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Exploring the Nature of Industrial Supply through the Application of Soft Systems Analysis to the Machine Tool Industry

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CHAPTER ONE - INTRODUCTION

Hence! Home you idle creatures, get you home:
Is this a holiday? what! know you not,
Being mechanical, you ought not walk
Upon a labouring day without the sign of your profession?
Speak, what trade art thou?

Flavius to commoners, in
Julius Caesar
William Shakespeare

Introduction

In this, the first chapter of a thesis submitted under City University's doctoral programme in the Department of Systems Science, the research project will be introduced. The background to the project is explained, including when the project was established, why and by whom. As this was a mostly independent, industry-funded project, a description of the industrial partner is given, and the chapter concludes with a statement of the initial objectives of the research.

A - BACKGROUND TO THE PROJECT

In the early part of 1992 it was arranged by John Chelsom, Professor of Engineering Management at City University in London, for a new research position to be funded by Litton Industries Inc. of America. Professor Chelsom had worked with various parts of Litton during his previous post as Director of Supply for Ford of Europe where his relations with the organisation were characterised by a common interest in education. There was a recognition of the need not only for research to be done into 'supply', and to raise awareness of its importance, but also to encourage the production of graduates who were trained not only in engineering skills but who were able to combine these with commercial knowledge and managerial abilities.

The Engineering Management Centre in the Department of Systems Science at City University was created to fulfill this latter role. Litton's agreement, sufficient to fund a research assistant for two years would also serve this end through the teaching and research the post would allow. It would also prove to raise awareness of the importance of supply, and perhaps more importantly to call into question the manner in which supply is traditionally perceived and managed.

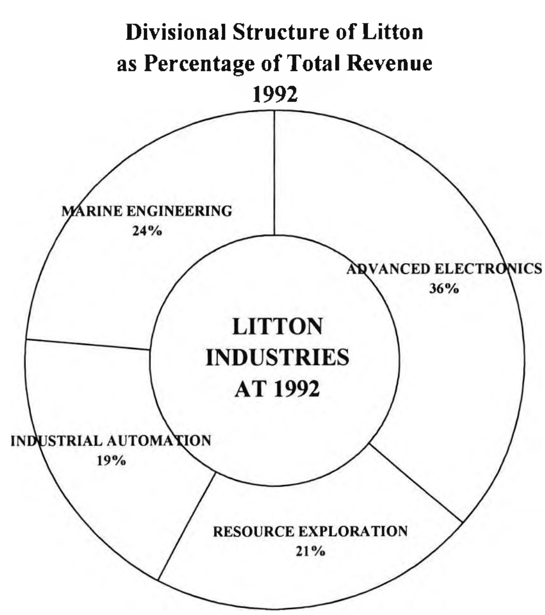
A.1 Litton Industries and Western Atlas - the funding partners

A brief description of the activities and structure of the industrial partner is given below.

A.1.1 Litton Industries Inc.

Litton Industries Inc. had, at the time the research was begun, four divisions. These four are represented in figure 1.1, along with the turnover of each, relative to 1992. The research presented in this thesis is concerned with the area of Litton Industrial Automation. All four divisions combined together to form Litton Industries Inc., with an annual turnover of some $5 bn.

FIGURE 1.1



As of January 1994, Litton was divided into two separate companies. The advanced electronics division along with the marine engineering division remained under the Litton Industries banner. Resource exploration and industrial automation combined to form a new company, Western Atlas Inc.

This move was market oriented. The divisions which would remain in Litton Industries were markets which were seen to be stagnating or declining due to their defense related activities. Western Atlas, however, was an expanding area, and it was felt that separation would allow its two remaining divisions to continue growing without being held back by slower market conditions. Considerable communication has been maintained between the two companies since the split, however.

A.1.2 - Industrial Automation in Litton and Western Atlas

The main activities of the industrial automation division can be categorised into three broad areas:

Machine tool production and assembly
The company has a world class reputation for the global supply of machine tools almost exclusively to the world's automotive markets. Lamb Technicon, Unima, Landis Lund and Gardner Grinders are the companies involved, the former was chosen to be the funding partner for the project.

Automated data collection and storage
These activities centre around automated bar-code reading systems for a variety of industries including aerospace and food processing.

Materials Handling
Also serving the food processing industry amongst others, this area provides systems for the storage, sortation and automated handling of

inventory and work in progress. In its activities there is much collaboration with the area of data collection and storage.

A.1.3 - Lamb Technicon

The research was to investigate aspects of the machine tool market. Definitions and statistics regarding this market are discussed in chapter two, and are shown in its appendix. It was decided that the funding partner to City University would be Lamb Technicon (Lamb). Lamb is a provider of specialised machine tool systems for the automotive markets. It has two areas of specialisation, one being the supply of transfer lines and the other the supply of 'body in white' welding systems[1]. It is an international organisation, with facilities in North America, in Canada, the UK and Germany. Considerable work is under way in China, studies have also been performed to test the proposal of expanding into other geographic areas - South Africa being one example.

Contact was formed with the European arm of the company. Its headquarters are in the UK, at Mildenhall in Suffolk. It has design and sales facilities in Solihull in the Midlands, and also has a daughter company, Unima, in the German Saarland.

A.2 Choice of industry

As mentioned above, the initial reason behind the choice of industry to be examined was the funding party. Having been engaged in machine tool manufacture themselves for decades, and being a global player it was deemed appropriate for the sponsoring of higher education to take place. More fundamental reasons do, however, exist which justify the effort from the researcher's point of view. Some of these are discussed below.

---

[1] Traditionally the transfer line activity is what would have been termed 'machine tool', with the body in white systems being administrated and managed separately. For the purposes of this research such formal distinction is not made since commonality exists in the nature of the two markets. Definitions of transfer line and body in white are given in the glossary, and are further discussed and illustrated in chapter two.

A.2.1 Low volume of research

The expert knowledge of the industry existing within the Engineering Management Centre and in the funding party was seen as the perfect knowledge base for the supervision of a research project. The sector in question is one which has attracted relatively little commercial research in the past, a fact recently confirmed by, amongst others, the managing director of the Daimler Benz Purchasing Co-ordination organisation, Peter Stangl[2]. A brief literature search into the main customer industries of the machine tool sector, i.e. automotive and aerospace, will soon uncover a mass of work[3]. A similar situation exists for their component suppliers, not for their suppliers of machine tools (non-production equipment). The nature of supply, and that which can ensure quality supply will vary depending on the type of good, or indeed service, involved. General lines of differentiation exist between component and machinery supply, as well as between specialised and standardised supply, amongst others[4]. As yet the extant literature does not seem to have drawn these distinctions in sufficient detail for the recommendations made therein to promote success.

A.2.2 Strategic importance

Is low research volume enough to warrant research? The answer here is quite clearly 'no'. The machine tool industry is small, and contributes little to nations' GDP. Hence why study it? The machine tool industry is in serious decline (Gaylord,

[2] Personal communication, 27.09.94

[3] c.f. amongst others: Cusumano et al 1991, Lamming ,1994 & 1995, Ganeson 1994, Lyons 1990, Richardson 1993 and Womack et al 1990.

[4] This topic will be revisited several times in increasing detail below, but is introduced by Kraljic , 1977 and Jones, 1992.

1991[5]); once one of the world leaders in manufacturing supply, the United Kingdom is now ranked between seventh and eighth in machine tool supply Does this matter? The answer here is emphatically 'yes'. Traditional non-systemic thought would lead one to believe that a low contribution to GDP equates to low importance. This particular line of argument has been followed by the press for some time, in particular by the Independent's Hamish McRae column (McRae, 1993, 1994). It is also an opinion that has gained the praise of the City of London's financial gurus in their award of the 1994 Amex Prize (O'Brien, 1993). This misconception has led to much of the lack of interest in manufacturing, with the adoption of mnemonics such as MISS (manufacturing is still significant) being used in a wholly negative manner (Brown & Julius, p.11 1993). It is a matter of conjecture as to the extent to which the lack of City and research interest in traditional industries has led to their subsequent demise in the UK. As service industries have begun to add more and more to GDP (Brown & Julius, pp.8), it has become accepted in many quarters that manufactures are no longer important to the economy.

It has not been taken into consideration, however, that with few exceptions, both the service and manufacturing industries are reliant almost totally on the same manufactured goods, prime examples being computers and telecommunications equipment. When one considers the fact that almost all of today's vehicles, weaponry, production equipment and power generation equipment are also 'manufactured goods' produced using machine tools, the strategic relevance of the manufacturing industry, and the knock-on importance of the products of the machine tool industry is clear.

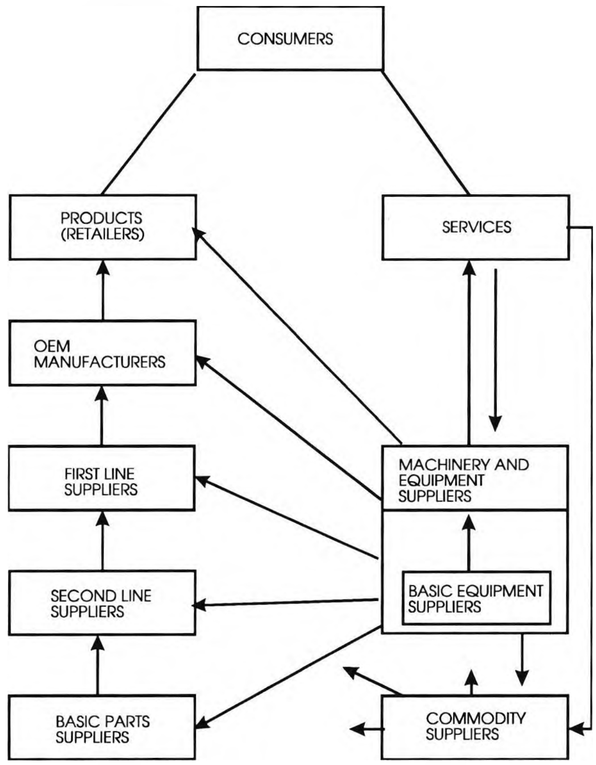
Figure 1.2 below, adapted from one created by the PA Consulting Group illustrates in a simple concise format the importance of the input of the machine tool industry in the manufacture of final products.

---

[5] This particular reference pertains mainly to the American market. Since its appearance the Western markets have suffered equally, and the Japanese market has struggled to maintain its lead in standard machine supply.

FIGURE 1.2

The Supply 'Chain' -
(example as used by PA Consulting)



A.3 - The Aims of this Research Project

Having agreed upon the funding partners and the location for the research to be performed, a more specific subject area was needed. It was decided that the project would begin as a broad study of the 'critical success factors' (CSF) in the development of the European machine tool market. Rather than analysing the engineering aspects of the organisations involved, the analysis would be upon the management of them and the macro-market within which they existed.

It was initially intended that financial management and planning would constitute a major part of this analysis, with the role played by the banks and government in the provision of funds also coming under scrutiny. It will be seen, however, that as the primary research progressed, more fundamental, wider ranging aspects were perceived to be more important. The aim of the research became an investigation of the very nature of the machine tool business - current paradigms of what the business is, and what is required to create a competitive advantage in it did not seem concurrent with what world class organisations were doing. Furthermore, the accepted academic models of the business also seemed to contain inaccuracies as, more and more, the West begins to change the way big business does big business.

