and balanced form. Flexibility was

required to alter the balance as circumstances unfolded. The long lead times inherent in the production systems of the Group's portfolio necessitated a comprehensive analysis of alternative futures. These were generated using a variety of techniques, ranging from a systems dynamics model of the organization and its transactional environment to a larger model of the contextual environment. Members of the Group Planning Departments condensed and subsequently assessed these scenarios and technology forecasts in the light of the resource allocation requirements of business units.

In other organizations, the concept of flexibility was not explicitly introduced to cope with the possibility of capricious occurrences. The ensuing section will describe practices which participating organizations adopted to promote flexibility using examples to illustrate these practices. Since some issues were confidential, restrictions have been placed on access to this dissertation.

#### 6.4. Practices Adopted to Promote Flexibility

##### **Practice One: Multi-Resource Variable-Input Production Systems**

##### Supporting examples:

- i) Imperial Chemical Industries - Ethylene Cracker
- ii) Dalgety-Spillers - respositioning
- iii) CEGB - retrofitting

##### Discussion:

This refers to the ability to use two or more interchangeable or complementary basic ingredients in the processes upon which the organizations' production system depends.

In 1981, the investment in extracting a barrel of North Sea Oil was around 50,000 Pounds (personal interview, Oil Company Executive, April 1981), a figure almost ten times that required to obtain a similar amount from the Middle East. Given such uncontrollable rises in the prices of primary feedstocks, planning for capacity and resultant viability is complicated. Dependence on oil-based feedstocks has restricted the resilience of existing capacity in the face of 300% increases in primary inputs. Technological improvements in catalytic convertors allow butane and other forms of hydrocarbon gas to be used as a substitute for oil-based feedstocks, but at a higher initial investment.

ICI has commissioned an "Ethylene-Cracker" which can use both oil and gas-based hydrocarbon inputs. This additional

capability resulted in an overall project cost "significantly in excess of 10% of a comparable plant based on conventional capabilities". The extra initial cost, however, was justified not on the basis of a premium, but on the basis of "life-cycle viability". Other factors played key roles in evaluating such an investment's feasibility, particularly:

- i) the speed of transition between feedstocks
- ii) the cost of the transformation
- iii) anticipated volatility of prices
- iv) expected availability of feedstocks
- v) potential losses from dependence solely on a single input.

As plastics and chemicals constitute one of ICI's distinctive competences, this new capacity enhanced the Company's flexibility. However, the project's overall success is contingent upon many other exogenous factors, and such an investment decision is not made in isolation. There are major difficulties involved in predicting accurately exchange rates, cyclical changes and governmental attitude. Hence, this practice was tactical in nature because it did not provide the overall flexibility needed when the Group's portfolio has life-cycles measured in decades.

Dalgety is a merchant company whose interests span forestry, farming and financing operations. Technology is likely to become more of a strategic factor in their business portfolio. The Group's strategy had been seriously impaired by the

poor yield, resulting from factors beyond their control, of their agricultural interests in Australia, The weather played havoc with both crop yield and animal produce during the mid to late 1970s. This critical dependence inspired Dalgety to search for more efective ways of harnessing their capabilities in the region.

The Group's distinctive competence had been built up since the time, over a century ago, when it began financing and advising Australian farmers in symbiotic relationship. Successive years of poor results combined with escalating fertilizer and animal feedstock costs resulted in a deteriorating performance. The ensuing diversification into an apparently unrelated area was motivated by the need to rechannel the group's distinctive competence in finance and knowledge of the region. They subsequently invested in mining and mineral extraction in Australia. The technological significance of such a move cannot be discussed, yet the link between the existing business and the apparently unrelated diversification programme may turn out to be significant. This action was thus strategic because it repositioned the Group's interests in a way which is likely to prove complementary in future years; it is also a "creative" move because of the foresight needed to perceive possible connections to the Group's technology portfolio.

The electricity generating system highlights the inertia and inflexibility of investment programmes for "capacity en-

largements" based on extrapolated forecasts and unquestioned assumptions. However, the final illustration of this practice is at an operational level: new oil-fired generating capacity, commissioned before the increase in oil prices was modified to use feedstocks which they were not originally designed to burn.

During the course of discussions with CEGB (Midland Region), it became apparent that the practice of converting a number of plants to use coal/oil feedstock had been given priority. The cost of conversion was justified because of the lower fuel costs, but a constraint lay in the particle size of the ground coal, which limited the extent of substitution. This passive type of flexibility did not ameliorate a situation where expensive capital could be made to function at a reduced cost; rather it provided a useful testing ground for experimenting with coal-oil feedstock, which is expected to be a viable alternative when used with fluidized-bed combustion units.

## **Practice Two: Inter-firm Cooperation and Collaboration**

### Supporting Examples:

- i) Racal-Milgo: modems
- ii) IBM-MCA/Thorn-JVC: video-disc collaboration
- iii) Lucas/GM/Chloride: electric vehicles
- iv) BP/NCB/Babcock - C.S.L.: licensing fluidized-bed technology
- v) Racal/Pilkington: fibre-optics

### Discussion:

Technologies from unrelated areas have increasingly been converging to form hybrid systems. During the course of this study it became clear that many companies sought to share their knowledge, experience, and resources with other firms in order to gain mutual advantage. These relationships include standard licensing agreements, whereby a licensor is paid some percentage of the value of every widget coming off the production line. This option may vary in significance, ranging from a component developed by some other firm to the production technology per se, as in the float glass process over which Pilkington Brothers have virtual control. Where two or more companies have competence in related areas of technological expertise, flexibility can be achieved by symbiosis.

The relationship between Racal and Milgo illustrates this process clearly: the former specialized in tactical communications equipment (mainly for the military environment), whereas



the latter specialized in manufacturing computer communications devices (modems). Racal had an extremely proficient world-wide marketing system with a reputation for technological competence. This was placed at Milgo's disposal in order to give it access to the UK and world markets; Racal in turn acquired the technical expertise which was Milgo's forte. A minority shareholding was acquired in Milgo as a goodwill gesture. Racal's ethos was compatible with Milgo's which was to prove valuable when Milgo was threatened by a "dawn raid" on its shareholding. The technological symbiosis allowed Milgo to grow while giving Racal access to a market which complemented its technological expertise. Milgo was eventually acquired through the entrepreneurial flair of Racal's resourceful Managing Director. As Data Radio Communications amount to 77% of Racal's sales in 1980, the strategic significance of the Milgo link and subsequent acquisition can hardly be underestimated. (Data communications grew from the 1977 level of 29 percent of gross sales to 39 percent of gross sales by 1980). The Company achieved its resilient position in the market through a series of acquisitions in contrast to its earlier days when it produced military tactical radios; the same process lay behind the recent takeover of Decca complementing the Company's existing technological base with infra-red navigation technologies.

Domestic entertainment was another area where intra-firm collaboration and acquisition provided opportunities for tech-

nologies to converge. Video discs, which were marketed in the UK in October 1981, represent a major union of "high fidelity sound reproduction" using digital sound systems with a colour TV, creating a totally new media. A number of competing systems are available or almost available although in the absence of any internationally accepted set of standards and specifications, complete interchangeability is not always possible. Thus, some firms which possess a particular link in the technological equation can form cooperative arrangements. (This technology, incidentally, will contribute to a new developing art which will have an increasing impact on society.)

The link between Thorn-EMI and JVC over video disc technology exemplifies such a collaboration. The acquisition of EMI consolidated this relationship by providing a versatile portfolio of recording artists and distribution channels for the new technology, which some rock groups use to market their products through existing media. Using digital sound recording and reproduction techniques also represents a substantial departure from previous technology. Existing stereophonic systems reproduce digitally recorded music whose extra quality is immediately perceivable with, as Hume would say, force and vivacity. The temptation to describe this as an evolutionary change is to be avoided since once the technology has become widely diffused, (fibre-optics, or some other form of cable interlinking), the potential for entertainment libraries of

sound and/or visual programmes should add substantial variety to domestic in-house entertainment choices. The potential for interactive programmes (used for referenda or public debates) is also likely to be increasingly significant.

Automobile manufacturers have borne the brunt of the energy price explosion's impact. The drive towards more efficient transportation has caused manufacturers to turn from the ethos of opulence to one of technologically driven change. Lucas and GM's mutually beneficial collaboration on electric vehicles and diesel fuel injection equipment illustrates this "flexibility inducing posture". In the case of Lucas and electric vehicle technology, collaboration yields access to what is likely to be the first market for such vehicles: areas where environmental considerations dictate adopting them. This initial market, an invaluable testing ground for the full scale diffusion of electric vehicle technology, will afford the company some years of operating experience before global diffusion (if this occurs). From the perspective of strategic flexibility, it will allow Lucas to participate in the manufacture of an estimated 20,000 units by 1985, as is currently anticipated by G.M. It will further gain experience from the acid test of public scrutiny through substitution of current "Internal Combustion Engine" technology in cities such as Los Angeles, where environmental problems will assist the product's diffusion. The discerning, educated consumer will be quick to point out any

deficiencies in the product and this reaction should prove invaluable for higher volumes of production. The Department of Industry is assisting in a scheme whereby Lucas, Bedford (GM) and Chloride are actively participating in developing electric vehicles.

A tripartite collaboration "Combustion Systems Ltd.," jointly financed by BP, NCB, and Babcock & Wilcox, was formed to develop and market fluidized-bed technology. Some commentators see the relationship as an alliance between companies with different objectives, but the switch from oil to alternative fuels supports the view that "fluidized-bed combustion" will be an integral technology of Combined Heat and Power Schemes.

The final illustration of collaboration in furnishing strategic technological flexibility comes from the area of fibre optics, alluded to earlier in the discussion of the Thorn-EMI-JVC link. The first full-scale fiber optic links are being installed in environments such as the Birmingham-Euston rail link where security rather than band width is an overriding constraint. Another application would be electronic funds transfer (EFT), which offers untold opportunities to the banking and insurance sectors of the service industries. Yet, a source of consternation to many involved in "computerized banking" is their vulnerability, stemming from conventional telephone links which shunt around massive amounts of corporate and other monies. The electromechanical field of disturbance

set up around conventional wire communications media can enable someone to break into the system clandestinely. Various strategies have been suggested or introduced to minimize the risk of intrusions; among the most widely used are data encryption devices which scramble the data to an incomprehensible form. This is then decoded automatically via a number of microprocessors<sup>27</sup> which have appropriate keys activated by pulses in the data stream. As a result of defense and similar contracts, Racal developed an expertise in this area, but their recognition that the system is as vulnerable as its weakest link led them to collaborate with Pilkingtons. The collaboration was focussed on the development of optical fibres. Such a "cross-pollination" of complementary talents could lead to a useful symbiosis, aiding the diffusion of EFT and data communication. Fibre optic links cannot be broken into, as can conventional transmission media, and its value for security-constrained links is phenomenal.

In promoting flexibility, a necessary ingredient for a successful recipe will undoubtedly be those human factors which uniquely determine how feasible a collaboration will be. Considerations of trust, reliability, technical competence and human affability are not trivial matters in such relationships and Board level agreement does not always reflect itself in

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<sup>27</sup>Systems International, 1980.

working arrangements. The influence of government objectives in relation to technology policy also interacts with the private sector, as can be seen in the recent creation of a ministerial position in the U.K. to enhance information technology's diffusion. One feasible way to create a competitive industry is the development of European rather than national companies. The latter tend to expect to be awarded public contracts by virtue of their being indigenous to a country and further considerations of national pride, employment, and balance of payments tend to override competitive excellence and financial performance. This is a poor recipe for the self-determined creation of a technologically competent, economically efficient and dynamic industrial base which, it is hoped, will substitute for decaying primary industries.

There are several advantages associated with the development of European companies. First, interested organizations can save valuable time by putting together research teams from divergent areas of technical competence, thus reducing the transformation period in those cases where the fusion of interests is harmonious. Second, the ease of transformation improves greatly when a new venture has available to it the joint wealth of experience of companies operating in completely unrelated markets with idiosyncratic technologies. The third impact involves spreading the risks of the project to create a lower cost of error where the investment is substan-

tial. Fourth, the time needed to create an appropriate repertoire of responses to technological change will, in most cases, be significantly reduced by intersectoral and interfirm coordination. In the research conducted by Schwartz (1973), this type of collaboration is illustrated by Texas Instruments and Digital Equipment Corporation's involvement in the design of components for the "PDP II" range of mini-computer. It subsequently resulted in DEC attaining the position of market leader in mini-computer technology; a position which had significant implications for TI in its early days.