The literature review presented in chapter three will reveal how few stones have been left unturned in the broad analysis of the commercial side to the machine tool industry. Both academic and non-academic institutions have, over the years, shown interest in the area, although the bank of existing literature is, as mentioned above, by no means large, and is nowhere near as extensive as the research into what may be regarded as the 'big brother' of the machine tool market, the component markets.

At no point in the literature is there, however, an exploration into the nature of the market itself. The machine tool market is situated in what is generally regarded as a supply, or value, chain[6]. Cole and Mogab describe how the chain approach of functional disaggregation accepts the existence of certain 'black boxes' which are exogenous to the firm. Technological change is one of these (Cole & Mogab, p.11, p. 21, pp.37), and the research presented in this thesis will argue that traditional organisational theory has also accepted the nature of supply as a given, rather than a manageable entity.

This research project is therefore a departure from the traditional CSF approach. It is far more an exploration not of the isolated success, or strengths of the links in the 'chain', but of the actual linkage itself, and what flows through the links, and how this flow, or flows are hindered, fomented, diverted, suppressed or accelerated.

[6] The concept of the value chain having been formalised in works by Porter, 1980, 1985.

It will be argued that the pervading paradigm of the 'chain' is inappropriate not just for the machine tool market, but for supply as a concept per se. Adherence to this paradigm will be shown to have presented barriers to competitive success and development. By illustrating what is believed to be the true nature of supply, suggestions are made as to how a new paradigm, or mental model of the 'system' can contribute to improved competitive success; indeed it may be regarded as pre-requisite. In so doing, it will also be shown how the CSFs identified in isolation in the extant literature do indeed all have an explicit role to play in this success. It is not the content of the extant literature which, in general, is in question. It is far more the typically reductionist approach to analysis that is evident not only in research, but also in broad education and in the business world itself.

Cole and Mogab address a similar situation in their new approach to the study of economics. Confronted with a far greater literature, where they accept that there is 'nothing new under the sun', they do make the following statement which is of equal value in understanding the aim and background of the research presented here:

> "Almost every issue that we take up has been studied in one form or another. We do believe, however, that the present work provides the basis for a heightened understanding of the differences between the old ways and the new. Furthermore, we believe that a rationale for embracing change emerges when these differences are analyzed together rather than left for separate study, as has been the case to date. The synergies that produce a distinct competitive edge ... do not clearly emerge until the blinders of the old paradigm have been peeled away and that requires a comprehensive approach." (1995, pp. xii)

A.4 Conducting the Research

The methodology of the research is likely to be equally new. The acceptance of Systems Science, although not a new area in itself has been slow and erratic to say the least. This, it is argued, is due to its vastly different outlook on the world compared with traditional Western 'rational' thought to date. As a result of this novelty, some time is spent on a description of the chosen methodology and its fundamental beliefs.

The methodology is applied to 'supply' with reference, as has been stated above, to the machine tool sector. This is achieved through a mixture of industrial analyses - secondary research both in the academic and trade literature along with primary research in the form of semi-structured interviews amongst machine tool suppliers, as well as their suppliers in turn, and their customers.

As will be seen to be consistent with the recommendations of the research methodology, the findings from these analyses are then used to conceptualise what is argued to be the true nature of supply.

A.5 Thesis Structure

To conclude this first chapter, a brief outline of the thesis structure is given. Three broad sections can be distinguished in the body of this research. The first of these is an introductory section, to which this chapter belongs, along with chapters two, three, four and five. The second section, comprising chapters six, seven and eight, contains discussion of the primary and secondary research carried out, and certain stages of work performed as a part of the chosen methodology. The concluding chapters bring together what has come before, in the presentation of a model for the industrial supply system. Along with this model come its implications for those affected by it, and recommendations for its wider application and use.

The next four chapters continue the introduction to areas of interest to the research. Chapter two opens the door onto the realm of the machine tool. Chapter three explores the literature covering the management of the machine tool industry. Chapter four then outlines the methodology chosen for the current analysis, and at the same time introduces the reader to the still emerging discipline of Systems Science. Chapter five presents a criticism of the development of the traditional model of supply, and its subsequent adaptations and refinements.

A.6 - An Apology....

As a post script to this introduction, an apology is offered to the reader. From time to time in the text reference is made alluding to further reading on the particular subject under discussion. Should these remarks be found even remotely condescending or patronising the author apologises unreservedly. As will become clear, this research adopts an interdisciplinary approach to the analysis of situations. It sees the marriage of thoughts relating to engineering concepts and products, traditional management literature from various schools of thought (especially organisational behaviour), some philosophy and also aspects of the still evolving areas of the Complexity and Systems Sciences as well as Chaos Theory.

The combination of these areas is the strength of the analysis - indeed the analysis depends upon it. It is the source of some difficulty. The inclusion of explicit references to literature and research in all these areas within the text would break up the argument and in the author's opinion detract from the message of the work. Such references are regarded as important, however, in the recognition of the valuable contribution made to the current research by the work of others. Many references are therefore given, and further explanation often given in footnote form, although these can be by no means exhaustive. The solution decided upon by the author is to give a more brief mention to certain works throughout the argument in a manner that hopefully affords them the recognition they deserve. It is hoped that this system will also assist the future reader to follow arguments further, should it be found at all helpful or useful to do so, rather than to provide a 'guide for future reading'.

CHAPTER TWO - THE MACHINE TOOL AND ITS MARKET

Your worship is your furnaces,
Which, like old idols, lost obscenes,
Have molten bowels; your vision is
Machines for making more machines.

'To Ironfounders and others'
Gordon Bottomley

A - Unveiling the Machine Tool

It would seem at this stage expedient to spend some time on what exactly a machine tool is. In what way does it differ from other machines or from other tools? A definition of a metal-working machine tool is given below:

> "Any power driven machine, not portable by hand while in operation, which works metal by cutting, forming, physio-chemical processing or by a combination of these techniques."
>
> (ICC 1992)

Photographic examples are also given in appendix A2.1.

A.1 - Lines of product differentiation

The description offered above becomes further honed when the distinctions of 'metal-working', 'wood-working' or 'plastics-working' are made. In the present study, the analysis is concerned almost exclusively with metal working tools, although some mention will be given to the other two areas.

Even in the metal-working classification, further classification resolutions exist. The first of these is to do with the design specifications. Here the classification is generally accepted to follow two distinct lines; standard (off-the-shelf) and specialised (bespoke) machines. The former includes product lines from which a customer chooses the machine which most closely suits the required purpose, and although standard by description the modern product will allow certain flexibility through programmable computer numeric control, as described below. A bespoke machine then is one where a specification is supplied, or a function or process described, from which an original machine, or set of machines, in the case of a transfer line, will be made.

Fierce competition in the machine tool markets has caused this pairing to become somewhat fuzzy. The Japanese have made rapid and seemingly permanent advances into the Western markets through the supply of standardised, high quality machines at competitive prices[1]. Companies who traditionally produced standard lines are increasingly allowing final adaptations to the machine which, in essence produces a specialised tool. Advances in programming, in particular the possibilities offered by computer numerical control (CNC) also allow the user of a standard machine to approach that which is possible with a bespoke one[2]. Nevertheless, there still exist components whose machining will always require newly designed machines, and where the possibilities of standardisation in product lines are not sufficient. It is this side of manufacture with which this study will primarily concern itself, although there are some generalities which apply to both standard and specialised manufacture.

Having discussed the distinction of design type and product line, there is yet a further distinction to be made in the function involved. Again, two broad categories are defined by ICC. The first is that of metal cutting, and the second is that of metal forming[3].

Under metal cutting, the processes of drilling and boring, grinding, milling and cutting are included. Metal forming on the other hand includes pressing and stamping, welding, bending and pinching. Much of the discussion in the chapters below will be concerned with metal cutting lines, some however, will also include reference to welding and assembly lines as the nature of the business of their manufacture will be seen to possess certain commonalities.

A.2 - Statistical trends in the industry

[1] Just how quality and competitive price can go together hand in hand will be discussed in detail in chapter six.

[2] The meaning and development of CNC is described in Kief, 1992.

[3] Metal forming and assembly is another important process contribution of the machine tool. Since welding and assembly (body in white) lines are of importance to this project, it could be argued that these functions warrant a separate, third category. The ICC classification splits the functions into either fission or forming - fusion, it would seem, belongs in the second category which for now is accepted as a valid assumption.

Although this research is by no means a quantitative study of the dynamics of the machine tool market, the extreme cyclicality, heightened competition and derived nature of demand are best shown through such market data. The following sections present some statistics and discuss the meaning of them for the market and its organisations. The figures mentioned in this section are to be found in the appendices

A.2.1 - World rankings and increased competition

Appendix A2.2 shows the relative position of the UK in the world machine tool market in terms of production and export[4]. What was a prominent position enjoyed by the UK during the boom period of the machine tool industry in the twenty or so years after the second world war is now far from being the case. An industry which was led by the US and the UK has now seen the Germans, the Japanese and increasingly the Pacific Rim countries eating away at market share. The UK now ranks seventh or eighth in the world depending on the assessment criterion.

These data are not only of relevance in their depiction of the slide of the UK. They are also of importance in that they illustrate the entrance of more and more players into the market. The Japanese, in particular, have rapidly sprung to prominence. Whether they have achieved this by displacing existing players in the market or by finding, entering and exploiting gaps in the market will be a point of discussion in the body of the research.

A.2.2 - The Trade Balance of the UK Machine Tool Market

[4] The data are to be viewed with caution, however. It is a totally global industry, and as such the translation effects of currency and the effects of inflation have to be considered. Furthermore, with international enterprises, the whole value added of a contract is unlikely to have originated in one country. It can thus be difficult to pin-point the value of production down to one country.

Recent data from the MTTA[5] has suggested that this decline in the UK sector of the industry is slowing, a fact also reported in the national press[6]. Indeed, the most recent figures show a move back to a positive trade surplus in machine tool manufacture. This is evident in appendix A2.3. Once again, this observation must be viewed with caution. It firstly does not mention where the upturn is coming from, nor the fact that one reason for such an upturn is that the UK market per se is still not expanding. This keeps the apparent importance of imports to exports low. It also cloaks the fact that the traditional trading partners of the UK in the EU are not buying as many UK goods as has previously been the case. Much of the export effort of the UK has been going to the US, and indeed a growing proportion to China. Although the UK industry must be commended for this achievement, it is doubtful as to whether the industry has the capacity and marketing and cultural know-how to be able to depend on the new, emerging markets for sustainable, reliable sales which have previously come from within the EU. The EU itself must be reconstructed as a significant, although not exclusive market[7]. This is a point which analysis and research into the industry has been making since the early 1970s (P-E Consulting Group 1970, Johne et al 1978, Machine Tool Expert Committee, 1970).

A.2.3 - Customer segments

Appendix A2.4 shows the generalised customer segments of the machine tool industry, illustrating the importance of the automotive industry. As a major capital element which directly affects the quality and quantity of the output of these industries, the importance of the machine tool is self-evident. In order fully to appreciate the importance of the industry, it must be remembered how each of these segments uses and is dependent upon the quality output of some of the others for its own quality. The

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[5] MTTA - the Machine Tool Technologies Association. The MTTA is the UK organisation which represents the industry in political lobbying to the Treasury and the DTI. It organises trade fairs, seminars on business performance and practice and constantly analyses the industry.