To attempt a quantification or ordinal ranking of any one factor's importance would require substantial encoding competence. The workability and eventual benefit of such relationships can only partially be predicted with any confidence and a number of examples could be used to support the argument that this strategy is dysfunctional. Two oil companies, Shell and Gulf and Western, attempted to develop jointly a nuclear power generating technology which was available, ostensibly, at the pilot plant development stage. The technological and other problems experienced in scaling up the reactor design caused both companies to withdraw from the project at a considerable loss. However, at a later date the reactor design was appropriate for a specific government requirement. The project was resurrected and some of the losses were recovered.

The criteria of success for such ventures are specific to the situation; for example, the speed of response engendered by a change in technology will depend on a competitor's ability to make similar changes or acquire the capability to design new production facilities. Thus, although the factors set out in the preceding section are pertinent for evaluating flexibility, one factor's dominance over another is dictated not by axiomatic logic but rather by pragmatic considerations and the stage of the policy formation process.

### **PRACTICE THREE: Shortening the Lines of Communication To and From Senior Policy Makers**

#### Supporting Examples:

- i) IBM - appeals procedure
- ii) Racal - weekly meeting of divisional chairmen
- iii) Plessey - Strategic planning Director in contact with both Group Chairman and Divisional staff.

#### Discussion:

In one form or another, communication transmits information about values, attitudes and grievances as well as markets, technology and management. To respond rapidly to threats or opportunities, policy makers should be able to transmit new



intentions and receive information in as short a time--but with as much clarity--as possible.

The upshot of this practice is to reduce two significant variables in forming or modifying policies as a result of unanticipated events. The first variable is the "decision activation time", i.e. the interval between a choice and its implementation; the second is the degree of clarity, i.e. the distortion inherent in the number of channels through which the information must travel. Information is continually distorted in order to accommodate personal ends within the overall corporate ethos. To assume complete truthfulness with no clandestine use of information is too naive for any normative study.

Notwithstanding this limitation, an historical illustration demonstrates the strategic significance of the practice in achieving flexibility. Despite their military origins, the formal strategic theoreticians are increasingly having their ideas examined by business strategists, (Widmer 1980). Napoleon, having inherited the command of the French Army, added the further ingredient which complemented two innovative strategic overhauls. The first of these, introduced by Bourcet some 30 or so years prior to Napoleon's taking command, was the divisional structure. On the battlefield, this facilitated the "Star" formation made famous by Napoleon. The second innovation, introduced by Guibert prior to the Revolution, raised the marching speed. The normal speed of march had been 60/70 paces

per minute, as used in the ornate drill sequences of the parade square, but Guibert, who disliked the impractical nature of training practices, tuned them more acutely to operational situations.

Napoleon's contribution was to replace the divisional commanders (most of whom fell from grace during the Revolution) with his trusted friends, which allowed him to convey instructions rapidly and to receive accurate reports of the operational and tactical conditions. Furthermore, the field commanders' familiarity with his viewpoint enabled them both to anticipate headquarter's intentions and also to have on hand a repertoire of recipes suitable to genuine situations when instructions were absent. Toward the latter stages of Napoleon's career, the repertoire lost its novelty, becoming ossified and predictable, although the Battle of Waterloo was by no means a simple strategic victory for the "Allies".

In a corporate environment, the ability to communicate various types of information (i.e. processed and packaged data), ranging from attitudes and new work practices to the segmentation of a market for an innovative product, is of paramount significance. This study found that a number of companies explicitly paid homage to this practice. Most notably, IBM, in addition to its other practices for inducing flexibility, instituted an appeals procedure which allowed any employee to communicate a deep grievance directly to senior

management. Thus, at an operational level, a potential line of communication joined the senior management (including the CEO) with every staff member.

Another architected practice was the allocation of corporate and divisional functions to individuals. This was enhanced by a matrix organizational structure which allows dexterity in implementing major changes and also facilitates rapid response to crises. As Jung observes "changes which seriously affect organizations are typified by general uncertainty, necessity of extraordinary resources, multiple simultaneous problems, time constraints, stress, changes in power structures and changes in communication and information patterns" (Jung 1979).

Technology plays a crucial role in determining the strategic positioning and competitive strategy of firms within a particular industry. In the computer industry, lead times between innovation and maturity have been shrinking. In order to respond proactively, IBM has seriously considered the flexibility inherent in its policy formation practices. For continuous innovation, this flexibility may take the form of phasing in incremental product changes so that the newer product does not impinge upon the existing market for another product. On the other hand, a discontinuous technological change, such as the introduction of a completely new range of machines, may require organizational restructuring, i.e. refor-

ging the lines of communication, control and internal competition<sup>28</sup>. Such an overhaul was undertaken in 1981, creating a novel organizational structure, focussed on its markets.

Another company in the information industry, Racal, similarly attempts to keep its lines of communication as effective as possible. Racal achieves this at a tactical level by maintaining an almost patriarchal ethos within the company, reflected by a very low rate of labour turnover. At the strategic level, the Chairman maintains contact with divisional Managing Directors by weekly meetings to discuss pertinent issues. As a result of the relationship built over time, those problems of conflicting divisional interests which are likely to impinge on the Group's overall functioning are swiftly detected.

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<sup>28</sup>Courageous decisions such as the scrapping of the F-S program in 1978 (EDP Analyzer, Nov. 1979, "Get Ready for Major Changes").

**PRACTICE FOUR: Proactive Response to Anticipated Legislation  
and Litigation**

Supporting Examples

- i) Shell: unleaded petrol
- ii) BP: acquisition of Seltrust and Kennecot
- iii) Chloride: lead smelting
- iv) Dalgety: nitrosamine extraction
- v) IBM: anti-trust suits.

Discussion

An increasing reliance on technology defines a company's competitive strategy and makes it vulnerable to changes in government policy which can result, for example, in the withdrawal of subsidies or the imposition of stringent safeguards. Other types of legislation may exert a powerful influence on a company's positioning and strategy, as is illustrated by the deregulation of interstate banking or the moratorium imposed upon nuclear power station licensing in the U.S. In certain circumstances, recognizing impending changes early and taking appropriate action before the legislation is introduced may improve the overall flexibility of the company's strategic positioning when legislation is ratified. Such responses are contingent for their success upon a number of factors which include the following:

- i) severity of the likely impact of legislation
- ii) cost of compliance
- iii) uncertainty surrounding the impact of such change on competitors
- iv) perception of the risks involved which motivated the introduction of the legislation
- v) configuration of the systems which are affected.

The first example to be discussed actually seems to question the effectiveness of this approach. During a discussion, a senior executive of Shell (personal interview 14.4.81) related this practice's power in inducing flexibility to the company's experience when introducing unleaded petrol in the US market in 1969. Cognizant of the changing perception of the hazards of lead in petrol (McEvoy 1979), Shell took an early lead in switching its marketing outlets to accommodate what had been anticipated as a socially desirable change. However, the resulting short-term loss of market share called the wisdom of such a move into question. In the long run, however, the increasing effectiveness of Shell's distribution outlets was partially attributable to its commitment to serve society's needs sensitively.

Turning to the UK's other leading oil company, BP, one is led to speculate that the timely ventures in Alaska, which partially compensated for the 45% reduction in its crude suppliers as a result of the Iranian political upheavals, were due more to luck than to judgement. The company's acquisitions of

Seltrust and Kennecot could signify its recognition of changing international legislation in ocean bed mining. The acquisition of the mining house Selection Trust and the further acquisition of Kennecot Corporation by Sohio cemented the strategic direction of one of the business areas BP earmarked for future expansion. The "Law of the Sea" Treaty remains to be ratified. Kennecot and BP were members of a consortium set up to explore the feasibility of seabed mining some years ago.

On a more tactical level, Chloride, the battery manufacturer, was concerned that changes in regulations regarding lead emission from smelters might adversely affect its US operations. Abating pollution by retrofitting was costly and would probably have damaged its competitive position. As it turned out, the economic recession reduced the level of demand for most consumer goods, especially cars, and hence batteries as well. This further illuminates the poverty of relying solely upon anticipations about likely futures.

The penultimate illustration demonstrates clearly that the much-maligned invisible hand of the market can still flex itself in a positive way. One of the essential ingredients for producing whiskey is malt. Dalgety's subsidiary, Associated British Maltsters, is a major supplier of this product. While traditions surrounding the production of whiskey are largely sacrosanct, some research concluded that nitrosamines generated in the malting process may have deleterious health effects

(over and above extended periods of inebriation). Voluntary steps were taken swiftly to remove the offending substance, although before any major legislation could be introduced, much more evidence on the "hazardous" substance would have been needed. In this case, however, the market was likely to be a more efficient way of motivating changes due to enlightened self-interest. The decision to remove the offending substance was based on two counts: first, despite the evidence's ambiguity, the probability of potential teratogeneity was greater than zero; and second, the perception that a product might be suspect would lead customers (i.e. the whiskey manufacturers) to search for alternative sources of supply.

Finally, the case of IBM's anti-trust manacle is worth considering. IBM was involved in legal disputes in the US and Europe concerning the use of its competitive position in the market for mainframe computers. This burden has severely constrained the innovatory process, a long-standing tradition in Watson's spectacular venture. While the market for microcomputers and other "person-oriented" systems has been rapidly expanding, IBM has not been able to develop a strategy for entering this lucrative market until very late in the day. Its overall performance had begun to divide the company into smaller units when the litigation was anticipated. This outcome could have been unfortunate, however, if the company's style of organization and corporate approach would have been



jeopardized. In the event, the suit was dropped and a major corporate restructuring was implemented in line with its new product segmentation strategy.

## **PRACTICE FIVE: Redeployment of Key Personnel**

### Supporting Examples

- i) BP chemicals
- ii) ICI - rotation of senior staff
- iii) IBM - job security policy

### Discussion

In a written response from Ford (UK), the respondent argued that the most "flexible policy is to secure in an organization people who are competent, have the drive to succeed and determination to manage.... There are various techniques for improving performance. They all depend heavily on gathering and analysing information and the use of logic. They can be no better than the people who apply them". Most participating companies also considered personnel to be one of the most vital ingredients in achieving flexibility. This factor is particularly critical at a senior level; as Quinn argues (1980), a major policy change may not be accomplished until the balance of power had been rearranged, a process invariably redeploying key personnel. This happened at BP when the chemical division

was suffering from the combined effects of overcapacity and market contraction. BP anticipated a considerable amount of acrimony and dissatisfaction as a result of the policy of contraction which it deemed necessary. Thus, the divisional number two man was redeployed and when the furore died down, the number one man was replaced by the previous number two man, once he had implemented the required changes.

On a more strategic plateau, the planning director at ICI, who previously held a senior position in the company's Canadian Group, was transferred for three years to the Group's Headquarters to orchestrate, among other things, the weaning away of the company's dependence on UK-based production facilities.

As stated previously, IBM's policy of job security gives it a considerable degree of flexibility. Product migration strategies are thus formulated on the basis of complete confidence that obsolete production capability can be disposed of without fear of resistance.

IBM's innovative attitude has many features which collectively have enabled it to achieve and sustain its powerful market presence. Specifically, the policy:

- i) provides psychological security for all its staff
- ii) aids rapid product migration
- iii) captures the experiences of production personnel who can often be transferred to field customer support
- iv) stimulates the development of a corporate culture which encourages rather than resists change

- v) instills a socially acceptable commitment in all its staff

On an individual level, the type of flexibility is related to the range of novel situations in which a person can successfully act, in accordance with corporate goals. It is also connected to ability to modify objectives in the light of strategic changes, so that the company's internal components are appropriately positioned. Alternately, a double shock, technological hiccup, or ricochet may necessitate altering generic ends which are likely to be compatible with the transformed situation. The perspective which steps above the realm of daily operations and perceives the company as a whole is called 'helicopter vision' at Shell, and is a quality which the company encourages in its executives.

## **PRACTICE SIX: Incorporation of Incremental Technological Innovations**

### Supporting Examples:

- i) Pilkingtons : robotic glass cutting and polishing
- ii) Lucas : diesel fuel injection
- iii) CEGB : coal/oil slurry fuel
- iv) Dalgety : laser controlled timber cutting

## Discussion

A firm's competitive position can be improved substantially by incorporating new features into existing products or by achieving cost reduction through modification of process technology. (In some cases the modification may be required for regulatory approval). The ease with which such incremental changes can be implemented is critically dependent on a number of factors including:

- i) Stage of product/process life cycle
- ii) Cost of modification
- iii) Difficulty of modification
- iv) Disruption to other activities
- v) Rapidity of changes

New techniques are continually being applied to existing machinery; the old lathe, for example, has been significantly affected by microelectronics, resulting in numerically controlled machine tools. The frequency of this practice varied considerably depending on the business and technology portfolio of the companies in the study. In analyzing this practice, it is useful to distinguish between those improvements which will supplant existing methods and those which facilitate evolutionary development. Figure 6.1 depicts some of the variations which may arise with respect to such changes:

Figure 6.1 Types of Technological Change

Change Impact	Primary			
	Innovation	Diffusion	Convergence	Modification
Continuous				
Discontinuous				
Congruent				
Dynamically Discontinuous				

\* \* \* \* \*

Each type of change may require a special type of response depending upon the portfolio and the significance of the innovation.

As Quinn reported (1977), and the researcher confirmed during further discussions, Pilkington Brothers' dramatic innovation revolutionised the glass manufacturing industry. Over the last decade the company has pioneered the use of robotics in glass cutting and polishing, previously a task requiring extremely skilled staff. The company had enjoyed cordial relations with its workforce throughout its history but introducing this new equipment displaced highly skilled personnel. The ensuing strike damaged the company and was only concluded by negotiations which allowed the "gradual" introduction of the robotic devices. The company recovered sufficiently to embark

upon a major takeover of a European competitor in 1980. It has diversified into fibre-optics as described in Practice Two.

Dalgety did not experience this difficulty when it introduced laser controlled wood cutting equipment in its Canadian forestry operations. The resulting impact was dramatic, raising timber yield from 40 percent of the log to an impressive 70 percent. By further reducing the proportion of cuttings to usable planks, the price of the chips, which had previously been low because of the high wastage, also rose. The chips were used for making chipboard, which became more expensive as the supply of chips was reduced. The company had experienced difficulties in attracting skilled loggers to its remote sites, and so the improvement boosted its competitive posture. It also reduced the amount of timber felled in order to yield a given quantity of wood.

Another example of this practice is found in CEGB, which was experimenting with a coal/oil slurry fuel for its "mothballed" oil-fired stations, built before the dramatic rise in the price of oil. The limiting factor was the size of the coal particles held in suspension, which determines the amount of coal which can be used. Using the existing capacity has a 'two-fold benefit' since it both reduces the costs of meeting peak demand and provides valuable data about coal/oil slurry, which is anticipated to be a major fuel source in fluidized bed combustion units.

In an industry confronted by problems due to competitive pressures and the global recession, Lucas has been making major steps to carve out a market niche based on its growing distinctive competence in fuel injection equipment. The Group has developed diesel fuel injection technology adopted by the leading car manufacturers who are anticipating a significant trend towards the use of diesel engines in the domestic transportation market.

Recently, Porter (1981) discussed the importance of technology in a firm's competitive position. The role of technology is not always restricted to those "superstar" or "Cinderella" technologies which dramatically revolutionise an industry, as did microelectronics and nuclear power. In some cases, as in the Dalgety example, a small evolutionary change can have a significant impact and provide a considerable degree of flexibility. Thus, the ability to incorporate incremental innovations is critical for many firms.

**PRACTICE SEVEN: Contraction Planned so as not to Endanger  
Future Operations**

Supporting Examples:

- i) Southern Pacific - disposal of rolling stock
- ii) Thorn-EMI - body scanner divestment to G.E.  
and Philips
- iii) Racal-Decca - Coordination of technology portfolios

Discussion

The notion of economic cycles is hardly new, yet it seems surprising that so much attention is paid to predicting peaks and troughs during a downswing. In businesses which are critically affected by the combined effects of technological change (including public concern over risks) and economic 'stagflation', the tendency was to dispose of those assets which were not generating an adequate return or which were likely to show shrinking returns in the foreseeable future. This was not always possible in areas such as the chemical industry where chronic overcapacity could only be resolved by closures. Yet, to control costs in a negative cash flow situation one must look to the future and estimate the risk of holding a 'dog' against its possible metamorphosis into a more desirable asset. This happened to Southern Pacific whose original business portfolio was largely in the railroad industry, although it is now sagaciously diversified. Following the down-turn in demand for



commercial transportation after the Oil Crises a high proportion of relatively old inefficient locomotives and rolling stock was disposed of in order to restore profitability. However, the discovery of a substantial mineral deposit in New Mexico significantly raised the need for transportation which in turn demanded more capacity than was available in the Group at the time. The Vice President in charge of corporate planning cited this as a good example of how a potential longer term benefit was weakened because of short-term expediency. Had they retained the old stock, whose capital cost had long been discounted and whose storage charges were negligible, the negative cash flow caused by mothballing the stock would have been more than adequately compensated.

The next example of this practice involves a case where a company introduced an acclaimed innovation which could not be managed to yield a return. The body scanner, developed by EMI, was a major step forward for health care systems. A coordinated effort was required by marketing, maintenance and financial personnel to develop a strategy for bringing the product from the laboratory to the hospital. Unlike G.E., which has claimed an impressive 80 percent up time for their scanners (produced by licensing the EMI-Scan technology in the U.S.), EMI was beset with problems, primarily in field support. When EMI was acquired by Thorn, whose distinctive competence was in the white goods sector, the "EMI-Scanner" operation was sold

off to G.E. By divesting this part of the business, the new company defined its strategic thrust more precisely and so developed a new image aimed at making inroads in new domestic entertainment technologies. EMI's recording artist portfolio and manufacturing capacity naturally enhanced the new image and direction.

The final illustration of this practice has a bearing on the previous case. Racal, with a distinctive competence in communications, had grown by a series of acquisitions which generally doubled the size of the company. In February 1980 (F.T. 15.2.80) Racal took over Decca for 101 million Pounds, after an initial bid of 60 million pounds. The connection to the case above lies in the fact that those sectors of Decca's portfolio which were not in keeping with the new group's strategic thrust were divested. The Decca acquisition was intended to improve Racal's infra-red communications technology portfolio. Racal had generated the financial resources the previous year by selling shares worth six million Pounds in Plessey, the Electronic's Company, and 102 million Pounds worth of its Extel stock. Liquidating these assets in the face of a deepening recession was a brave move. Decca was a much sought-after prize, as the ferocity of the "take-over" negotiations showed. The early contraction in its cash resources did Racal no long-term damage; indeed it put Racal in a position to add a large pane to its technology window.

Of course there are no "cure-all" solutions to the problems of what and how to contract. The success of contraction in putting the company in a stronger position will be contingent upon other practices. (In IBM's case, for example, the transition is made easier by its non-redundancy policy). One general observation from many participants was that contraction ought to be carefully assessed so that potential opportunities could be grasped.

**PRACTICE EIGHT: Inculcation of a Calculated approach to Risk  
Taking**

Supporting Examples:

- i) Lucas - US electronic venture
- ii) Socal - CETUS investment
- iii) Pilkingtons - St. Helens Trust

Discussion

The complex international environment facing firms with diversified technology portfolio operating in widely disparate geographical regions distances the corporate headquarters from all its operations. The situation is further compounded by the competitive strategies adopted within a firm's domain entailing new coalitions, mergers, acquisitions and the opening of

new technology windows. The constantly oscillating economic and political factors which influence global and domestic activities, highlight the need for an evolutionary posture.

New ventures involve risk. Even existing products and processes may contain unwelcome surprises. Embryonic technologies in the research and development phase must be evaluated and selectively replanted. Migration to a new product segmentation strategy will require geographical and technological coordination. Gaining access to new markets may be a lengthy, incremental process due to cultural barriers which must be gently traversed. It can be perplexing to develop an appropriate corporate response in areas where uncertainty is high and the chance of an unfavourable outcome is large. Professional managers participating in the study were cautious in denouncing intuition in such circumstances. The consensus of opinion was, in order to improve judgement prior to major strategic repositioning, it would be prudent to have a successful venture "under the belt" to help build up confidence.

The major areas where prior success had an impact were new ventures involving the following:

- i) interfirm collaboration and cooperation
- ii) the acquisition of a technology window
- iii) gaining a foothold in a new geographical region
- iv) introducing a new product or process
- v) embarking upon a major acquisition.

A number of formal analytical techniques have been developed to aid such decision-making. Although they were once incorrectly considered to supplant intuition, approaches such as comparative risk analysis, decision analysis and technology assessment are increasingly used to complement intuition. This study found that three reasons appeared to be instrumental in their increased acceptance:

- i) growing diffusion of the microcomputer-based information processing system
- ii) Realization that plausible reasoning processes degrade with the number of variables in the problem. The sensible approach selects those variables at the appropriate level of variety which capture the complexity of the issue. Techniques such as influence diagrams have been developed for this purpose.
- iii) Recognition that dispersed decision-makers require an unambiguous vocabulary in order to communicate contrasting view points. This is especially useful where strategy centres must act in concert, yet are constrained in developing an informally accepted private language because of geographical considerations.

During the course of discussions, executive strategists perceived that a number of cases supported this practice.

First, Lucas wished to gain a foothold in the American market but it would not have been in a position to make such a major move for some time, given the constraints imposed by the recession on the car industry. Notwithstanding these short-term considerations, successfully acquiring a relatively minor company was likely to increase the decision-makers' confidence--just as an athlete's would be encouraged by a comfortable match in the early round of a competition. The acquisition, in addition, would provide an opportunity to make difficult decisions without the tension associated with a major allocation of resources, while incorporating many elements of such a situation.

In another example, Standard Oil of California, in association with another oil company, took a prudent minority holding in a genetic engineering firm "CETUS" when it went public. Such a move opens up many options for later consideration, which in view of the distribution of patents to gene-splicing companies ought to prove a sagacious move.

The last illustration of this practice differs from the preceding examples in that the risk-taking support was extended beyond the confines of the company. Pilkington Brothers, the UK glass manufacturing company, had long recognized the importance of establishing a harmonious relationship with the local community in St. Helens, which was and still is highly dependent on the Group for employment. Having realized that many

good ideas are generated either within their own research and development facility or by an aspiring entrepreneur in their workforce, St. Helens Trust was set up to provide venture capital and expert advice to prime the formation of new companies. To date the exercise has proven successful and sets an example which many companies are seeking to emulate.

#### **PRACTICE NINE: Blending of Trans-national Portfolios**

##### Supporting Examples:

- i) Shell - Regional autonomy
- ii) Pilkington - South American investment
- iii) Plessey - South African divestment
- iv) Lucas - Japanese presence
- v) Socal - Offshore development

##### Discussion

The Phoenicians perfected the art of multinational trade long ago. Now, equipped with increasingly sophisticated communication and transportation systems, most large companies carry out their operations in many countries. The location of production, distribution, marketing and sales, as well as post-sale support facilities, is critical in exposing companies to the various types of risk inherent in transnational operations.

Being able to adjust involvement within different countries turns out to be one key to strategic flexibility for the modern corporation. Exposure to risks associated with various levels of involvement in different countries (ranging from having representatives in the market to developing primary manufacturing capability) is a complex issue involving political, economic, socio-cultural and ecological considerations. Some participants in the study valued this practice highly as a crucial ingredient of "strategic flexibility". The emphasis varied, however, according to the nature of the involvement and risks in a specific country or region.

At Royal Dutch-Shell, the trans-national portfolio comprises a number of autonomous operating companies which are run by the nationals in each country. Implemented in 1947, the practice has been extremely successful since, from a practical standpoint, it gives a great deal of manoeuvrability to a very large concern. During the course of an interview, it was suggested by an executive that a primary function of the "Committee of Managing Directors" was evaluating the company's flexibility and then improving it by tuning the transnational portfolio to get the best blend of ingredients.

Turning to a more specific issue, the location of production facilities in South America had been the concern of Pilkingtons. The company was interested in formulating a strategy which would serve the growing market for their products (parti-



cularly car windscreens) in two geographical regions. Lucas, on the other hand, had considered closing its Japanese operations for financial reasons. After considerable deliberation by the Strategic Planning Group, it was decided to remain in the country because it was difficult to gain credibility without a sustained presence in the market. Thus, although a negative cash flow may result in the short term, the longer term benefits may outweigh the losses.