[6] Thanks are offered to Andrew Baxter, Industrial Correspondent of The Financial Times for his assistance throughout the project.

[7] Many of those companies visited showed interest in Pacific Rim countries, but few mentioned this as a portfolio balancing or expanding activity.

input from the machine tool is therefore multiplied throughout the supply and production process. This was illustrated in the above chapter in figure 1.2.

A.2.4 - Cyclicality and the Nature of Demand

As well as having to tackle increasing competitive pressures caused by new entrants into the market, the industry is also burdened with extreme cyclical shifts. Studying the trade trends over the last fifteen years shows how the market for machine tools has experienced two serious depressions since the beginning of the eighties, two of which are illustrated in appendix A2.5. Industry folklore suggests that this period is typical.

The machine tool industry is often used as a rough predictor of forthcoming economic performance. When confidence is low amongst either manufacturing industry or the public at large the marginal propensity to consume the products of the machine tool customer industries tends to fall. In order to help avoid the problems of over capacity and to preserve earnings in case of a downfall in turnover, customer industries will revise their capital investment plans. The effects of economic downturns are therefore often felt by the machine tool industry before the economy at large, and will be amongst the last industrial sectors to emerge from hard times.

Furthermore, machine tools last an ever-increasingly long time if need be, and the volume of funds required for investment in machine tools, and much non-production equipment in general, is immense. With single contract prices for transfer lines reaching up into tens of millions of dollars, these are the first investments to be postponed by customers in times of expected recessionary trouble - the demand for machine tools is therefore a totally derived demand, the whole industry being subject to the strength of the pull of the market. The historical link of trends in the UK machine tool market to trends in the market of its major customer, the automotive industry, was evident in the car to machine tool comparison of the figure in appendix A2.5. In appendix A2.6, total vehicle production trends are compared to UK machine tool tends, and the relationship is visible.

This point is a characteristic of the Western market. Recessionary pressure forces the automotive customer (for example) to rationalise expenditure, hopefully according to both qualitative and quantitative criteria. The line dividing acceptable and unacceptable process contributions has to be raised, so to speak. The features offered by the UK machine tool market, and arguably by other Western sectors, often fell below the line, hence the link between sales and investment as outlined above. The entrance of the Japanese into the market was, however, not characterised by this apparently determinant relationship. Their exploitation of new CNC technology, as described below, within reliable machines was a qualitative advance, attractive to the customer. The cost of this quality was kept low through achieving economies of scale in the standardised side of the market. Having said this, the Japanese were able to design standard product ranges that could then be 'tweaked' to conform to a certain sophistication of customer requirements. In other words a mixture of low cost, market driven quality and technological advance.

Whilst what much of the Western market offered fell below the line of acceptance in hard times, the Japanese offered solutions to the requirements of the customer that could still contribute to financial and quality performance.

A.3 - The Implications of Market Trends

From the market statistics discussed above two general trends in the macro market can be drawn ; increased competition and cyclical instability. The implications of these trends have been many and varied and indeed are arguably the raison d'être of this project. Some of the further ramifications are introduced here, and will be revisited in greater detail in later chapters.

A.3.1 - Pricing and Investment

The graphs in appendix A2 show a story of long term decline in one of the strategic industries of the UK, a combination of increased global competition and decreased domestic competitiveness. This has had significant effects on pricing and investment within those companies that remain in the UK. As competition has become stronger and stronger, major customers have been able to exploit this to gain lower and lower prices (Porter 1985, Peters 1989, Doyle et al 1993). Although it must be recognised that dictatorial, confrontational purchasing strategies are today less focused on nominal price reduction, margins are nevertheless still small, and have to be fought for[8]. It has been a trait of the UK and US industries to forgo much investment as a result of this - their funds being retained or being paid to shareholders in preference to investment[9]. The Germans and the Japanese however, have adopted different policies, relying on, very broadly, engineering excellence and reputation requiring substantial investment, high quality and volumes leading to lower unit costs as methods of successful development[10].

[8] As a general trend the machine tool market has been forced to move from so called 'cost-plus' pricing to market or target pricing. With further changes in sourcing strategy in the major customer organisations there is pressure to move towards 'open-book' costing or cost 'transparency'. These concepts will be discussed in detail in chapter six.

[9] That this policy has survived the recession and become an unfortunate part of UK business is described by Tieman 1994.

[10] see Parkinson 1984, Shaw 1992, and Peratec et al. 1994

A.3.2 - Competition and Instability

How to cope with and manage competition through new entrants and cyclicality are two of the major 'macro' challenges facing the industry. Competition has forced firms to become 'lean', i.e. cut out all waste from their processes and improve quality[11]. In the current research, leanness will be equated to process efficiency, with the acknowledgement that overly lean can mean starved of funds or capital. It will be shown how it is the management of lean enterprises which determines the creation of an efficient, lean, healthy system or one which is simply anorexic[12].

Cyclicality has led the organisation to look to geographic and product diversification as a method of smoothing out what otherwise can have disastrous cash flow ramifications[13]. Furthermore, the issue of diversification will be looked into with the necessity of the balanced portfolio.

A.4 - Technological developments and Organisational Developments

From modest beginnings with the expansion of mass production before the second world war, the machine tool industry boomed in the post-second war period. Since then it has experienced almost constant market and technological change which has had significant consequences for the policies and organisation of the firm. The following discussion is an outline of these changes and trends, and also of the impact that they have had on the machine tool builder. The purpose of this chapter is to introduce the reader to the machine tool industry and its environment, and therefore the issues raised are only intended to introduce rather than to explain in detail. As with other arguments outlined above, detailed explanation is left to the discussion of the

---

[11] For explanations of the concept of 'leanness', see Womack, 1990, Gwyther 1994, Fisher 1992 or Cole & Mogab 1995)

[12] An analogy used by Cole & Mogab, 1995, p.3.

[13] The issue of instability is explored in detail in Himes, 1962.

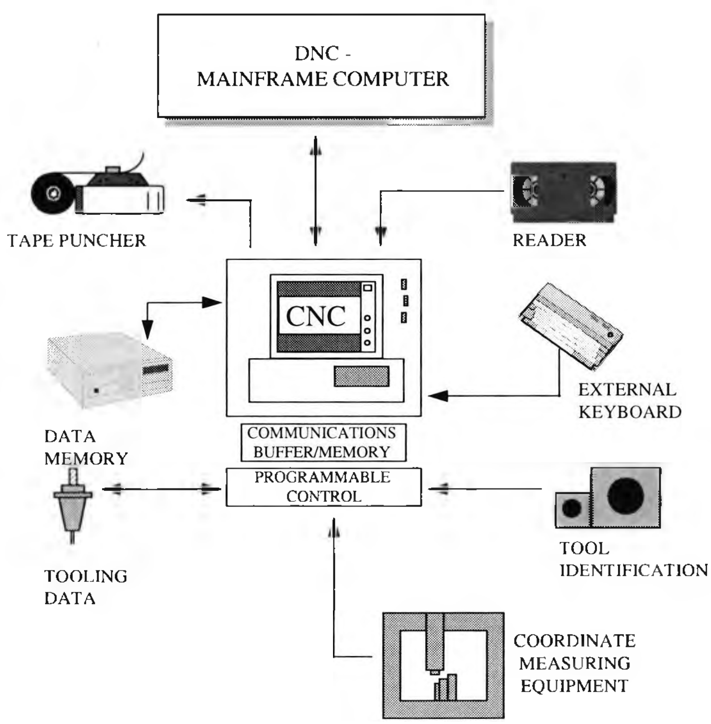
research itself and its conclusions in later chapters. The following points are merely a flavour of the focus of the research.

A.4.1 - Machine tool control

One area of change has been the nature of machine control. Initially machine tools were manually controlled. This developed into control by use of punched tape, followed by the advent of electronic control by microprocessor[14]. This Numeric Control (NC) has been improved upon to become what is now a standard term in the industry - CNC, computer numeric control

FIGURE 2.1(a)

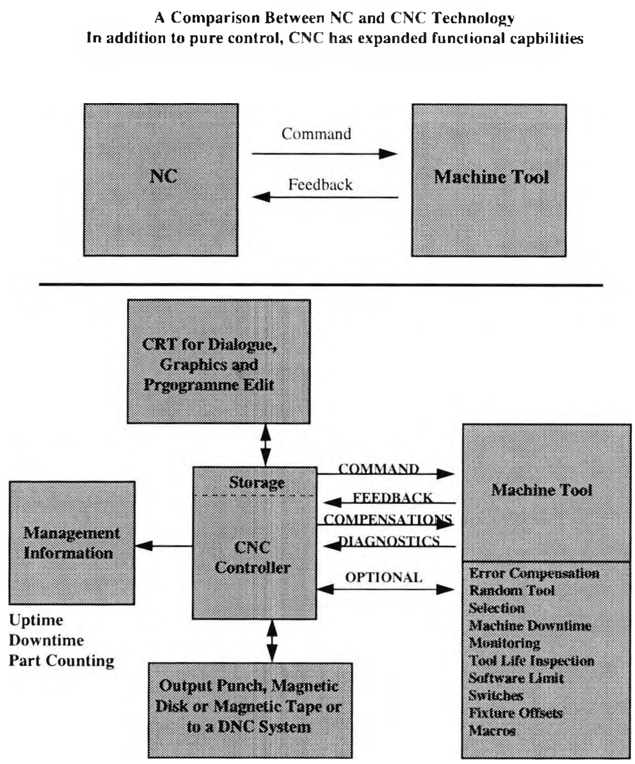
Interfaces of Modern CNC Equipment



[14] For more in-depth descriptions of the historical development of the machine tool see Spur 1991, or Sciberras et al. 1985

CNC allows operators to oversee the process by way of a connected workstation, generally consisting of a key-board and screen (the programmable logic controller - PLC)[15], and incorporates greater memory capacity and a wider set of functions than NC (Kief, 1992 pp.71). Further improvements have seen this change into a programmable, flexible system with the extreme case being direct NC (DNC). DNC allows control through EDI CAD/CAM[16] systems by designers as well as production staff. Diagrammatic representation of the major components of CNC tools is given in figures 2.1(a) above, and 2.1(b) below[17].

FIGURE 2.1(b)



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15 In many cases the operator becomes an overseer responsible for the supervision of many machines. The development of CNC has caused a reduction in manpower to a point where if human activity is necessary it is in the physical input of components into the cell. Even this activity has been extensively automated. The cost benefits initially believed to be associated with such action are now disputed. Increasingly a second school of thought is making itself known through its actions and results, where such reduction of man to a mechanised input is not only called into question, but actively discouraged.