In all the cases the paucity of methods for evaluating risks within the transnational portfolio clearly exacerbated a complex situation. Flexibility was a vital ingredient, primarily because of the volatile and unpredictable elements in international affairs, as B-P found to its dismay in Iran and Nigeria. However, the exploration capability at B-P had brought new reserves to the company which provided alternative sources at the appropriate time. In conclusion, one can scarcely understate the importance of flexibility in dealing with political fluctuations. The influence any company may exert on world affairs is minimal and so flexibility is sought for survival in this field.

**Practice Ten: Coordination of internally diversified diffusion  
of new technology.**

Supporting Examples:

- i) ICI - policy committee on microcomputers and information processing technology.
- ii) Reed International - evaluation of the impact of
  - a. information technology
  - b. robotics
  - c. genetic engineering
- iii) Bank America - teleconferencing

Discussion

A growing body of experience suggests that companies which manage to initiate new technology contiguous to existing methods are more likely to be successful than those adopting a fixed, rigid strategy. More specifically, it has become apparent that information technology in the form of microcomputers and telecommunications (which are diffusing at a rapid pace) cannot be implemented without careful planning. For example, a number of business units all go their separate ways in implementing information systems, each using different and often incompatible equipment to solve problems; some of these problems are specific to their environment, others are contingent upon other parts of the company, and a few are identical across business areas. An often costly and detrimental syndrome is

the "NIH" or "not invented here" syndrome which can lead to duplicating efforts, or reinventing the wheel in diverse parts of the organization. As one company in the first-time user study found in these cases, it is difficult to pull together such diverse systems without replacing the many and various configurations with compatible equipment. Furthermore, the political implications which accompany the alignment of business units (so that they can be directed in unison by the centralised management) are tremendously significant, particularly when the autonomy of a business unit is highly prized.

To avoid this problem, some of the companies participating in the study have set up "Policy Committees" to facilitate the coordinated diffusion of such technologies as robotics, information systems, and genetic engineering. This serves a number of purposes, such as establishing internal expertise which can be shared by those sections of the organization which have operational problems related to implementing similar technology. Establishing internal user groups to share experiences can be invaluable in resolving psychological as well as technical problems. ICI had set up a policy committee to oversee the acquisition of microcomputers and to develop a coordinated approach for using information processing technology. At Reed International, the planning director had undertaken to evaluate the impact of such technologies in the broader environment. A technology assessment had been conducted to evaluate the econo-

mic, social and political consequences accompanying the diffusion of genetic engineering, robotics and information technology; all of these were heavily coupled to the production and client environments in which the company operated. Bank of America's primary concern was directed towards "electronic funds transfer", associated security problems, and the diffusion of teleconferencing for international loans.

A common idea generally observed in all the companies was that the internal strategy-technology coupling was a vital ingredient in adapting to change. Recently, Porter (1981) argued that technology forms the foundation for a firm's competitive strategy and is therefore a necessary component in its continuing viability. The internal linking of strategy and technology is emerging as a vital ingredient for the cohesiveness of a diversified corporation.

### **Practice Eleven: Output Variability**

#### Supporting examples:

- i) Lucas Industries: new plant
- ii) C.E.G.B.: pumped-storage hydro generating station
- iii) Shell: computer-controlled refining
- iv) N.C.B.: production inflexibility

### Discussion:

At the time of the study, manufacturing industry was suffering from the combined effects of a severe recession and geo-political turbulence. As a consequence, production volumes had to be continuously adjusted to avoid overstocking with associated costs of tying up resources in slow-moving products. Two strategic postures can be prescribed to deal with this problem. The first was suggested by Hart in his thesis on flexibility<sup>29</sup>, which advocated ability to manufacture semi-finished goods when fixed costs could be readily converted into variable costs. Following this line of argument, the ability to vary production volumes in accordance with the uncertainty of the selling market places a premium on plans which lend themselves to revisions without loss. A number of the participating companies were experiencing difficulties because they had invested in a productive capacity which allowed little variation in volume (upwards or downwards) before excessive marginal costs were incurred.

This difficulty was especially acute at the National Coal Board where production volumes could only be varied by 1 per-

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<sup>29</sup>"If all the possible market contingencies are very much alike, and if a flexible program offers very high costs in case expectations are confirmed, flexibility will not be carried far. If the range of reasonably probable market contingencies is large, and if flexibility offers only small disadvantages in case expectations are confirmed, flexibility will be pressed to the limit". (Hart 1940)

cent (upwards or downwards) per annum. This severely restricted the response to changing market conditions, particularly as Australian and South African coal was being brought on stream by oil companies responding to the most recent OPEC price hike. Alternatives to varying production volumes which could influence output were politically unpalatable, since they involved closing down pits. Government employment policies were compounded with industrial relations issues when NCB considered production contraction. The ability to increase output was severely constrained by the speed at which new mines could be developed. Long lead times, inherent in capacity expansion, led to difficulties in justifying the exploitation of green-field sites such as the "Vale of Belvoir."

In the oil business, the massive expenditures involved in off-shore production and the risk of expropriation in volatile regions also tend to place a premium on the ability to vary output. Research missions were being developed to enhance recovery methods for off-shore reserves and tar sands which could increase the recovery rate from 25 per cent to 32 percent of the available reserves in a field. The methods tested ranged from chemical to thermal-based technologies; injecting carbon dioxide into a reservoir was a promising technique while tar sands presented a bigger challenge. In addition to these methods specific programmes sought to use biological techniques aimed at transforming tar sands into a more readily extractable

substance which could be easily processed in order to produce lighter end of the barrel fractions.

Lucas was investing in a new plant where production volumes could be varied between a factor of 2 to 5 with marginal cost changes kept to a minimum. This modular view of production units represents a significant departure from the economies of scale paradigm. The justification for choosing the modular view stems from:

- i) the technological opportunities for flexibility
- ii) range of uncertainty surrounding anticipated market size.

The rate of change in technology would seem to mitigate against being locked into a particular technological process which may be replaced by an incremental innovation requiring new production systems.

In battery manufacturing a technical innovation, a sealed-unit requiring no topping-up, led market researchers to estimate that the newer type of unit would capture most of the original equipment market by 1985. Existing production facilities can not be incrementally modified to manufacture this new type of battery, but, instead, require complete refurbishing since the technology is so different. (The use of plastic frames as in Dunlop's Pulsar holds significant promise)<sup>30</sup>

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<sup>30</sup>Financial Times, June 30, 1980.

As batteries account for about half the lead used in the world, this trend has strategic ramifications for those companies locked into refining, capabilities. Thus, where integration of lead smelting, refining and battery fabricating represent a significant part of a company's portfolio, such as Chloride, a move into the newer type of unit was viewed as a necessity. A competitor, while recognizing that change was imminent, withheld investment in new facilities until the situation became reasonably clear before deciding to embark on such a venture.

Another example supporting this viewpoint was the investment in pumped storage generating capacity undertaken by the C.E.G.B. at Dinorwic. The scheme was designed to take advantage of the low unit costs accruing from the continuous operation of nuclear units even when there is no immediate demand for their output. The energy stored in the pumped hydrostation could be brought on stream to meet peak demand. According to the C.E.G.B., the response time of the pumped storage unit for meeting a surge in demand is phenomenally short; an output of 1320 MW can be achieved in 10 seconds, thus "allowing conventional thermal power stations to continue operating at their most efficient output rather than being run at uneconomic part-load for short periods or shut down".<sup>31</sup>

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<sup>31</sup>Source: C.E.G.B. publication - Dinorwic Pumped-Storage Power Station, February 1979.



The range of variability of output, the cost of variation, and the speed by which the volume of production can be modified determine flexibility relative to the fluctuations in the market-place. The investment in production capacity which is higher than "conventional" units is justified because "conventional" units are no longer viable when fluctuations in the market are severe.

## **Practice Twelve: Reshaping divisional plans**

### Supporting Examples:

- i) NCB - Realignment Strategy
- ii) Reed International - repositioning
- iii) Plessy - Holography

### Discussion

On surface, this practice bears little relationship to the issue of flexibility. As the Director of Planning at the NCB remarked (personal interview September, 1980), a central issue of flexibility involved making centralized control commensurate with operating autonomy. The ability to vary output, at the time of the study, was restricted to approximately 1 percent of total coal production per year. With such a long response time, the pursuit of flexibility was likened to the ability to water-ski behind a supertanker. (Personal Interview September

1980). The reaction time of the system in responding to changes are as depicted in the table below.

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Table 6.3 Control Options Open to NCB

<u>OPTION</u>	<u>SIGNIFICANCE</u>	<u>LEAD TIME</u>
Open new deep pits	Strategic	10-12 years
Commission open-cast mines	Strategic	3-5 years
Increase the proportion of low cost pits	Tactical	7-11 months
Extend existing mines to full capacity	Tactical	3-5 weeks
Substitute capital for labour	Tactical	3-5 weeks
Stock pile	Operational	Weekly/Daily
Suspend high marginal cost production units	Operational	Weekly/Daily
Find new customers	Operational	Weekly/Daily

\* \* \* \* \*

Such a response time severely circumscribes the ability to adapt quickly to changed circumstances and to compete with open cast mined reserves from South Africa and Australia. The National Coal Board is organized on a regional basis and instead of adopting a centralized planning system, undertook this on a

regional basis. The plans were formulated on a participative basis and coordinated by the central planning office. Having agreed upon a negotiated strategy, the Union expressed their concern with some tenacity, forcing Mrs. Thatcher's government to recapitulate. Despite the subsidy which was offered as an olive branch to the Board, the financial basis for its long term viability was subsequently weakened. This started a rapid revision of regional plans on a much restricted time frame. Sir Derek Ezra's corporate plan "Coal 2000" was undermined; In the longer term, the coal mining industry has had to locate new sites for deep mines which are likely to incur controversy, as was the case with the "Vale of Belvoir". This type of environment is not particularly conducive for strategic planning. In the face of such adversity, the practices adopted by the National Coal Board to promote flexibility were focussed on two critical issues:

- i) Effective decentralization so that flexibility existed for special arrangements which could be made at local rather than national level.
- ii) Centralized coordination of the Long-term strategy of the organization.

In discussing this practice, much emphasis has been placed on the NCB because of the Board's need to reshape regional (divisional) plans in the light of government action. Similar practices emerge as a result of transnational exposure to

policy changes in host communities. Shell had astutely adopted a practice in 1947 which gave partial autonomy to its regional operations and provided the group with the ability to reshape plans in the light of the changing international scene and the requirements of specific local situations. In a firm with a dispersed portfolio of activities, or one which relies upon innovation as a central plank of its competitive strategic posture, the ability to integrate divisional aspirations into a corporate plan requires skills of diplomacy as well as strategy.

Most of the strategic planners participating in the study held the view that an important phase of the annual planning cycle was the "smoothing out" of divisional plans. The corporate strategic planners must interpret the Board's viewpoint and consider the attitudes of other divisions. This generally took place prior to the corporate appraisal of divisional budgetary aspirations and resulting resource requirements. The director of strategic planning at Plessey pointed out that this optimism is a healthy phenomenon which ought not to be discouraged since it tended to indicate that a division was 'biting at the bit', i.e., was keen to expand, consolidate, or reverse a trend (Personal interview January 1981). Often a mismatch is likely between the divisional and the corporate perception of the situation facing the company. The 'Weltanschauungen' or mind-sets of the divisional units which normally operate in only one business area do not always embrace the complexity of factors

affecting the groups' involvement in other strategic business areas in which it may want to diversify.

Prior to the implementation of Reed International's divestment strategy, the company was active in many diverse strategic business areas. After the dust had settled from the pruning of the company's portfolio, Mr. Chandler said the problem was:

It is easy enough to derive a strategy for a single business, but to put 60 together and optimise within your limited resources is a highly complex task. (Financial Times, 21 July 1980)

Sharp yet subtle coaxing, assisted by a strong corporate strategic viewpoint, was required to communicate the message that the business units, though semiautonomous, had to develop an approach which would give due cognizance to the impact of their tactical manoeuvres on the Group's other business areas.

Optimism can be a dangerous liability for a divisional unit which hopes to harness a new and as yet untried technology. The initial enthusiasm and excitement displayed by engineers can lead to an appraisal of the technical and financial feasibility of a project which overestimates or misplaces either the capacity of the division to incorporate the innovation or the qualities of the technology itself, e.g. holography in Plessey. On the other hand, should this optimism be constantly rebuked, it could seriously impair the company by changing its internal ethos.

The strategic planner must employ diplomatic skills, as well as technical planning expertise. The artificial separation, generation, approval, and implementation of strategic plans does little to highlight the difficulties of the task.

### **Practice Thirteen: Decisive Leadership**

#### Supporting Examples:

- i) Racal Electronics - Milgo and Decca Acquisition
- ii) Pilkingtons - Policy document +  
Float-Glass Process Innovation
- iii) Dalgety - Modification of Regionalisation  
Strategy - Spillers Acquisition

#### Discussion

In a country whose industrial prowess was fired by the entrepreneurial spirit, the role of leadership in corporations has in some cases become subsumed in a quagmire of bureaucracy. The tradition of strong leadership persists in the 1980's and plays a considerable role in steering an organization through capricious times. An underlying talent is the ability to motivate in times when an action or course of action seems to be lacking in credibility or when backs are to the wall. The highly individualistic qualities of a leader can, of course, be used to good or bad effect.

Policy and strategy may converge at the apex of an organizational hierarchy. When used effectively, the response time to strategic issues can be significantly shortened by firm action by a leader who coalesces the various power groups behind unified aims. By reducing organizational inertia, the strategic thrust of a corporation may be more rapidly realized to meet the challenges of the day. This allows dispositions to be focussed and allows concentration at the decisive point.

Several examples can be used to support this practice but few prescriptive guidelines can be suggested to implement this practice. When Racal Electronics were confronted with an unexpected takeover bid for a company with which it had entered into a successful joint venture, the chairman wasted no time and merged the two companies. At Pilkingtons, the tone of the organisational ethos was set by Sir Alastair's valiant persistence, which gave rise to the float-glass process which he spent the best part of a decade perfecting. Quinn (1977) eloquently describes this long and sometimes painful quest. As a testimony to the leadership started by a family, rather than an individual, the policy document drawn up by Sir Alastair, has lasted some fifteen years.

The situation was different at Dalgety when, in 1978, its new chairman was faced with rapidly growing cash flow problems as a result of poor weather in Australia which caused low yields in its agricultural business concerns. The company had

embarked upon an ambitious overseas expansion programme which had proven difficult to manage. Upon taking the helm, the new chairman took three measures to ameliorate the situation:

- i) Stream-lined management communications: There were 26 head office staff in 1979. This high visibility enabled managers of its profit centres to contact appropriate persons swiftly and thereby facilitated the flow of information.
- ii) Regional companies were motivated to operate autonomously within host countries.
- iii) A trip ratio management control system was initiated (see practice sixteen for further elaboration on this system).

When Dalgety took over Spillers, the chairman, David Donne, was criticized for taking too much of a gamble. However, Spiller's animal feed business was complementary to Dalgety's existing business, in which they exhibited a distinctive competence. Donne had carefully considered their ability to integrate Spillers' food business during some 13 months of investigation prior to the takeover bid.



## **Practice Fourteen: Commitment to Social and Community Responsibility**

### Supporting Examples:

- i) IBM - Research sponsorship, Employment security
- ii) Pilkingtons - St. Helens Trust
- iii) Dalgety - Farm financing
- iv) Lucas - Electric vehicle technology
- v) Shell - Regionalization posture

### Discussion

In spite of charges of enlightened self-interest, the researcher found considerable awareness of the need to legitimise the role of the corporation. This concern was felt to be genuinely held and took many forms. IBM considered the practice of non-redundancy to be tantamount before turning attention to society at large. One ought, therefore, to distinguish community from social responsibility.

This is clearly seen in St. Helens where Pilkington Bros. started their enterprise. A trust, set up to stimulate the growth of small firms in the area, is a good example of the type of scheme put into practice by some companies. Social responsibility, on the other hand, constitutes a much broader issue. In the final analysis corporations have an obligation to society to be successful by adding value and hence generating employment, and paying taxes on profits. This view is

often overlooked by many critics. Furthermore, the flow of new products and technologies is an essential function performed by many corporations.<sup>32</sup>

In a philanthropic sense, social responsibility is a crass concept left over from the Victorian Era. The role of the corporation is of paramount importance in view of the transformations which society is undergoing, thus ensuring the purposeful pursuit of the highest quality of life available to all through the efficient utilization of resources.

Dalgety had, for many years, operated in close symbiotic relationship with farmers in Australia. By providing investment resources to the farmers (seeds, fertilizers, new breeding stock, or capital intensive technology), they too became vulnerable to climatic conditions. This had drastic consequences when Australia was hit by consecutive droughts. As a result of these close relationships with farmers, Dalgety arrived at the conclusion that their social obligations were fulfilled by being responsible at the community level.

A longer term perspective adopted by Lucas was reflected in its commitment to electric vehicles. The scheme was assisted in part by government funding and partly through joint ventures with Chloride and General Motors (through one of its

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<sup>32</sup>IBM has expounded considerable effort in adapting its technology to enable partially-sighted people to become usefully employed.

Bedford Divisions in the U.K. and directly with the parent company in the U.S.). The project is far-sighted, risky and subject to bursts of enthusiasm depending on prevailing oil prices and supply continuity. It is anticipated that the technology will gradually diffuse by means of a hybrid vehicle containing both internal combustion and electric propulsion units. The options provided by Lucas' commitment to a product with a tiny market are driven by considerations of the company's long-term aspirations and a deep-felt need to provide society with options not currently available. This provides flexibility by substituting hydrocarbon-based transportation with that based on a fuel generated by alternative sources.

Shell has a commitment to enriching society. The company sought to inform the public about the various activities and technologies in which it was engaged. A fundamental issue was that in conducting their business, Shell was committed to efficiency and to ploughing back an equitable portion of the added value recovered in its operation. Furthermore, in terms of its transnational policy, fostered in the spirit of regional autonomy, it was recycling resources into many development projects.

The strategic planning system at Royal Dutch Shell is constantly evolving to meet changes in the environment ahead of time. In one of several interviews with their senior executives, the importance of social responsibility in providing

flexibility for a corporation was particularly emphasized. While many companies had only recognized this recently, Shell had been silently pursuing this objective for many years. For example, Shell introduced unleaded petrol before any legislation in the U.S. and consequently suffered a drop in market share. Throughout the study, this issue continually arose. "How are we to fulfill our obligations to society?" How will this role change as a result of technology-induced social change?" Corporate strategists participating in the study paid considerable attention to these questions and were experimenting with novel answers.

#### **Practice Fifteen: Phasing-in of Changes at Functional Levels**

##### Supporting Examples:

- i) IBM - New product strategy
- ii) Reed - Divestment strategy
- iii) Dalgety - Integration strategy

##### Discussion

The lead times between innovation and diffusion are diminishing and fundamental research is maintaining its momentum by spawning new products and processes. As a consequence, product migration strategies can be either driven by evolution-

ary development or, when radical innovations occur, diffusion will substitute and displace existing technologies; as such, it will be discontinuous with potentially disruptive effects. In industries where technological factors are the main determinants of competitive strategy, the management of product life cycles and product migration strategies must be carefully coordinated with other functions in the company. IBM undertakes 5 year strategic planning and one year budgeting; however, manufacturing policy is developed in conjunction with a seven-stage phased implementation. At the appropriate stage of product development, usually as a product emerges from the research laboratories, the field service engineers are consulted in order to build in to the machines the capacity for easy diagnosis, fault finding and repair. This ensures that their prospective clients achieve maximum product utilization. In addition, the marketing staff assess new products in order to ensure that machine capabilities are matched to perceived client requirements. A new product will, therefore, be checked early for any 'bugs' which might detract from its potential value to their clients. This illustrates the theoretical notion that policies designed to incorporate information from diverse sources and products with built-in modifications at its early development stages are fundamental in providing flexibility.

Reed International had a debt-equity ratio of 200 percent when its current chairman took the helm. He subsequently divested one-third of its assets to take the ratio to a healthy 34 percent. In order to introduce strategic thinking, Messrs Jarret and Chandler attempted to divest the unprofitable business units and develop links among business areas. Its backward integration strategy previously pursued, had resulted in the acquisition of a pulp and paper mill in Quebec by the former chairman, Lord Ryder. This turned out to be unprofitable and was a potential target for disposal. However, when the mill was up for sale, the planning director became aware of an impending change and instead of selling it off, he decided to plough in some capital and turn around the venture. This was especially successful. Responsibility for strategic thinking was subsequently delegated to the business units which were closer to their clients. Such an approach inculcated a sense of responsibility and got divisional thinking into a positive dimension. As Mr. Glenn of Decorative Products remarked, "We're asking who buys our product and for what purpose?" As Lorenz remarked - (Financial Times, 12 July 1980) "It is the unusually fast moving nature of Glenns' consumer markets that make him keen to secure greater flexibility in the way his divisional plan is handled at the centre."

This is further illustrated by Dalgety's takeover of Spillers. The interests of the two groups had to be integrated.

spillers had a head office staff of 175 compared to Dalgety's 24; the new group's head office staff in 1980 was composed of 60 people. More importantly, a radical reorganization of Spiller's U.S. operations was required to restore viability. In order to achieve this, the head of Dalgety Inc. made changes but, most importantly, help was enlisted from its Martin-Brower subsidiary to reorganise the distribution service to the food industry after ensuring that the new plant of Spillers' subsidiary worked efficiently. The changes instituted at this level played a part in turning around these interests and flexibility was achieved by shortening the lines of communication and phasing in the changes directly at functional levels.

The phased approach allows time to receive feedback and thereby enhances a company's learning capability. Such a mechanism allows adjustments to be made. Seldom are the results of implementing strategy a complete success or failure. Moreover, the implementation process invariably has an impact upon the situation. Such a practice is essential in order to refine a strategy both to better match the situation and to tune it to a heightened degree of efficiency.

## **practice Sixteen: Trip Mechanisms Linked to Environmental Intelligence**

### Supporting Examples:

- i) Pacific Gas and Electric - Monitoring social attitudes
- ii) Chloride - Electric vehicle strategy
- iii) ICI - Energy futures
- iv) Dalgety - Financial triggers
- v) Shell - Lines of control in overseas companies

### Discussion:

The problems associated with nuclear power are a source of consternation to many utilities in the U.S.; Pacific Gas and Electric is no exception. Indeed, the controversy over the Diablo Canyon Reactor has been rancorous and lengthy. Within the corporate planning department a function was established to attempt a comprehensive, continuous assessment of attitudes towards, among other things, the nuclear issue. This posture was of passive significance, bounded by the irreversibility of the capital investment in existing generating capacity. The flexibility hoped for would by nature be limited. On a decision-focussed basis, it may provide a justification for switching existing investment from nuclear to another steam



generating fuel, thereby salvaging some of their investment. A further function of this surveillance capability was to scan trends. This function was present at Chloride as their future was tightly coupled to transportation and hence oil price and availability. At ICI, these trends are critical to their business and appropriate tracking is undertaken. The problem underlying such attempts is the **reaction cycle time**. By the time the signals become less highly attenuated and their significance recognized there may not be enough time to generate a response. Thus the flexibility of a system will only be enhanced if this information is reported to senior decision makers and its interpretations respected enough to warrant action on what may to some appear as whimsical insights.

At Dalgety, such a procedure was introduced at an operational level in order to make the best use of limited funds and to strengthen central control. Financial data is passed from all business units on a monthly basis to the small company headquarters. In the intervening time, should any budgets exceed a specified variance, then appropriate bells are sounded and the cause investigated. While such a practice may seem penny-pinching, in times of high interest rates it proved to be the correct procedure as the company managed to take over one of its rivals, Spillers, and become one of the U.K.s leading companies in the food industry.

In contrast to this almost micro-focussed practice, Shell, as a by-product of their regionalisation strategy instituted in 1947, had installed a geopolitical surveillance system. This system grew organically out of two policies; first, a commitment to the autonomy of an operating company in a given country and, second, a desire to let those companies be run by nationals of the country in question. This installs the necessary capability to interpret the significance of events on the spot. Verification procedures would then be much swifter than if the information had to be filtered back to a central office for an appropriate response to be orchestrated. The will and the ability to act collectively occur only when both the significance of the intelligence and the authority of its interpreter coalesce. Thus the decision activation time is reduced and flexibility is enhanced.