16 See glossary for definitions.

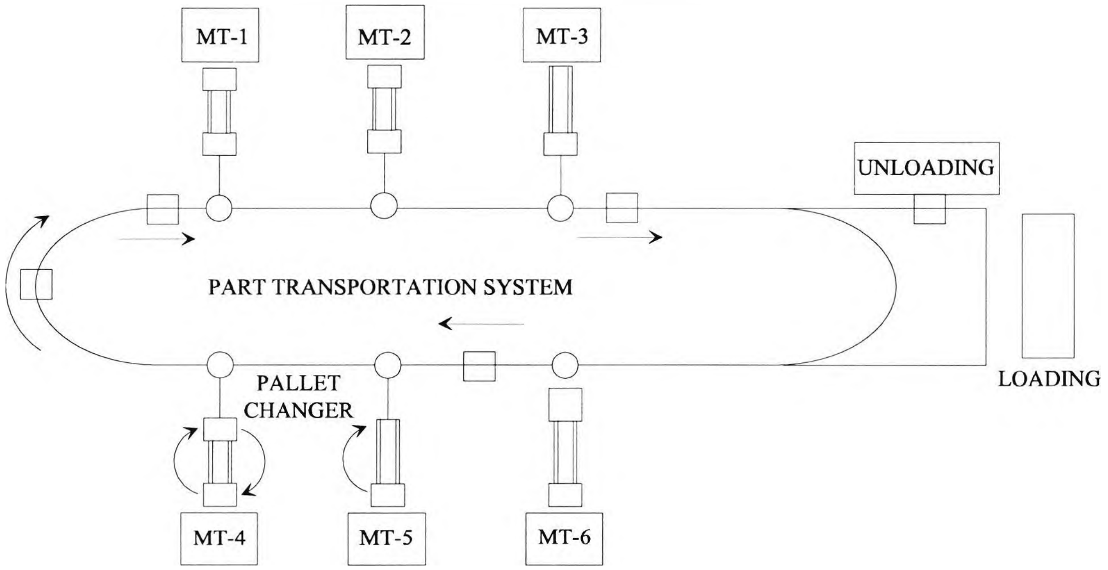
17 Both figures 2.1(a) and (b) are taken from Kief, 1992.

A.4.2 - Operations Management

Controller developments have been accompanied by developments in the design of work flow. Group technology and cellular design has been used as the basis of transfer line technology, or smaller manufacturing 'cells'. The flexibility, reliability and capacity offered by NC and CNC has also meant that fewer machines are required to perform given tasks (Kief, pp.55). With these developments the possibility of faster throughput of work in progress, shorter distances travelled, increased employee empowerment and increased productivity have been realised (Hayes 1988, Ingersoll, 1994). Improvements in handling and materials flows saw the creation of flexible manufacturing cells, or systems (FMC/S); multiple tasks can now be performed within the guarding of one 'machine'[18]. In essence, the FMS is a set of interconnected CNC stations. The transfer of material within an FMS or along transfer lines is performed automatically by robots, transfer bars or conveyors - even by automatic guided vehicles. An example of the layout of such operations is given below in figure 2.2:

FIGURE 2.2

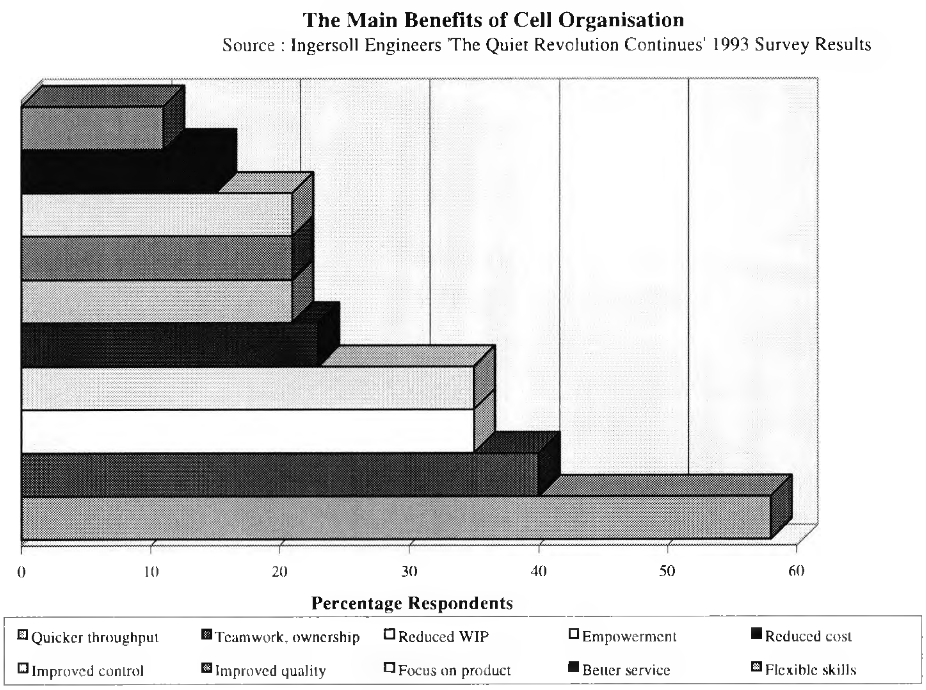
Schematic of a flexible manufacturing system (FMS), consisting of six CNC machine tools, MT 1-6



[18] Flexible manufacturing cells (FMC) are, however, not appropriate to much high volume machining, and hence the need for transfer lines - in essence a stretched FMC - is still great.

A major review of the benefits to be achieved through the adoption of flexible manufacturing and cellular manufacture, all facilitated by machine tool technology and human resource management was carried out by the Ingersoll Engineering Consultancy in 1993. The results are summarised in figure 2.3 below.

FIGURE 2.3



Other technological developments have included increased speeds and reliability of the machining process itself, as much through control technology, as design integrity and materials science. Improved materials in tools have aided this, and drive technology has seen quality and speed improve even further.

A.4.3 - A practical example of the gains to be made through CNC

A clear example of this is described in the July 1994 issue of Auto Industry. Four Ikuma & Howa CNC turning machines were supplied by Sheffield's Ward Hi-Tech to the Redditch based Quinton Hazell (QH) organisation, a company owned by the US based Echlin Corporation.

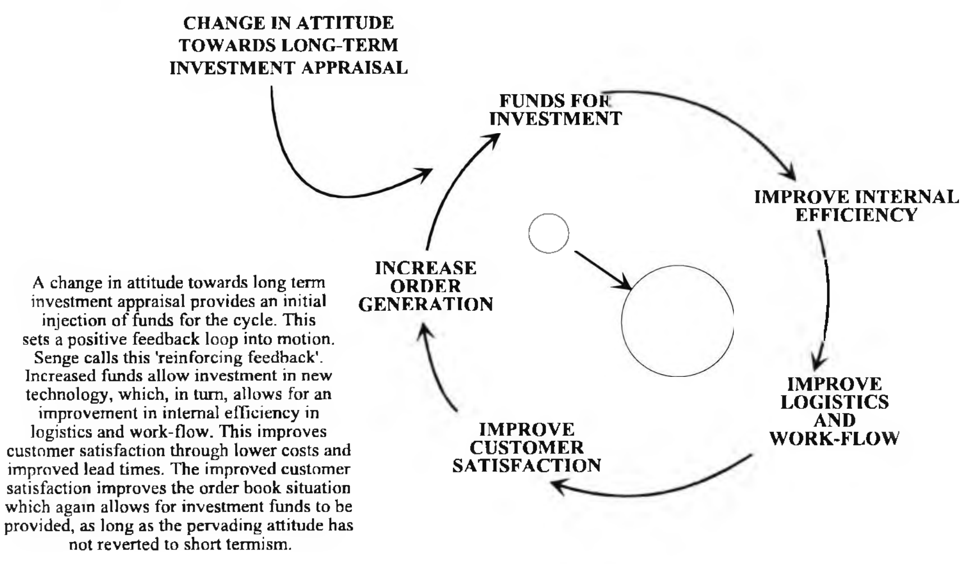
These machines have a substantial effect on productivity in the clutch component supply area - a machining time of 50h being reduced to just 2h on certain components. Much of this time saving is from the time taken to set the machine on the controller rather than manually. In other areas, it is the quality of the output and the flexibility of the process which is of importance. Other CNC cells have also been installed for milling and drilling.

The company acknowledges that the benefits achieved from such improvements are not just to be felt within the organisation itself. The customer is seen to benefit through a move towards JIT delivery facilitated by the new speeds, quality and reliability. Furthermore, QH sees the increased satisfaction of its customers per se as a tangible benefit which will help to win future business. This introduces one of the systems of influences that will be later discussed. By investing in new equipment now, and not using short term payback appraisal methods, the long term benefits from positive feedback can far outweigh the initial costs. Figure 2.4 below uses Senge's format to depict how, through feedback, the long term influence of a stimulus can be far wider ranging than at first believed[19].

FIGURE 2.4

Reinforcing Feedback and Investment

Using Senge's format to illustrate the potential feedback from a long termist attitude to investment



[19] The two circles and arrow in the centre of the diagram represent a 'snowball effect' as the result of the feedback.

A.4.4 - The flip-side of CNC technology - the destruction of competitive advantage

The ramifications of this array of developments - many of which have been developed by the sector itself - have been both positive as in the QH case and negative. Research has proved that the development of CNC in the West actually sowed the seeds of much decline, it being a 'competence destroying' development (Tushman & Anderson, 1987). This means that processes and capabilities employed by traditional companies became obsolete very quickly, and were, furthermore, so in-grained that it was deemed impossible to change. Being able to start their competitive challenge at the time of this development, the Japanese did not have such hurdles to overcome. In the West the reality has been a slow and arduous process of re-learning the business. Some companies have been able to do this, many have failed.

A.4.5 - The need for simultaneously engineered (SE) product

Another problem presented by technological development and complexity both within the machine tool markets and those of its customers is the necessity of the simultaneous design, development and engineering of new machines. Examples abound of NPD[20] without input from the customer resulting in a technically perfect machine which cannot be sold (Peters 1989, Parkinson 1984, Engel 1991). The reasons for this, be they price, capability, design etc. would often to a great extent have been removed or dampened by early customer inclusion in the design and development process.

It must be said here, however, that the same applies for the customer sector. This point will be made in greater detail below, but cases have also been found where OEMs[21] are still adhering to outdated, inappropriate policies of developing their own machines in their entirety and 'throwing the specification over the wall' at suppliers, expecting

[20] NPD will be used as the abbreviation for new product development
[21] The term OEM, original equipment manufacturer, is generally used as an abbreviation pertaining to the major customer organisations. Although these organisations no longer make much of their equipment, if at all, the abbreviation is still in use in industry, and as such is to be employed here.

them to be able to not only understand this specification straight away, but also be able to comply with it, disregarding the fact that the supplier's standards or standard processes might well be equivalent or even better. (A light-hearted characterisation of the problems associated with this process is shown in appendix A2.6). Ignorance of problems caused by this, and the expectation that the supplier must change its standards, costs time and money. By maintaining, or beginning, out-of-contract communications it would be possible for the OEM to become accustomed to the supplier's standards before the specification has to be drawn up. Perhaps more importantly, by working together in the conceptual stages, the customer and the equipment supplier can optimise the customer's production processes, and together devise the ideal machine or system to perform these processes.