The preceeding practices illustrate specific ways in which flexibility has been incorporated in the policy formation process. Where possible, the use of these practices was discussed with reference to corporate strategic decisions. In addition to practices which could be illustrated in terms of their manifestations in policy situations, it became apparent that general practices were also pursued in their quest for strategic flexibility. These are as follows:

**practice Seventeen: Continuous Assessment of a Wide Range of Strategic Options.**

This refers to the way in which companies seek constantly to find new opportunities or novel alternatives to impending threats. At Pilkington, for example, the Director of Planning had to appraise 60 or so options at any given point in time. As one of the participants suggested, a strategist's function is to assess continuously where major changes are occurring, thereby generating options to cope with them. This is in the words of one of Shell's senior strategists "the name of the game" (personel interview, April 1981).

**Practice Eighteen: Reserves Held For Unanticipated Expenditures.**

It is clear that holding reserves or having slack to act as a buffer is a rudimentary way of "cushioning" a company or a project. At B-P for example, ten percent of a project cost is generally added in order to compensate for any cost overruns or price increases. At the time of the study, most of the companies were afflicted by the combined impacts of the recession as well as high interest rates. These conditions were not conducive to holding liquid reserves.

### **Practice Nineteen: Adoption of Alternative Criteria in Financial Resource Allocation Decisions**

A company may forfeit an opportunity to participate in a desirable venture if it insists on adopting a standard approach to evaluating investments. This can be related to emerging R & D projects or acquisitions with long pay-back periods. This was the case with Lucas' presence in the Japanese market. The company's Board of Directors questioned the viability of maintaining activities in the face of a neutral cash-flow situation. One of their senior strategic officers suggested that Lucas' presence should be continued due to the lead times involved in gaining credibility in that market. His suggestion was duly accepted. A company's reward system has a considerable bearing on the ability to implement this practice since short-term profitability is favoured frequently at the expense of long-term prosperity.

### **Practice Twenty: Balance Between Divisional Autonomy and Central Corporate Control.**

This practice refers to the ability to maintain a minimum of central interference in directing a company's activities. This is achieved by giving the divisions or business units the freedom to pursue their won course of action within the framework of corporate policy guidelines. Dalgety achieves this by means of a small, but powerful corporate staff. G.E.C.

functions on a similar basis, whereby the corporate staff focus on issues related to international financing and major acquisitions. Lord Weinstock personally reviews divisional budget requirements and intervenes only when performance slackens. The Director of the Central Planning Unit at the National Coal Board also stressed the fundamental importance of this practice in furnishing strategic flexibility.

#### **Practice Twenty One: Establishing Liaison with Governments.**

Transnational corporations and large nationalized industries are influenced heavily by government policies in both domestic and foreign areas. It is not surprising to find close links between the two parties. Shell's regionalization policy demonstrates how a company's goals can be blended harmoniously with those of the host nation. Political changes can have serious repercussions for transnational corporations in terms of expropriation of assets or currency inconvertibility. In view of such eventualities, it is not surprising to find corporate strategists charged with the task of "Government Liaison". Greater familiarity with a host country's idiosyncracies will result in a more appropriate corporate style. The closer they can get to viable sources of information, the less the risk of receiving distorted reports and the greater the likelihood of receiving early warning of impending change. Political risk is a key issue confronting senior strategists.

## 6.5 Observations

The corporate study was exploratory. We sought to become acquainted, first-hand, with the formulation, orchestration and implementation of strategy. In talking to senior corporate strategists the researcher was exposed to a body of practical wisdom which offered many insights. Perhaps it may be reasonable to criticise the study for its lack of statistical rigour, but the researcher is of the opinion that the quality of the information derived from the informal discussions (which were not tape-recorded) far surpassed that which might have ensued from a more narrowly-focussed approach. In this area, deriving any definitive conclusions which can be substantiated at appropriate levels of significance is quite difficult. This section merely sets out the observations which the researcher made after reflecting upon the many hours of discussion with senior corporate strategists.

Two issues became obvious during the study. First, no one practice on its own will give a corporation the necessary degree of flexibility to respond to evolving situations. Yet, one thing may render ineffectual all the other qualities which collectively give rise to flexibility. Second, those practices which give one corporation strategic flexibility may prove to be inappropriate for another corporation even within the same sector.

Flexibility is not achieved simply by having many options, though it is, however, clearly prudent to have more than one iron in the fire. Many different things give rise to flexibility. Five general capabilities distilled by the researcher are conjectured to be required, in varying degrees (according to a corporation's situation), to furnish strategic flexibility. Each of these is discussed in relation to the practices set out in Section 6.4.

#### 6.5.1 General Capabilities

##### **Capability One: Mobility of Resources**

Mobility of resources allows ease of reconfiguring which in turn provides responsiveness to changes in such things as availability of raw material, product demand, market segmentation and attractiveness of various locations. Mobility is thus the fundamental requirement for making modifications.

The importance of this practice is clearly illustrated in the example of ICI's ethylene cracker, which was built to utilize both oil and gas as a feedstock. This type of mobility, however, is very different from that provided by IBM's global research and development facilities. These are designed to ensure that new ideas are transferred and cross-pollinated to arenas where they will be most useful. In a transnational context it is clearly prudent to be able to expand and contract

output or exposure as market and political contingencies evolve.<sup>33</sup>

Technological change is exerting a profound influence upon the practicability of this capability. Flexible manufacturing systems (see Sigismund 1982) provide the ability to vary product design and output very rapidly. This gives rise to substantial logistical flexibility. However, the ability to incorporate such systems hinges on still other capabilities if there is to be smooth implementation and uninterrupted operation. Lucas invested in such a system which is modularly expandable so that uncertainty in product demand could be positively accommodated ahead of time, not only enabling expansion to occur when required but also minimizing the holding of unused capacity in the hope that predicted demand levels would materialize.

Pursuing the technological component further, practices two, six, ten, eleven, and fifteen are all necessary ingredients (varying in accordance with company requirements) for mobility. Inter-firm collaboration is becoming increasingly evident in the high-technology sector. There are many reasons

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<sup>33</sup>A common way to achieve this is to raise the discount rate applied to ventures where exposure to currency inconvertibility, expropriation, or revolution is high. The upshot of raising the discount rate is to reduce the payback period of a venture so that it can recover its investment early. This approach provides a type of mobility in that resources are swiftly recovered, although it is impractical in ventures such as mining.



for this phenomenon. It not only helps to spread risks but can also be used more positively in situations facing new companies such as Genentech (the bio-engineering company) where in order to generate some revenue while waiting for the arrival of their first products in the market place, the company entered into R & D licensing agreements with a number of Japanese companies. Frequently, this type of collaboration involves companies which operate in different technological arenas, and thus the competitive element is removed.

The output of such activities, particularly those at the research and development stages, would be of little value if they could not be incorporated into the participating firms' current product portfolio or processes. In highly dynamic technological areas, the key issues are product life cycles, the interconnectedness of the various components required to produce, market, install and operate advanced systems in addition to the various learning curves which need to be experienced to implement systems effectively. In view of these considerations, the ability to transfer resources in a timely manner with little disruption is at the heart of successful strategy.

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This enables the marginal cost of capacity to meet "Peak demand" to be reasonably low because the storage station helps to manage the loading of nuclear capacity. The rigid nuclear resource is thus partially transformed into a much more mobile form to enhance flexibility by virtue of its response time.

As we suggested earlier, in order to benefit from the transference of resources, one must use this potential effectively. Thus it is prudent before making a major acquisition to have a "dummy-run", so to speak, to enable the firm to learn which functional areas will be affected. This ensures that the changes can be phased in more smoothly. Practice Fifteen illustrates this in a technological setting with IBM's new product strategy which carefully incorporates the opinions of marketing and field support personnel to ensure the trouble-free diffusion of new products.

### **Capability Two : Variability of Thrust**

An analogy used to great effect by Wilf Corrigan, Chairman of LSI Logic (formerly CEO of Fairchild), to help articulate his perception of strategic flexibility was a comparison of corporate strategy to a missile guidance system which constantly adjusts its trajectory to follow a moving target (personal interview June 1982). This splendid analogy is helpful in defining what we mean by variability of thrust: the ability to change emphasis speedily from, for example, R & D to mar-

keting or from acquisition-driven growth to internal venture-based evolution. From this perspective the most interesting company in our sample was undoubtedly IBM which had succeeded more than most in constantly varying its thrust while maintaining a general course.<sup>34</sup>

Differences between the high-technology environment and more mature industrial sectors are pronounced when considering this capability. In mature sectors it is extremely difficult to imagine ways of increasing flexibility. Harrigan (1979, 80) proposes an interesting strategy for companies in business areas where chronic over-capacity is present. She suggests that where the market is not large enough to support total output capacity then the leading companies ought to buy out the smaller companies which cannot extricate themselves from the business because the exit barriers are prohibitively high. It is, however, difficult to envision how this could be achieved when only the very large firms are left in an industry, as is the case in petrochemicals, for example. In such circumstances, Practice Seven is one of the techniques companies have used to vary thrust.

Another good example of how this may be achieved can be seen in the N.C.B.; Mike Parker, Director of Planning at the Board, compared installing flexibility in coal mining to an

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<sup>34</sup>Currently, speculation has it that IBM is moving away from its hardware orientation to place more emphasis on software.

attempt to water-ski behind a super-tanker. Notwithstanding this somewhat graphic description of their limitations, the Board has attempted to resolve the problem of massive stock-piles by introducing, with the assistance of some merchant bankers, a futures market for coal. If successful, this plan will lessen the huge financial burden of slow-moving stocks and thereby release underused resources for much needed investment.

In order to vary the thrust of a corporation, linking corporate intelligence to the senior strategists is of crucial significance. Practices three, eight, fifteen and sixteen are all necessary ingredients in achieving this. Early warning systems are only useful if they are both tracking appropriate phenomena and are coupled to decision-making systems where the activation period is less than the time taken by the deviant phenomena to exert its impact. Thus, in the first instance, "trip mechanisms" can alert an organization to the need for a response; this in itself is useless unless the lines of communication permit the information and its significance to be relayed swiftly to staff members with the wherewithal to respond. Once a response has been engineered, then (as described in Practice Fifteen), changes should be smoothly phased-in at functional levels to ensure that the desired course of action is implemented.

Time horizons will vary according to the type of strategic issue which engenders the response. Strategic factors are not

temporally uniform. Some events, such as an impending change of government or a dramatic price reduction by a competitor, require almost instant reaction. Other events, such as the trend towards plasma etching in microprocessor fabrication, necessitate a longer time period where in order to get the best window on the technology it may be prudent to embrace several research projects. The trend towards the internationalisation of "high-technology" is again a very different strategic issue requiring gradual and careful establishment of organization, lines of supply, distribution channels, and above all a sympathetic eye on the development of markets.

In conclusion, variability of thrust can mean many things according to the particular circumstances of a company. Its function is both to fine-tune the direction of a company and to permit major changes of direction when required. Clearly the effectiveness of this capability is contingent upon the ability to reconfigure resources. It is thus the driving force which gives direction to Capability One (discussed above) by providing the rationale for using the available mobility.

### **Capability Three: Versatility of Personnel**

In the introductory Section of this chapter, we alluded to IBM's personnel policy as one of the central planks of the company's ability to institute rapid change. Additionally, Practices Five, Eight, and Thirteen all bear on this capabil-

ity. Versatility of personnel both aids the generation of novel, creative strategies and provides responsiveness to make subsequent fine-tuning.

In the "high-technology" environment, companies such as Rolm, Tandem and Hewlett-Packard place considerable emphasis on the development of their staff. In such an environment changes have to be made continually and new trends have to be detected quickly. With their objective of constantly providing their customers with the most up-to-date and cost-effective systems, they must close down plants operating with obsolete equipment. This requires a work-force which is willing to be both mobile, in order to relocate, and versatile, in order to change function.

Shell use the term "helicopter vision" to refer to the quality possessed by individuals who can perceive phenomena and relate them to the overall direction in which the company is moving. This visionary quality is actively encouraged by the company, and one way of achieving it is through job rotation; by having employees working in a number of different functional areas, the ramifications of changes at the corporate level can be more accurately gauged at their point of impact.

Once the ability to conceive the overall situation facing a company exists, then the staff members are in a much better situation for making decisions in the face of uncertainty. In large concerns decisions are usually made by groups of commit-

tees each playing a role. However, in some situations, particularly during crises, decisions have to be made quickly and with authority. These two components are essential. We shall address each separately.

Making decisions in the face of uncertainty is notoriously difficult. Information and expertise are prone to fallibility. Yet in order to use the best judgement available, a consistent method for incorporating all the factors and arriving at a logical conclusion is desirable for at least two reasons: first, a common way of addressing a problem will facilitate communication and highlight points of conflicting opinion or incoherence in reasoning. Second, the means of arriving at the decision are open for inspection after the event so as to permit the maximum amount of learning from experience.

Once a quick decision is made, the means of implementing it expeditiously becomes the paramount strategic factor. The ability to rally people around and gain commitment to a course of action in the face of uncertainty and stress is contingent upon the leadership powers of the individuals playing dominant roles. There are no hard and fast rules one can invoke to foster this quality.<sup>35</sup>

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<sup>35</sup>Even the great philosopher of strategy von Clausewitz almost altered the outcome of the battle of Waterloo because he felt Wellesley's strategy to be less than sound.



As reported earlier, Ford (U.K.) argued that the most "flexible policy is to secure in an organization people who are competent, have the drive to succeed and the determination to manage.... There are various techniques for improving performance. They all depend heavily on gathering and analysing information and the use of logic. They can be no better than the people who apply them." In the final analysis, implementing plans and decisions depends on the people who carry out the task.

Strategies operate within the boundaries laid down by policy; they match ends to means. The problem of flexibility exists because not only do the means of doing things change over time (as a result of raw material availability and technological innovations) but the ends themselves are also dynamic forces.

Changes in the internal environment may reflect both changes in the social and contextual environment as a whole and changes in the attitudes of the transactional environment as suppliers and customer needs and wants evolve. Changing objectives such as those expressed by the current quest for corporate social responsibility can only be accomplished by perceptive and versatile individuals.

#### **Capability Four: Malleable Organizational Structure**

The significance of this capability is no better illustrated than with reference to Napoleon's famous star formation. It was like a fluid body. The ability to congeal around the decisive point was crucial in that theatre of operations. To pursue the analogy of the military environment in business can be useful but occasionally misleading unless restricted to the realms of meta-theory. From the perspective of corporate strategy, however, organizational structure is an area unto itself. Chandler's (1962), famous dictum "strategy follows structure" underscores this significance, although Burgelman (1982) demonstrated recently that it is more reasonable to suggest that structure is determined by autonomous strategic behaviour.

Organizational structure was considered to be the critical success factor of the 1960s and 1970s. The trend has evolved from a "functional" to a "divisional" and more recently to the "strategic business unit" concept. Whatever name is adopted, the issue at stake is "control" and how it is to be delegated. Thus an organization's structure will reflect the degree and type of desired centralized control. Three companies illustrated this point. Dalgety has a very small corporate staff whose main function is not to manage the individual businesses but to ensure that the company's various businesses perform in a satisfactory manner and will do so in the future. Responsibility for running the various businesses is given to the

divisional management who are on the spot and are experts in their areas. The sophisticated financial trigger system facilitates an "exception-based" intervention system. Moreover, the small size of the central staff allows it to be reconfigured around issues much more easily than a monolithic structure.

The Royal Dutch Shell Group of companies have pioneered a resilient organizational structure by giving autonomy to each country-based operating company. This enables these operating companies to be much more responsive to the needs of the situation confronting them. Such an approach takes a long time to cultivate; Shell initiated this system in 1947 and the benefits are perspicuous today. It is a good example of strategic flexibility in that the action was taken long before the need arose (even before the need was totally foreseen) yet when the capability was required to match situational demands the response time in dealing with such demands was clearly minimal.

IBM have an innovative approach which is reflected in the matrix form of organizational structure as well as the formation of country-based operating companies. From our perspective, IBM epitomized what is meant by a malleable organizational structure. Recently a substantial structural reorganization was implemented by IBM to ensure the technology--market link was comfortable. This represented a substantial departure from their previous disposition but the change was made in a unique style again well before the urgent need arose. By

entertaining a willingness to reposition itself, the company, despite its size, has retained a high degree of dexterity. Royce and McLeod (1980) have argued that structure is vital in achieving strategic flexibility. They contrast European, Japanese and U.S. company structure and comment:

Social, political and technological change will make flexibility the key word in business organization, as business restructures itself in response to new environments. (P.1.)

Practices Two, Three, Five, Six, Seven, Ten, Twelve, and Twenty all reflect aspects of this capability. It must be stressed that on its own this capability is almost futile, but in connection with the other capabilities it can give rise to a degree of strategic flexibility contingent upon how well it is used.

#### **Capability Five: Manoeuverability Across, Within, and Into New Business Areas**

Manoeuverability is the term used to describe the skillful planning of resource allocations which facilitate the adroit manipulation of activities in order to gain an advantage. The balance between central control and divisional autonomy and the melding of transnational portfolios lie in the heart of this issue. Clearly the response time is constrained by the ability to realign the strategic thrust which in turn necessitates the development of an organizational structure suited to the reconfigured resources.

During the corporate study, it became evident that three companies preprogrammed such manoeuverability in rather unique ways. In the Royal Dutch Shell group of companies, this was partially achieved in 1947 when the company divested control of the operating companies to the host countries. This allows each operating company to be sensitive to the needs of the market and avoids undue delays in waiting for a response from the headquarters. In any event, this response may be inappropriate as the situational requirements may be constantly changing (as for example, during a crisis). By not tying the company's future with the status quo, strategic flexibility is enhanced significantly (personal interview 1981).

IBM achieves this by not being over-committed to any single strategy or technology. This resulted in the cancellation of a new line of systems, the F.S. range, during the early 1970s and a complete organizational restructuring in 1981, designed to meet the needs of the evolving environment.

Dalgety engineers a high degree of manoeuverability by having a small but visible and powerful central headquarters. Corporate intervention is triggered by a sophisticated control and monitoring system.

Identifying opportunities in new business areas or mature businesses, and recognizing early the unattractiveness of existing business areas is a difficult task. To be effective, the corporate response must be swift and disguised from competi-

tors. The time available to orchestrate the move into or away from a business area is constrained by the ability to channel resources in different directions. When the direction is new, considerable attention is required to maximise learning in order to ensure that corrective refinements can be made. It is in this context that strategic flexibility can be most useful.

Many corporations are faced with an increasingly hostile environment. In these circumstances the firm can come under close scrutiny and its role can be questioned. Shell and IBM both place considerable emphasis on the significance of "social responsibility" in order to achieve the required degree of manoeuvrability. A corporation whose role is seen as being legitimate by those societies in which it operates, is much less likely to encounter resistance. Therefore, it becomes much easier to implement major changes when the need arises.

One can view this capability as the collective juxtaposition of the preceding four capabilities with the addition of a further component, legitimacy. This is essential, as Hart noted with perspicacity (1940), for it is plain that firms can not know which way they might need to change. From a strategic perspective manoeuvrability is necessary so that concentration at the decisive point is made effective by having dispersed dispositions which can be redirected rapidly. It is the achievement of a balanced tension between central control and operational autonomy which is the hallmark of good leadership.

## CHAPTER 7

### CONCLUSION

This chapter will summarise the main findings of the study; in addition it will point out major limitations of the research and will propose specific directions on which future studies could be focussed.

#### 7.1 Summary of Findings

The objective of the present study was to find out what flexibility is and how it might be incorporated in the policy formation process. We set out to achieve this by a combination of analytical and observational means. In the first instance, a comprehensive search of the literature revealed a paucity of previous research on flexibility. The research which had been undertaken was fragmented across a wide range of disciplines over which little consensus had emerged. A cursory examination of these revealed that little cross-disciplinary fertilization had occurred. Our first task was, therefore, to pull together the disparate strands of earlier work on flexibility.

In view of the diversity of arenas in which flexibility had been invoked as a means of enhancing control, it became apparent that the concept needed to be clarified. In order to

examine the features of the concept, a technique called "conceptual analysis" was employed to highlight the similarities between the various uses. In this regard, our first task was to examine its linkages between flexibility and closely related concepts. These concepts are:

ADAPTABILITY - the ability to adjust to the conditions of the changed environment

ELASTICITY - the ability to return to a normal state following contraction, dilation or distortion.

LIQUIDITY - the ease of conversion.

PLASTICITY - the ability of a system to assume changing postures according to variations in the environment.

RESILIENCE - the ability to absorb or accommodate shocks and discontinuities.

ROBUSTNESS - the ability to satisfactorily endure all envisioned contingencies.

VERSATILITY - the ability to accommodate unknown future contingencies.

Having examined these concepts, we subsequently arrived at four kernel meanings of flexibility. Implicit in the notion of flexibility, is the idea that despite unforeseen circumstances, functioning will continue. Thus, one meaning of flexibility is the "ability to bend", while a second meaning, similar to the first, is "yielding to pressure". The most common interpretation of this meaning has been used in connection with exchange



rates and wage negotiations. A third definition of flexibility is the "ability to affect timely alterations", and the fourth is the "capacity for ready adaptation to new situations". After unravelling some of the ambiguities associated with this concept, we proceeded to examine a number of hypotheses proffered by previous studies.

The diverse range of disciplines in which previous related studies were embedded, presented a major investigative challenge. A parallel activity was undertaken to clarify the need for, and the means of, acquiring strategic flexibility. This was directed toward studying the use of the concept in policy formation as distinct from various theoretical attempts to explicate the notion. In this regard, two field studies were undertaken, one focussed on a micro decision situation, the other toward a macro and hence more complex policy setting. In order to understand the critical underlying forces, it became apparent that theoretical developments had to be tied to pragmatic situational requirements.

In the first of these investigations, we observed the situations confronting the first-time users of computer technology. This policy setting encapsulated many of the features which highlight the need for flexibility, yet at a level of complexity of variety which facilitated a grasp of the relevant issues. Five U.K. based manufacturing companies participated in the study. These firms were at various stages in the acqui-

sition of E.D.P. technology and provided an empirical vantage point of the situational requirements of the need for flexibility during the different phases. These phases were:

- a. Company Analysis
- b. Feasibility Study
- c. Invitation to Tender
- d. Choosing a Configuration
- e. Implementation
- f. Operation and Audit
- g. Development

Following a description of these phases, an attempt was made to outline the attributes of the technology which promote strategic flexibility. The seven attributes identified were:

1. "Procedural" and "Configurational" COMPATIBILITY: the former refers to the internal coupling between the new technology and existing procedures; the latter is technological in nature and refers to the ability to interconnect a number of different systems.
2. EXPANDABILITY: refers to the ability to extend the processing capability of a system so as not to leave too much unused capacity at any given time.
3. MAINTAINABILITY and SUPPORTABILITY: refers to the susceptibility of the system to continued operation and development.

4. UPGRADEABILITY: refers to the ability to capitalize on improvements in available hardware and software.
5. MODULARITY and PORTABILITY: the former refers to a self-contained but integral part of a system; the latter is the ease with which a module can be transplanted onto another part of the system or to a new system.
6. Potential for INNOVATION: refers to the likelihood that a given system will be used as the basis for development, thus allowing the user to exploit the "learning curve effect" which critically affects the efficient utilization of a system.
7. PROCUREMENT OPTIONS: refers to ways in which a system can be initially acquired and the impact which this may have on subsequent decisions.

The second field study was undertaken to ascertain the use of strategic flexibility in relation to corporate policy formation. Whereas the "FTU" study was focussed on a homogeneous decision, corporate strategies address complex issues within a nexus of technologies spread across diversified business areas. Moreover, the "FTU" study examined the microfactors in strategic decision making, while the corporate study was concerned with macro policy issues. Twenty-one transnational corporations were studied; the majority of these were based in the

U.K. These companies embraced diverse technology portfolios ranging from energy and transportation to information application areas.

Following a preliminary round of interviews with senior corporate strategists in these companies, a number of practices were identified, which when adopted, enhanced flexibility. These were as follows:

- i) Multi-resource variable input production systems
- ii) Inter-firm cooperation and collaboration
- iii) Shortening the lines of communication to and from senior policy-makers
- iv) Proactive response to anticipated legislation and litigation
- v) Redeployment of key personnel
- vi) Incorporation of incremental technological innovations
- vii) Contraction planned so as not to endanger future performance
- viii) Inculcation of a calculated approach to risk taking
- ix) Blending of transnational portfolios
- x) Coordination of internally diversified diffusion of new technology
- xi) Varying output volume without incurring prohibitive marginal costs

- xii) Reshaping divisional plans
- xiii) Decisive leadership
- xiv) Commitment to social and community responsibility
- xv) Phasing in of changes at functional levels
- xvi) Trip mechanisms linked to environmental intelligence
- xvii) Reserves held for unanticipated expenditure
- xviii) Adoption of alternative criteria in financial resource allocation decisions
- xx) Balance between divisional autonomy and central corporate control
- xxi) Direct government liaison

It became apparent that no single practice will provide the necessary degree of strategic flexibility to accommodate evolving situations. Those practices which give one corporation strategic flexibility may be inappropriate for another. Notwithstanding these limitations, five general capabilities were identified, which underpin these practices in the quest for flexibility:

- 1) Mobility of Resources: allowing ease of reconfiguration which provides responsiveness to unfolding circumstances
- 2) Variability of Thrust: changing emphasis from one strategic focus to another

- 3) Versatility of Personnel: modifying procedures to meet new situations
- 4) Malleability of organizational structure: allowing issue driven coagulation at the decisive point
- v) Manoeuverability across business areas: capitalizing on changing distinctive competences

These capabilities underscore the strategic flexibility of a corporation, yet exhibit a generality which may allow them to be transposed to other policy settings. The appropriate mix of these capabilities is contingent on a number of factors. An inflexible part of the system may render useless any of these capabilities. Although strategic flexibility is an intuitively simple and appealing notion, putting it into practice is quite the reverse.