Simultaneous (or concurrent) engineering (SE/CE) is the environment, or organisational culture, where during the design, development and production of the machine there is communication across the interface of the buyers and suppliers involved in the process - and that means both internal and external relationships. Included in this communication are engineer users of the machine (the internal customer), process and product design engineers, (from both the OEM *and the supplier*), procurement teams and finance[22]. This 'machine development team' forms part of a larger team simultaneously engineering the complete end product (engine, automobile or aeroplane)

By not engaging themselves in such co-operative behaviour, be it SE, or whatever informal development communication, the OEMs and suppliers have been harbouring and perpetuating the belief in closed systems. This is the belief that the organisation is an island, and can operate quite independently from the rest of the supply system. As was stated above and as will become clearer below, this can no longer be accepted as being the case. The policy of a closed system approach to machine tool development has in the UK and the US seen increased cost, low quality, long lead times, and has

[22] Together these groupings form what Carlisle & Parker term a project 'mandate team'. The success of the group, or project team, will depend greatly not only upon the functional areas involved, but also the timing of their inclusion, and the nature of the teams shared values. For discussion in the literature on CE, see Cyan & Menon 1994, Carlisle & Parker 1989, Hartley & Mortimer, 1991

presented barriers to competitive development, not only of machine tools, but of their end-products in the face of stiff Japanese and German competition.

A.4.6 - Improve or disappear, improve and disappear - Hobson's choice or Catch 22?

A challenge was presented by new technology and competitive developments. By slowly reacting to the challenge and improving the technologies they employ, the machine tool firms of the UK and the US have indeed made significant steps at improving speeds, quality, costs and capabilities as well as flexibility. The result of this is that fewer machines are needed for a given job. This was hinted at with the QH example above where the time savings were quite considerable. A transfer line cutting engine blocks similarly may now only need on average 6-8 machine stations (albeit double-sided ones - i.e. stations whose tools approach the component from left and right) which can possibly be programmed to perform other tasks too. This contrasts to the traditional situation of dedicated lines of more than twenty machines. An output level of less than twenty components per hour in the infant stages of the industry's development has now greatly increased to some 200 per hour, with tight tolerances once not even dreamed of. The advent of high-speed machining in the mid-nineties will see this figure increase even more.

The NPD effort of the machine tool industry has thus had a negative feedback effect, as well as a positive one - it has reduced the size of its own total market by trying to improve the individual company's competitive position and satisfy the customer. This, again, is an example of a feedback system influencing the development of the industry, and is probably one with which the individual companies themselves had not reckoned with when the new technologies were discovered.
Again using Senge's format, this situation can be depicted as influence systems, figure 2.5 showing the balancing effect of the increased efficiency of new technology and figure 2.6 the combination of the influence systems of technology and investment.

FIGURE 2.5

Balancing Feedback and the Introduction of New Technology
Using Senge's format to illustrate the effect of new technology on the machine tool sector, using the concept of balancing feedback

Advances in microchip technology increased the potential for machine tool efficiency. The change from manual to computer numeric control made machines less likely to break down, and more productive at the same time. With a given amount of work, this meant that fewer machines were needed, and therefore fewer machine builders. The heightened competition amongst those who remained only increased the advances in new technologies and their introduction into new machines.
This downwards spiralling cycle Senge calls balancing feedback, and is represented here by the large sphere moving to a smaller one.
The negative effects of the cycle bring any inital improvement back to a state of balance.

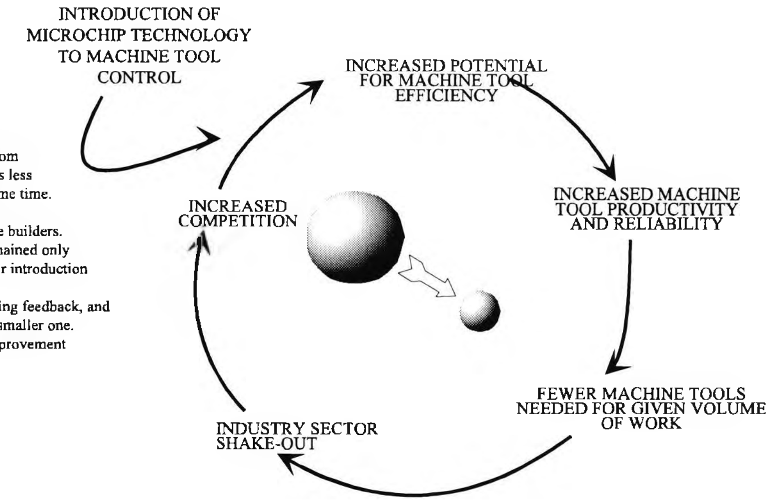


FIGURE 2.6

An Introduction to Interconnectedness - Combining Reinforcing and Balancing Feedback

Feedback does not exist in isolation, neither do the cycles, or systems, through which feedback passes. The balancing effects of one stimulus can trigger reinforcing effects in others, as shown here.
The sum result will depend upon the environment in which the systems interact, and upon the attitudes of the individuals involved.

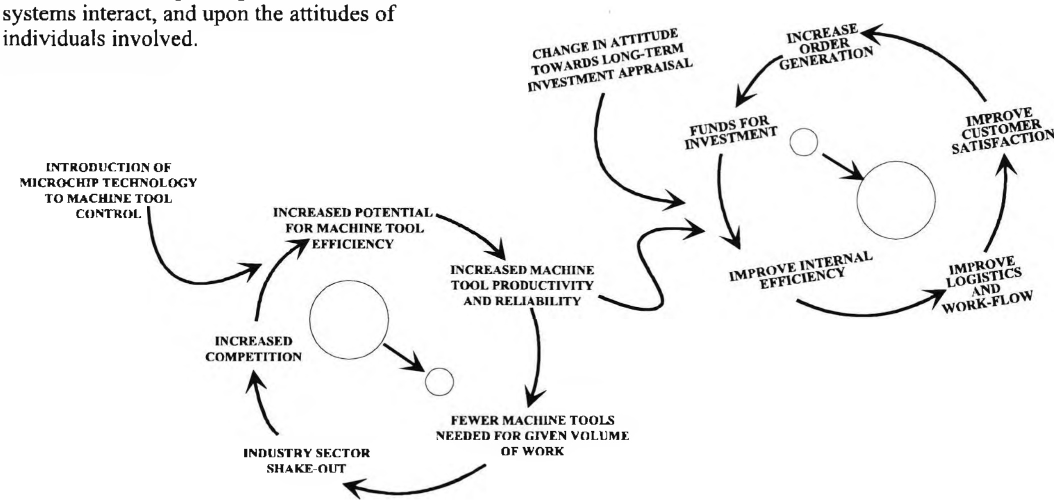


Figure 2.6 shows how feedback systems can be interconnected. Referring to the example given, advances in productivity and reliability create benefits for the customer. Where improvements in technology, or investment in new machinery

allow cost reduction, it would seem to be the not unreasonable demand of the customer for such savings to be passed on. This being the case the balancing influence is likely to outweigh the reinforcing one.

Were the customer to realise that it is in its own interests to let it suppliers invest, the situation would be different. The customer should adopt a similarly long term view to investment and funding as the supplier is trying to. It must understand that by allowing some part of cost reductions to stay within the supplier in order to be reinvested, there is a higher potential for greater benefits in the long term.

It will be seen in later chapters how the major motor manufacturers have, over the last five to seven years, slowly begun to realise this. Only in the last two years has this begun to materialise into real action, however. It will become evident that such interconnectedness is a leit motif in this discussion of the current research, as is the concept of the interdependence of the customer and the supplier.

A.4.7 - Technologies to recycle and refit

A further technological development which will be discussed again in a later stage on the real supply 'chain' system is that of retro-fitting. This is a practice whereby machine tools, no longer needed for what they were intended, are re-fitted by the machine tool manufacturer in order that they may be used for another purpose. It is facilitated to a great extent by modular manufacture or 'design for recycling'. It saves the OEM the cost of the development of a new machine, saves the machine tool manufacturer much of the project management chagrin (where it has been devolved from the OEM to the supplier) and benefits them both through the comparatively cheap extension of business. It is also environmentally sensible. Mentioned in the extant literature (ICC 1992) this activity will be the subject of discussion in the following sections on the construction of a supply system model.

A.5 - The results of technological development on market organisation.

The above section described some of the advances in technology, primarily CNC, which have been hatched in the machine tool industry over the last twenty years. These improvements have had an effect on the nature of the market itself.

A.5.1 - Polarisation - a challenge to traditional economic theory?

As has been stated above, fewer machines are now needed to do a given job. Machines are more reliable, and last longer if needed - they can even be re-fitted to perform new or modified tasks. At the same time, global purchasing strategies have been evolved amongst the customers of the machine tool manufacturer where experience and reputation in the field are increasingly becoming strong and powerful implicit selection criteria. No longer does the manufacturer *need* to be near the plant - whether this policy is advisable or not is not a subject for discussion as yet. Furthermore, there are significant cost and efficiency benefits to be enjoyed through economies of scale in machine tool manufacture.

All of this has seen a polarisation in the manufacture of machine tools, i.e.. the most significant supply is coming from fewer and larger companies - which applies as much to standard as to specialised machine tools. The recessions of the last decades have, of course, only served to accelerate this process; it would arguably still have happened even in a period of more stable growth.

The over capacity created by technological improvements has seen a shake-out of immense proportions. In the US, where the process began, a market with some 1400 machine tool manufacturing companies in the early eighties saw 50% of these go out of business before the end of the decade. This trend has further continued into the nineties, and has also been evident in the UK, the wider EU - with the notable inclusion of Germany, and even in Japan.

A paradox exists here when one compares reality with the economic 'theory of the firm'; margins are decreasing, the market is shrinking, but competition is increasing as more and more entrants to the market begin to supply from emerging market areas. This would seem to contradict traditional economic theory. According to the theory of the firm, companies would leave the market in such hard times - a negative feedback process (diminishing returns) which would tend to an equilibrium position of stability. The machine tool market is an exception that calls into question the acceptance of economic models as generic. In fact the market has seen positive feedback in operation as more and more firms are attracted, it would seem, despite smaller margins.

Such behaviour must call into question the motives of the firm and the theories accepted to explain their behaviour. Whilst they would appear correct as applied to one geographical area, this area alone does not comprise the total market. Discussion below in chapter four, methodology, raises once again this issue of the appropriateness in modern industry of economic theory. The work of Arthur (1994) and Stacey (1992, 1993) and Cole & Mogab (1995) being just some of the examples mentioned. All cast a shadow of doubt upon traditionally accepted theories which have exerted influence on the way that industry is structured and the way it behaves.

Such new schools of thought are experiencing certain 'barriers to entry' in the acceptance of their theories in academia and the wider environment. Having gone through a period when they were 'fashionable', Complexity Theory and Systems Science seemed to lose ground, as 'fads' will tend to do (Jackson, 1993). Nevertheless, with an increasing amount of work into the area and an ever greater awareness in the business world of complexity and the need to harness its potential, the systems view does seem to be regaining ground whilst avoiding the pitfalls associated with fashion. In May 1995 the Observer Business section devoted its 'management' article to this very trend with reference to a well-known author on Complexity Theory:

> "Not surprisingly, there is still fierce resistance in the profession [of economics] to increasing returns economics. As Mitchell Waldrop notes in his book on the Santa Fe experience, by calling into question the existence of the single equilibrium outcome, it attacks the US 'state religion' of free-market capitalism based on the primacy of individual choice. Nevertheless, it is remarkable that pragmatic companies have no such scruples, admitting that the new model provides a much more satisfying fit to reality than the old one."
>
> (Caulkin, in 'Chaos', 1995, p.9)

It is precisely the conception of such a new model, and a description of the implications of it for management which will be the results of this research.

A.5.2 - Organisational strategies and the role of the machine tool manufacturer

There have also been changes on a more micro- or operational product level. The first of these has been brought about by a turn around in the way that big business does big business. Many strategic managers and thinkers of the post-war period advocated the policies of integration. Integration both laterally and vertically was seen as desirable as a way of ensuring constant business and protecting competitive advantage. The flip side of this strategy was the promotion of organic growth encompassing not only core competencies, but also up and down stream activities. Great monoliths like General Motors advocated further internal growth, whilst others like Siemens grew both internally but also by aggressive external integration. Such growth was considered to contribute to competitive advantage by achieving stability, control and order. It will be argued in chapter four that such a policy is counterproductive.

Product and technology life-cycles began to shorten, however, and competition increased, and the rigid structures of integrated organisation were seen to limit innovation and adaptiveness. The large OEMs thus began to spin off the non-core activities of their companies as policies of 'core competencing' and 'sticking to the knitting' became fashionable and successful.

In manufacturing, and particularly in the automotive industry, this has meant that the term 'OEM' is, in fact, somewhat misleading. Many of the so-called OEMs no longer *manufacture* much at all. From having machined almost all components and having had subsidiaries which built facilties and equipment, the major manufacturers - still called OEMs for convenience - now out-source much of their supply and have reverted to doing what they do best[23]. This means marketing, collaborative design, and assembly[24].

As this process has gained momentum, the demands on the machine tool manufacturer have likewise changed. From being involved in the supply of 'the machine', the contracts involved are now more frequently geared up to the supply of the system or process. The term 'turnkey system' is coined to describe the supply of an integrated manufacturing system supplied to a manufacturer by one main, 'first tier' supplier.

As the addition of value is forced back up the value 'chain', the role of the supplier changes. It is the supplier who becomes far more responsible for the project management of those parts of the process formed by the supplier's system or sub-assembly. It is the supplier who is responsible for the procurement of much of the system's components. It is also the supplier who is responsible for much of the system design and layout, having initially been given a functional rather than a design specification. This form of contract is, as yet, still comparatively rare in the West (Peters 1989), for reasons which will be discussed below.

In the above discussion, the practice of co-operative design, development and production was introduced as a way of matching the needs of customers to the developments of machine tool experts. The underlying principle here is that the OEM can concentrate on its own core businesses whilst relying on and exploiting the

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[23] c.f. The Daily Telegraph, 19.08.94

[24] This statement needs further refinement. Not all supply is outsourced; not all supply is the same (Jones 1992, Kraljic 1977). The major auto companies like to outsource to gain the advantages that SE/CE and parallel sourcing for example bring (see chapters six to eight). Nevertheless, there are certain process inputs that are regarded as strategically critical, and therefore are still if not manufactured in-house, then certainly machined. A prime example here is engine machining and assembly. Although the casting of engine blocks is increasingly outsourced, the machining and assembly of the final engine is still carried out in-house.

powerful combination of expert knowledge in both machine tool manufacture *and* component processing found in the machine tool company. More and more, the machine tool manufacturer is approached by the OEM with a functional requirement to manufacture a component, and will be expected to develop the whole or aspects of the production process. Using the metaphor introduced above, this means not only the machines in isolation, but the whole system which can 'turn the key' to 'unlock' the product from its conceptual design. The optimal situation - that advocated under SE - is the joint, collaborative development of the machine and its final product. Having combined the two knowledge sets into one project team, one optimal specification can be the result. This contrasts with the traditional Western method of supplying the supplier with a complete design and expecting it to be built to exact specifications.

The changing face of the supply base, the demands placed upon the suppliers therein and the demands placed upon their management are discussed in chapter eight. The result of the changes has been of increased importance in the buyer-supplier relationship. No longer is the OEM a closed organisation where 'black-box' suppliers can be expected to supply to quality standards, or where technological change is similarly exogenous to the activities of the OEM. Such 'black boxes' never existed in reality, but because of the traditional approach to organisational structure and the West's culture of reductionst, rational thought, the black box approach was believed to be the easiest, most cost-efficient path along which to travel. The successful OEMs of the future will be those who realise that not only do they have to 'open up' to the customer but to the supplier too.

B - Summary Of Industrial Background - Market Challenges

To summarise, the machine tool industry is a small industry which is relatively poorly known. It contributes little directly to GDP, and has for some two decades been in decline in the US and the UK - in more recent years in other countries too. Despite this, the strategic importance of the industry is immense, it having input into almost all manufacturing and service activities of industry as a whole.

Characteristics of traditional Western industry today are as follows:

- heightened competition
- competition from emerging markets
- derived demand
- demand cyclicality
- market polarisation

The companies involved in the West are becoming fewer and fewer, and the roles they play more important as the meaning of 'value added' changes from a quantitative cost-based one to a mixture of both cost and quality, and knowledge.

At the same time as being expected to work more closely with the OEM, the machine tool industry is also being leaned on more and more for technological development in machining and materials technologies. The unfortunate paradox here being that technological improvements too often mean an acceleration of the polarisation which has caused the disappearance of much of the industry.

Two words summarise the current challenge facing the machine tool industry as much in the UK as in the wider global markets - 'efficiency' and 'flexibility'. Those companies that do not efficiently remain on the edge of market-driven technology will not survive.

CHAPTER THREE - LITERATURE REVIEW

The machine tool has become a strategic weapon in the game of gaining competitive advantage.

WS Atkins Management Consultants/Ifo Institut

Introduction

A review of the extant literature was conducted at the start of the research, and was continued throughout. The purpose of this review was two-fold. Firstly it was necessary to become acquainted with the nature of the market, the organisations active in it and the very products themselves. The second reason was to become familiar with the *research* previously carried out in the area, as much to ensure novelty in this research as to learn from the existing bank of literature.

As this thesis unfolds, it will become apparent that it covers a variety of topics. The first of these is that of the machine tool market. Others include Systems Science as the fundamental methodological approach to analysis, buyer-supplier relations, concurrent engineering, supply base management and procurement, and quality. Each of these areas has its own bank of distinct literature. The review of literature presented in this third chapter only covers the work carried out in the machine tool area and describes those works referred to in the process of choosing the specific area for study. The remaining areas will be introduced as they are included in arguments. Short reviews will be given, as in the methodology chapter, or text references and footnotes provided for guides to further reading.

For simplicity, the review presented here is divided into the areas of academic research and industry literature. In some cases it is recognised, however, that there is an overlap and the distinction should not be considered rigid. The chapter finishes with a general discussion of the literature which links into, and helps justify, the subsequent discussion on methodology.

The bank of work existing in the area of the management of the machine tool industry is not large[1]. Much work has been carried out on the historical

[1] It was noted above in chapter one with reference to communication with the Daimler-Benz group that the low level of interest shown by academic institutions is characteristic of the low interest shown by government and industry at large to the development of this sector. Although praising the growing awareness of the importance of supply, the lack of importance given to the non-production side of manufacturing is seen as a source of competitive disadvantage. This point is reinforced by Gaylord, 1991.

development of the machine tool per se and its social implications (e.g. Spur, 1991, NEDO, 1977) or developments and refinements in the engineering and design of the machines and tools themselves (Tobias & Königsberger, 1970, HMS 1983, Kief & Waters 1992). A surprisingly small volume exists, however, for the management of the market and its players considering the strategic importance of the product. It is hoped that the review presented here will list the salient research in the area, highlighting the topics covered. It is also hoped that it will aid others in their search for machine tool based literature in the future, as the apparent lack of such a list was seen as a hurdle to the progress of the current research.

A - Research Carried Out in Academic Institutions

For the purposes of this review, 'academic research' is defined as analysis performed within or in connection to an academic institution, rather than an industrial body or publication.

Due to the low volume of published work in the area, it is intended to touch as many as possible on an individual basis. A general theme runs through all of the work relating to the UK, and seems to have been the premise for much of it: Why has a nation once successful in the supply of a sector of products strategically important to the nation's industry now become such a minor player in the market?

The earliest research found to have been conducted in the specific area of economic analysis in the machine tool market was written by Himes (1962). In a doctoral project at The American University, Himes studied the problem of instability in the machine tool market. Mainly a statistical analysis, the conclusions of Himes' work are that instability is an inherent part of the machine tool market, reinforcing the conclusions drawn from the statistics relative to the UK market in chapter two of this work. This instability is primarily a function not of organisation-specific actions, but of environmental, political, market and governmental influence and interference. It is also concluded that the machine tool producers are accustomed to this, and have learned to expect the large cyclical variations in their market. Recognising that the instability was becoming an increasing problem, Himes predicts rationalisation in the machine tool market, meaning a reduction of the numbers of firms engaged in machine tool manufacture. This is indeed what has been seen to occur in the US market, with firms engaged in machine tool related activity numbering over fourteen hundred at the beginning of the eighties but at the start of the nineties the number had been cut by half.

Some sixteen years later a working paper from City University looked more into the direct managerial effort in the machine tool market, and of its effects on organisational performance. Johne et al's working paper entitled 'The British Machine Tool Industry's Recent Marketing Performance' (1978) uses the machine tool market in the UK as a part of a wider study into comparative marketing strategies. This particular paper looks into the marketing strategy of UK machine tool makers, and draws conclusions about its effect upon company and sector performance.

General conclusions include the inability of UK machine tool companies to realise the importance of the international market. Being a global, open market[2] this has inhibited the UK's success. Foreign competitors have not only secured footholds in their respective domestic markets, but have also complemented this with a portfolio of international contracts. Such international effort increases the potential for full order books, and also offers the ability to smooth out national cyclical fluctuations and hence 'hedge' against the dynamism of the market illustrated by the statistics in chapter two.

The next point made is the nature of products marketed. As also described in chapter two, machine tool technology has increased in complexity and sophistication as, for example, control techniques have moved from tape control through NC towards CNC and beyond. According to Johne, although the UK has

[2] 'Open' here relating to the absence of formal barriers to entry or exit in the machine tool market.

kept up with the technology, is has not expended effort into marketing its innovative abilities abroad[3]. Where international marketing has been evident, it has been seen as a method of 'dumping' old product lines. Although not an inadvisable policy in itself, it has had the effect of the UK being regarded as a producer *only* of low sophistication products. This was not the case, but the reputation nevertheless led to a competitive disadvantage abroad.

At the same time, new competitors, especially the Japanese were breaking into the UK, and indeed the markets of most other significant industrial nations. They were able to supply quality machines in the areas already supplied by domestic producers, but at lower prices. The result of this was a loss of domestic market share to a hitherto unimportant competitor which has to this day not been regained. American organisations have also successfully entered the market - both before Johne's work and after it. Their survival as machine builders in the UK (as opposed to the agency based approach of the Japanese) has been at the cost of the indigenous builders. One main difference between US and Japanese competition is the type of machine offered. Japan's strength has been in offering a high quality, low cost, standard product line that can incorporate some customer requirements. The strength of American competition has been in bespoke manufacture and design, with certain standard manufacturers managing to ride the Japanese storm.

Johne concludes that the UK's loss of competitive success in the machine tool market is marketing based. Its inability to realise the importance of an international portfolio combined with the ignorance of the Japanese threat led to a loss of both domestic and international status and performance.