## 7.2 Limitations of the Study

Some may argue that the fundamental limitation of this study is the absence of a prescriptive model or set of guidelines which could be used to evaluate the cost of flexibility and its usefulness in specific circumstances. Further limitations stem from methodological deficiencies and analytical flaws. It is hoped that the present study will be viewed as a regrouping of many existing ideas and as an attempt to update a concept whose significance has been frequently articulated.

It may be argued that the hallmark of a good piece of research is the rejection of the initial problem statement which proves to be inadequate in the light of subsequent endeavours, redefining original hypotheses which might enhance an understanding of the problem. The problems of evaluating the need for flexibility in a given situation and the empirical basis for making trade-offs between cost and value, still remain unresolved. This is reflected by the paradox embedded in the notion of flexibility. How can we respond in advance to situations which we know to be changing although we have limited knowledge about the nature of these changes? This is the main reason for our rejection of the notion of "robustness" as the only criteria for strategic flexibility and of any measures purporting to quantify flexibility. The only way to assess the need for and benefits of flexibility is retrospective.

The assumption that flexibility is an "add on" feature to be conjoined with strategies is the basis of an erroneous assertion that a flexible strategy will always cost more than its counterpart. This study set out to enhance our understanding of the problem first by identifying those features of a technology which enhance flexibility and second by distilling a set of general capabilities which underscore the practices adopted by large companies in their quest for strategic flexibility.

From a methodological standpoint this approach is fraught with pitfalls. It would be difficult to replicate the study and arrive at the same conclusions. Specific aspects of the study could be usefully tested in future studies. The validity of our "observations" or more precisely, moving from our observations to theoretical generalizations is somewhat tenuous. This is partly due to the absence of an analytical technique which facilitates the deduction or inference of these linkages. Statistical clustering techniques were suggested as a method assisting in the evaluation of the data collected during the corporate study. While these techniques may be useful in testing assertions which have been already explored (such as market share determines a firm's profitability), their value in exploratory research is far from apparent.

A further limitation of the research is that the information derived from the field studies were based on interviews conducted with a small number of individuals who participated in the policy decisions studied. It can be argued that the information derived from a small number of respondents is likely to reflect their interpretation of specific situations rather than providing "objective knowledge". This flaw is acknowledged. It would have been preferable if a large number of senior strategists could have been interviewed. This was not possible due to time constraints on the part of these executives. Our recording techniques did not lend themselves



to statistical precision. It should be emphasised that too much information may obscure the key issues. By relying on interpersonal means of communications, the researcher was in a position to discuss significant issues in a candid manner.

### 7.3 Suggestions for Future Research

The notion of strategic flexibility is intuitively appealing. Putting it into practice still requires a sound theoretical basis. One area where future research should be directed is in the theoretical domain. In order to use the theoretical notion of strategic flexibility more empirical research is needed. Finally, we will discuss "practical" research areas where future research might be focussed.

#### 7.3.1 Theoretical Research

STRATEGY: Two types of questions could be addressed in this context. First, how should an organization decide on the appropriate degree of flexibility required to cope with uncertainties? Second, given alternative ways of acquiring flexibility, which of the available criteria should be used to choose between them?

TECHNOLOGY ASSESSMENT: Embracing techniques such as decision analysis and comparative risk assessment to evaluate the diffusion of innovations, technology assessments may be better focussed towards examining ways in which flexibility may be

induced to ensure that positive afteractions occur while the negative afteractions are avoided. The misplaced emphasis on forecasting consequences may be deleterious. Epistemological foundations based less on determinism and more on vision and intuition will enhance strategic flexibility in the early stages of policy formation. An appropriate field would be the electric utility industry which is being confronted with searching questions concerning the choice of technology (Tomlinson 1982).

**FLEXIBILITY IN DIVERSE POLICY CONTEXTS:** As indicated in the FTU study, tension may arise between users' and manufacturers' flexibility. This phenomenon may be present, where the interests of various purposeful systems converge. Flexibility is often sought to resolve conflict in such circumstances. Future studies could be usefully focussed on the way in which diametrically opposed preference structures may be accommodated within an option which exhibits a high degree of flexibility.

**ECONOMIES OF SCALE:** In complex technological systems, the rationale that "volume drives down costs" is a redundant assertion. There may be an inverse correlation between the size of the unit and its inherent flexibility. Clearly, systems involving complex technologies are vulnerable to malfunctions, mistakes and poor performance. This might be related to the interconnectedness of various subsystems, the complexity and

learning barriers which need to be overcome in order to successfully operate the system. The concept of economies of scale may be appropriate in situations where the pace of innovation is likely to recede, although in most situations, the quest for improvement is never ending. In such cases, a system which permits the incorporation of incremental innovation may prove to be flexible.

### 7.3.2 EMPIRICAL RESEARCH

DEVELOPMENT OF CASE STUDIES: In this study an attempt was made to enhance our understanding of the notion of strategic flexibility. We set out to accomplish this, first by looking "vertically" at the process of policy formation in relation to a homogeneous technology and, second, "horizontally" in relation to heterogeneous technology policies. It would be interesting to examine case studies of the diffusion of complex technologies which might result from the actions of a number of large organizations. Three pertinent examples spring to mind:

1. Biological mining using bacteriological leaching or bacteriologically-induced in situ liquefaction
2. The fast-breeder nuclear reactor cycle
3. Flexible manufacturing systems which combine robotics, artificial intelligence, computer-aided design, numerically-controlled machine tools,

automated handling devices and their integration with electronic data processing.

These examples are of interest because they are in the early stages of diffusion, where in theory, considerations of flexibility ought to be most effective i.e. there is greater freedom for control.

LARGE SAMPLE STUDIES: One of the limitations of the present study was that it was neither an in-depth case study of one particular situation (e.g. Burgelman, 1982) nor a large sample investigation. It would, therefore, be interesting to test our findings across different technologies and industry sectors, by using a large sample of companies.

DECISION AIDING SYSTEMS: A variety of aids such as decision support systems, strategic planning models, data base and rapid information retrieval and graphical display systems are available to assist policy makers. The added processing power and communications capability of these systems ought to enhance strategic flexibility. It would be interesting to study whether these systems open up the minds of senior executives and examine the ramifications of educational entry barriers to access the technology on the power structure of organizations.

Strategic flexibility is not a panacea for coping with uncertainty yet it undoubtedly helps. An attempt has been made in this dissertation to derive a clearer understanding of this

concept. Cognizant of the transformations facing society, a capability which actively allows refinements to be made in the light of experience will be intuitively valued; for as Whitehead remarks:

The character of existent reality is composed of organisms enduring through the flux of things... The changing environment is no longer, by reason of its variety an enemy to the endurance of the organism. Those organisms are successful which modify their environment to assist each other.  
(1926:282-283)

# THE UNIVERSITY OF ASTON IN BIRMINGHAM

Gosta Green, Birmingham B4 7ET/Tel: 021.359 3611 Ex 735

**Technology Policy Unit**

Professor Ernest Braun

Dear .

I am currently engaged in a research programme investigating the process whereby corporate policies are devised to cope with a capricious future. Particular attention is focussed on the inclusion of an aptitude to respond to unforeseen situations.

The research would be greatly enhanced if an opportunity were afforded to gain an insight into the difficulties associated with the design of flexible policies in an organisational setting. I therefore request your permission to discuss these and related matters in an informal manner with a member of your Company.

Yours sincerely

-----  
J S Evans  
Doctoral Research Student

Section I      General

- I.i      To what extent have technological factors induced strategic change within the company, or in the environment in which it operates?
- I.ii      Were there any early signals of such changes which were detected by the company's scanning and monitoring operations?
- I.iii      To what extent did interpretations of such situations differ?
- I.iv      Which procedures were used to obtain estimates of the impact of such changes:
- a)      Were any independent or intra-sectoral studies commissioned?
  - b)      How was the planning system affected by such changes:
    - were new methods introduced?
    - were some functions modified?
    - were the lines of communication redefined?
  - c)      In what ways were the assessments of the situations presented to senior management?
- I.v      If the changes were anticipated, what type of measures were involved in response to the strategic change before the effects/consequences began to exert an impact upon the company?
- I.vi      What was the time span between detection and impact of the change?
- I.vii      How long did it take to formulate a policy to cope with the new situation?
- I.viii      Were any deficiencies detected in the generation of policy options?
- I.ix      What steps were taken, if any, to ensure a swift transformation once the new strategy was decided upon?
- I.x      Did this have any effect on the policy making process?
- I.xi      How much variation can be tolerated in production volumes whilst ensuring an adequate rate of return?

I.xii Is this likely to change with the use of robotics and flexible manufacturing systems?

I.xiii How much time is required to:

a) expand production?

b) contract production?

c) change the quality of production?

I.xiv Are there any considerations relating to strategic flexibility which you feel have not been adequately covered by this interview?



## Section II      Electric Vehicles

II.i      Which variables determine the feasibility of electric vehicle production?

- |                   |                       |
|-------------------|-----------------------|
| a)      economic  | d)      legal         |
| b)      political | e)      environmental |
| c)      social    | f)      technological |

II.ii      What levels of production would be needed to justify investment in manufacturing facilities?

How would different volumes affect policies?

II.iii      Given the uncertainties associated with the early diffusion of electric vehicles, how much variation in out could be tolerated by the envisaged production system to ensure an adequate return on capital invested?

II.iv      How far would existing production facilities allow:

- a)      component manufacture?
- b)      propulsion unit production?
- c)      power pack production?

II.v      What percentage of the components for electric vehicles are completely novel?

II.vi      Would existing plant be able to cope with the specifications of such components?

II.vii      How are the lead times associated with the tooling up required to produce novel components linked in to the planning process to create the appropriate policies for the initial production?

II.viii      If existing capabilities are not adequate for production, how are development policies regarding the siting of new facilities formed; how many alternative configurations would be assessed?

II.ix      What form does the comparative assessment of the competing technological options for the propulsion unit of the car of the future take?

II.x Similarly, how are the various fuels, which may become available, assessed:

- |              |                           |
|--------------|---------------------------|
| a) syncrude  | f) methane                |
| b) gasohol   | g) bio-engineered options |
| c) l.p.g.    | h) lead-acid batteries    |
| d) petroleum | i) sodium sulphur         |
| e) hydrogen  | j) nickel-cadmium.        |

II.xi How are the environmental issues associated with ix and x above considered?

II.xii Would the cost of stringent regulatory legislation alter the feasibility of any of the above options?

II.xiii How is the cost of environmental issues assessed; are environmental impact statements formulated?

II.xiv What type of export advice is sought?

II.xv How is information generated by xiv above, assimilated into the corporate strategy-making process?

II.xvi In what manner do the corporate policy makers participate in this process?

II.xvii What type of inter-divisional consultations occur?

II.xviii Outline the techniques and other means by which an examination of the possible development paths which may occur with respect to electricity generation and supply systems? [Would this development of wave power, for example, be considered a positive attribute in the feasibility of large scale electric vehicle diffusion?]

- a) Which methods are used
- b) What type of computer models
- c) Research organisations contracted
- d) Number of scenarios considered
- e) Data base employed
- f) Technologies considered
- g) Cross-impact assessments performed.

- II.xix How is the infrastructural change required for the large scale diffusion of electric vehicles thought likely to occur?
- II.xx How are the financial consequences over the range of production volumes forecasted?
- II.xxi What is the expected reduction in cost associated with the 'learning curve' effect as output levels grow?

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