Much the same conclusions are drawn by Doyle, Shaw and Wong (1993) and subsequent works by Shaw (awaiting publication). Publications stemming from a doctoral thesis from Warwick University (Shaw, 1992), these papers look at a

[3] This argument itself will be challenged by other research presented below. Much of the UK's failure in the machine tool market has been attributed to its inability to incorporate new technology or new materials into the product, let alone market them successfully abroad.

cross section of UK, German, US and Japanese machine tool manufacturers. The team from Warwick University also analyses the marketing strategies of the organisations. Not only are the British companies studied criticised for their lack of international effort, but the internal organisation is also not deemed appropriate for international marketing orientation. Too little formal attention is paid to understanding customer requirements, and the amount and nature of the marketing force is substandard when compared to foreign competition. In addition to this, the UK organisations are criticised for being short-termist in their approach and for having an overbearing profit concentration at the cost of generating and reinvesting funds in research and development.

These last points are also given attention by Parkinson (1984). This Anglo-German study compares the new product development (NPD) effort in the two nations' machine tool markets. It forms part of a wider study by Baker et al at Strathclyde University. As a general observation, the success of the German and failure of the British effort is said by Parkinson to rest on the appropriateness of the NPD effort.

Both national markets displayed signs of NPD. In the German market, however, two general differences were observed which affect the appropriateness of the NPD process. The first of these corroborates some of Doyle, Shaw and Wong's findings: the German NPD is driven by customer requirements which are actively sought after in the market place. Secondly, once these market drivers have been identified, there was a difference noted in the 'buyer-seller interaction'. British companies displayed distance between the seller and the buyer organisations during the development phase of the machine, whilst in the German model there was more involvement of the buyer organisation's employees in the process.

Parkinson is at pains to separate the link between 'customer-supplier interaction' and successful NPD. A significant level of interaction cannot constitute alone the recipe for success in development. However, the level of buyer-supplier interaction certainly facilitates a greater fitness for purpose in the resulting product.

The topic of buyer-supplier relation will be frequently discussed in later chapters of the current research project presented here. It will be seen that a substantial amount of prior research has been devoted to it[4] covering many industries. This prior effort has analysed, amongst others, the issues of who is included in the process, when, where and what the results of a 'partnership' approach are. Little effort seems, however, to have been devoted into the question of *why?* It is not sufficient to validate a process merely by empirical evidence. One of the aims of this research is to give intellectual, theoretical reasons for the move towards systemic, partnership based supplier relations.

Tushman and Anderson (1987) look to a mixture of technological and cultural factors to explain the downfall of the UK and American machine tool producers in relation to the Japanese. Looking at the management of technological change, the subject of their analysis is the *type* of technological innovation to break out of the science base onto the market. Two types were observed to exist, competence enhancing and competence destroying technologies. The names are easily understood. The former pertains to an innovation that adds to the competitive strength of the organisation's competencies. The latter is so radically new and different that existing capabilities are seen as barriers to its adoption.

Relative to the machine tool industry, the development of CNC technology is regarded by the authors as a competence-destroying innovation for the UK and the US. Although developed to a great extent in these nations, the domestic manufacturers and users of machine tools were so deeply entrenched in the 'traditional' technology of the day that two factors prevented their changing to CNC. Firstly they did not fully realise the potential for its widespread application

[4] Amongst the many examples in this area are Carlisle & Parker, 1989, Cusumano & Takeishi, 1991, Turnbull & Valla, 1992, Bergman & Klefsjö, 1994. A more exhaustive discussion of the buyer-supplier area will be given at a later stage.

and use. Secondly they did not possess the knowledge or skills to fully understand the new technology within their respective organisations. It was believed that a move over to the 'new technology' would entail either the replacement of existing engineering staff, or the additional employment of a new set of staff with new skills. Neither solution was regarded as consistent with the maintenance of the firm as a going concern.

B - Research Carried Out in Conjunction With Non-Academic Institutions

The above review presented the extant literature in the area of managerial analysis of the machine tool sector conducted solely within academic institutions. The following section presents a larger bank of work - that which has been undertaken by or in conjunction with non-academic institutions. These include various parts of the government, research institutions and independent consultancies.

UK governmental research into the machine tool industry seemed to reach a peak from the mid 1960s to the mid 1970s. Throughout this period much government sponsored research was published. Subsequent to this the volume has, however, drastically fallen back, with the more independent institutions taking over the lion's share of analysis.

The most significant of these publications are 'The Machine Tool Industry' (1964), a report from the Machine Tool Advisory Council and 'The Machine Tool Industry' (1970) Report of the Machine Tool Expert Committee. Closely connected to these two reports are the NEDO publications 'British Machine Tools in Europe' (1972) and 'A Handbook for Marketing Machinery' (1970). It is an indication of the falling degree of interest shown in the machine tool industry that there are now no government departments or committees devoted to the research, analysis or promotion of the machine tool industry.

The four reports are similar in nature, although the sophistication and detail of the analysis increases with time as the sophistication of the tools themselves and the understanding of the market increased. The general themes are similar to those uncovered by the academic research presented above, and are as follows. The UK market suffered greatly from the mid sixties, a fact born out by statistical analysis in all four reports. The size of the market and the number of players in it, as well as employment were all in decline.

The UK market is criticised for its slow exploitation of international markets. Similar criticism is earned by the UK's inability to remain at the forefront of machine tool technology in application, although the UK's research in the area is considered innovative and successful. Investment and its encouragement, education and training, research and development, marketing and sales strategies are also discussed with the conclusion being that for an industry recognised as being key to the industrial success of the nation too little attention and effort is paid to it.

For the purposes of this present research in particular, one area of discussion from the NEDO (1970) findings is that of the customer-supplier relationship. The lack of interaction between these two groups was found to be a characteristic of the UK market and strong recommendations were made to correct this at company levels. It is ironic to note that conclusions drawn by governmental research over twenty years ago were reiterated in academic research ten years later. (It is arguable as to the extent to which the same conclusions could be drawn today.)

The theme of education and training is picked up again by a discussion paper from the National Institute of Economic and Social Research. The failure of British companies to adopt and exploit new technologies is blamed on the standard of output from the education system. Graduate engineers are singled out for special criticism for, amongst other things, poor commercial awareness. It is also as a result of this that plant size and efficiency are not able to be optimised, which in turn leads to an inability to exploit to the full the economies of scale enjoyed by foreign competitors[5].

A further discussion paper from the Institute (Matthews & Mayes, 1992) studies the impact on the British and German machine tool markets of the removal, at the beginning of 1993, of certain trade barriers to create the Single European Market. The statistics used in the study are those already used in the academic analysis above, and the conclusions drawn are mainly speculative. It is not felt that this particular report nor its findings are of importance to the present research.

Perhaps the most comprehensive work carried out on the machine tool industry is found in the partially OECD sponsored work of the Technical Change Centre (Sciberras & Payne, 1985). Following a discussion of the historical development of the machine tool and its market, the book then divides into seven broad areas of activity, including management areas, government policy and education. These areas are compared across the UK, the US, Italy, Germany, Japan and Switzerland - arguably the most important machine tool markets in terms of volume and development.

Although to be recommended for its comprehensive approach to the analysis of the machine tool market, there is little contained within the conclusions that had not previously been reported in prior research. Again, the lesson here is that nothing but the same conclusions *could* be drawn. It must be asked whether such comprehensive research has the value of specific research such as that of Shaw above. Is there any relationship between the various areas that have been researched, all of which are present in Sciberras and Payne's book? No attempt has been made in the literature to join the various elements of the research, to draw linkages between them. This point will revisited at several stages in the ensuing conclusion to this chapter. Sciberras and Payne's work does, however, cover a far greater subject area than that of other research.

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[5] In this case the example of Germany was named.

As Chairman of the Ingersoll Milling Machine Company, one of the world leaders in its field, Edson Gaylord, has produced two papers concerning the management and development of the capital goods industry, one of these appeared in the Journal of Applied Manufacturing Systems (Gaylord, 1990), the other remains unpublished in the form used in the research (Gaylord, 1991). Both papers contain a similar message and as such they will be described here together

Both papers outline in brief the history of the Ingersoll Company, its strong family ties and culture. The historical importance of the machine tool industry is charted, pin-pointing its vital contributions to the economic success of the nation. This issue of strategic importance has been covered by much of the literature, but rarely in such an emotive fashion as here. Three broad reasons are given for the decline. The most fundamental of these is the short termist nature of the West and its inability both to realise or care about the ramifications of its current actions upon its own future.

The results of this are manifold, but two further negative issues arise pertinent to the capital goods industry. Firstly the obsession with short term financial measures, the 'return on investment culture' being decried in the paper. Such short termism has starved the industry of investment funds for development in favour of other industries, information processing being quoted here (1991, p.3), where the payback is quicker and higher. In 'Competing World wide in Machine Tool Manufacture', Gaylord criticises the ROI preoccupation not only for its effect on investment funds, but also because of the basic erroneous assumption that a payback on a machine tool is quantifiable at all:

> "There is widespread belief that management should look to return on investment (ROI) to decide when to invest in machines. There is no logic to this. No one gets a return on the investment in a new machine more than one gets a return on the investment in a new sales manager. Returns come when the whole company is working right. When the sales department is selling, the engineering department is designing correctly, and when the shop is producing top quality, the result is profit."
>
> (Gaylord, 1990, p.63)

This is a highly intuitive and informative statement. It illustrates a further example of the existence of feedback systems as introduced in chapter two. To analyse the payback from one machine is to analyse only one part of a reinforcing system. By so doing, and not letting the system run its course of influence, the maximum benefit cannot be measured. The sum result in Gaylord's opinion, and reinforced by this research, is that much capital investment is foregone because of the inability to appreciate these feedback connections. Policies aimed at short term success, assisted by reductionist analysis, negatively affect the potential for long term survival.

The issue of the payback assessment policy is further criticised in an article by Brittan (1993). The article explains the 'endogenous growth' theory of economics. This theory is an augmentation of much accepted economic theories of economic growth, as Brittan explains:

> "The reasserted orthodox view [of 'mainstream economic theory'] was that the growth of output depended on technical progress and the growth of the labour force. Investment was necessary to support this growth; but any attempt to force the pace by installing capital more quickly would lead to diminishing returns."

Investment was therefore regarded as a reacting, or derived variable, rather than a proactive force. The endogenous growth theory refutes this assumption:

> "The assertion is that capital is the key to growth after all, and that the technical know-how to support more output and a superior range of products was something not existing in a vacuum but came out of the investment process."[6]
>
> (Brittan, 1993)

[6] The sciences have often used terms such as 'vacuum' or 'black-box' to represent what is not covered by any analysis or theory being developed. In chapter four a discussion of the work of Cole and Mogab (1995) will revisit this theme. In agreement with Brittan, Cole and Mogab reveal how technological development has been regarded as a factor exogenous to the environment of the worker, and is treated as a black box. Such treatment has prevented organisations from encouraging the workers' vital input into the process of technological product and process development.

Growth can, according to the theory, be stimulated by investment within the organisation (hence 'endogenous'). Brittan continues by describing Maurice Scott's research into endogenous growth. Scott found a positive correlation between investment (in this case in capital equipment stock) and per capita GDP in Germany, Italy, Japan, the US and the UK - the UK faring the worst in the analysis. Having done this, Scott alludes as to why much investment is foregone by introducing a market failure. The growth in GDP is generated by social returns from investment, these being the result of the 'multiplier effect'. Such social returns are far higher, and are subject to much longer delays, than the financial returns that are used in assessment. Such narrow returns therefore present a barrier to the growth not only of the organisation, but also to society at large.

The next issue in Gaylord's work is that of human resource management and the actions of the unions. Although less of an issue in the second half of the nineties, the industrial relations history of manufacturing industry is decried as being too preoccupied with its own internal wranglings at a time when the threat from 'outside', i.e. the Japanese, was far more important. At the same time, the people-management from the owners and managers of industry is also seen to have been at fault through its failure to promote good practice, again in favour of short term cost issues[7].

From the narrow point of view of Ingersoll's experience, the paper offers three reasons for the continuing success of Ingersoll; money, man-management and markets[8]. The first of these is its attitude to money and the constant injection of funds into R&D. This has maintained a position of world leader in many of its areas of activity on the leading edge of technology. The second ingredient in Ingersoll's success is another aspect of investment; investment into skilled capable

[7] An insight into exactly why the West developed this culture, stretching back into the days of Adam Smith is offered by Cole & Mogab, 1995.

[8] The recent failure of the organisation to retain its preferred supplier status at Ford would suggest the inadequacy of this list and an element of irony in the title of the 1990 paper - Ingersoll was dropped for lacking a sufficiently global supply base. This recent experience points to the need for a fourth policy, already hinted at by other papers, this being the creation of a global capacity, both in the satisfaction of its customers' requirements and in its own internal processes.

people. Ingersoll introduced some years ago what are becoming standards in current quality HR policy, these include the twenty four hour standard and procedures manuals (Gaylord, 1990, p.61), which are held as a significant advances in man management and therefore in the company's competitive position[9]. Employees know that they are able to make positive or negative criticism and that they will receive an answer from a formal system in twenty four hours, and furthermore that they ought not to attract criticism themselves for doing so. This has been a step towards the creation of a 'Kaizen-like' environment, the importance of which will be expanded upon in chapter four.

The final success factor mentioned which is exogenous to Ingersoll is the importance of free markets and freedom from governmental interference. Although giving mention to the issue of international trade and protectionism, Gaylord also discusses the over- bureaucratisation of business in the US. By adding up the costs associated with adherence to the red-tape formalities of safety standards, equal opportunity, product liability and environmental protection a burden is found which constitutes a 'substantial competitive disadvantage' (Gaylord, 1991, p.12). Not intending to decry the importance of these issues by any means, it is the cost of the enforced procedures involved which is highlighted, and which ought to be addressed.

Three further reports have been found which are worthy of mention, although they only in part deal with the machine tool sector. The first of these is from the RSA (1994), and speculates on the requirements, structure and function of 'Tomorrow's Company'. Drawing on Shaw's work mentioned above in relation to the machine tool market, the RSA report is of interest due to its conclusions that the interrelationships between companies and their closeness to others will become of paramount importance to 'tomorrow's company', no matter how good their internal processes are. This line is one which will be seen to run throughout the present research.

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[9] For details of further application of the One Day Standard and its contribution to the success of Save & Prosper, see Horsfield, 1994.

Two reports were inaugurated by the Commission of the European Communities (CEC) during the 1980s. The first, conducted by the Boston Consulting Group (BCG), looked into the global market for machine tools in the period 1984-1985. The second, undertaken by WS Atkins Management Consultants in association with the German Ifo-Institut, amongst others, researched the same market towards the end of the decade. It builds upon the BCG's findings, and presents a comprehensive analysis of the market *at the time of publication*. It makes several revisions of the BCG's findings, and then goes on to make predictions of its own as to the development of the European market for machine tools. These predictions have not been realised as fact.

Dynamism in the market is important in the WS Atkins report, both explicitly and implicitly. The changing pattern of demand has already been touched upon; the changing face of competition is also discussed. The fact that the BCG report does not accurately reflect the market of 1988/89 is less an indication of the quality of the BCG work than an indication of the inherent market complexity, and perhaps the difficulty experienced in collating accurate, reliable data. This is borne out by the criticism that may now be leveled, from the mid-nineties, at the WS Atkins predictions of future market developments which, as has been stated have not been seen to come true; the prediction of a 'buoyant EU market for machine tools' being just one example.

Despite the many inaccuracies in the report's predictions, WS Atkins' findings do present some important aspects of the market hitherto left undiscussed. Other aspects are mere confirmation of the findings of previous work. It illustrates areas not highlighted in the BCG report. A company-internal example here is the failure of the West to apply new materials science and new materials themselves to machine tool R&D. An extra-organisational example being how increasing sophistication of customer requirements has affected the ability of machine tool manufacturers to standardise manufacture.

Also given attention in the report are factors which confirm others' findings. For example the issue of unexploited economies of scale is discussed, as is the nature of Japanese competition and the need for increased integration of education and customer industries into the R&D process of machine tool manufacture.

The final project felt worthy of discussion in this chapter was conducted by the McKinsey Global Institute (Lewis et al, 1993) and presented to an invited audience from industry and academia at the CBI in June 1994. The emphasis in this study, comparing Germany with the US and Japan, is placed upon the importance and nature of competition in the open markets, and the impact this has upon national success in various sectoral areas. One of these areas is metalworking, the bulk of which pertained to machine tool production.

The nature of competition across the three markets was compared to techniques in biological science. The US example was compared to natural biological growth, the Japanese to genetic engineering, and the German case to the promotion of growth through pharmaceutical intervention. Hence the US market has been left alone to fend for itself in the forces of the market. The German market has also grown in this way, but has been aided by external forces in the form of subsidies and a favourable mixture of industrial, governmental and financial policy. The Japanese market, however, is characterised by 'artificial' growth, by which it is not meant that the growth itself is artificial, but the way in which this growth has been managed.

The Japanese identified manufacturing as an industrial area of strategic importance of the success of the nation. As such its various sectors, including machine tool manufacture and development, have been promoted by the representatives of financial and industrial policy within both government and large scale manufacturing alike. This promotion has occurred both directly through the MITI[10] and indirectly through implicit governmental influence in the Japanese Kieretsu structures.

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[10] The Japanese Ministry of International Trade and Industry

The approach adopted has been firstly to ensure that there is a manufacturing base of critical mass and secondly that there is a domestic market willing and able to buy from this base of supply. This domestic market has traditionally been well protected, officially and unofficially, and has for some time been the subject of international trade talks. The next step has been the promotion of international sales - both to Japanese facilities overseas and foreign domestic companies - through a mixture of high quality, low cost (achieved through standardisation) and aggressive marketing tactics.

Through this mixture of a strong domestic base and an equally strong international effort, the Japanese market has fulfilled the recommendations of the marketing oriented literature above. This however does not explain the 'wholeness' of their success. Other works such as Imai (1986), Deming (1986) or Mintzberg & Quinn (1991) throw light on other well documented, machine tool non-specific, systemic issues also contributing to Japanese success.

C - DISCUSSION OF THE LITERATURE

It is hoped that this literature review will aid the reader in several ways. Firstly it is intended to list the major research output relating to the management of the machine tool market over the last two and a half decades from an academic standpoint, both from within academic institutions and other research bodies. It will then complement the statistical sources from trade bodies and the media as used in chapter two.

It is recognised that the list is not exhaustive. At the time of compilation certain studies were in the process of publication that could not be included. One hurdle that was encountered during the early stages of this research was access to a bank of titles. IT based literature searches generated a plethora of engineering specific titles, and disguised the 'softer' side of machine tool analysis. By collating the above titles and discussing their areas of interest in turn it is hoped that this may, in the future, be avoided.

Another way in which it is hoped that the review will be of value is the ease with which the reader follows the arguments presented in subsequent chapters. In the appendix to chapter two, statistics were shown which highlighted a situation which for the players in the market is regarded as problematic. This stems from the increasing complexity of the market in both detail and dynamism.

The research conducted in the field of the management of the machine tool manufacturer and its market has, on the whole, attempted to highlight what has caused national failure or success. It must be asked, however, what conclusions can be drawn from having read the review of the extant literature as a whole. Many perspectives are touched upon, each of which is given importance by the author in question. Which is to be believed or adhered to in preference of others?

It is argued here that the extant literature, rather than shedding light on possible areas for success and improvement, adds to the complexity of the situation through a confusion of viewpoints. The next chapter will return to this point, and continue the criticism. Although covering a wide area of issues, the literature has failed to tackle, perhaps to appreciate even, the situation as a 'whole'. As Saunders writes:

> "Analysts have drawn up a long list of contenders that may be relevant as explanations of poor performance. No one point is sufficient on its own, but rather all have had some part to play at times, though not altogether in any one firm."
>
> (1994, p. 46)

This point is supported by the author of the current research. Saunders continues by attempting to bring the seemingly diverse 'list of contenders' together in strategies for purchasing and supply management. This fails to address the fundamental flaw in the literature which stems from the very way in which 'business' and 'supply' are perceived. Both are seen as separate functions, themselves consisting of separate units. Although the recent work of Saunders and others in the field attempts to illustrate the interlinkage between these ‘units’, they do this within the same reductionist paradigm.

The work presented in the chapters that follow will reveal a new approach to the analysis of business and supply in the machine tool market. Understanding of the nature of the market and of industrial supply will be improved by improving the ‘mental model’ of what supply really is. In this manner, it is hoped that, rather than disproving the conclusions of the literature, a loose framework is offered which will illustrate their importance as constituent elements of a system, and perhaps even more importantly how it is their interaction which is the key to success.

CHAPTER FOUR - SYSTEMS METHODOLOGY

"Would you tell me please, which way I ought to go from here?" she asked. "That depends a good deal on where you want to get to," said the cat.

Alice's Adventures in Wonderland
Lewis Carroll

Introduction

The preceding chapters have introduced the origins of the research project under discussion and its area of interest, that of the machine tool and its market. Statistics were presented showing the dynamic nature of the market, recognisable in the cyclical swings, and also its complexity, caused by the increasing numbers of national competitor markets[1] and the players within.

Next, the literature was discussed in some detail, this detail will now be justified. It was seen how, although not extensive by any means, the machine tool related literature does cover a broad range of topics - few areas related to the market are left untouched. Many pieces of the literature claim in some way to present reasons why some regional sectors of the market are buoyant while others have failed.

This chapter will begin by continuing the discussion of the literature, and questioning its appropriateness and relevance to modern business analysis. By concluding that a new approach is required to complete the 'rich picture' of the market and bring together the disparate nature of the extant literature, arguments will then be presented for the choice of methodology adopted in this research. This methodology will be seen to differ substantially from the extant literature. Following on from this will be a description of the methodology, its theoretical background and how it was pursued in primary and secondary research effort.

A - The Need for a New Approach to Analysis

What lessons are to be learned from the literature described above? By having presented the reader with what is, hopefully, a full, detailed review of the varied literature relating to the machine tool markets, what conclusions can be drawn

[1] Here it is important to define 'market' as consisting both of buyers *and* sellers (Begg et. al 1984, p.10). Variations in the numbers of both of these groupings causes constant, complex changes in the possible permutations of collaboration.

which lead the reader closer to understanding what could be called 'Critical Success Factors' in the running of a machine tool enterprise? It has been popular in the management literature to discuss these so-called Critical Success Factors, and 'CSF' has even become a recognised abbreviation[2]. Despite the apparent legitimisation offered by statistical evidence, does it not depend upon one's particular field as to which *particular* CSF is thought important or not from the outset? The results of statistical research cannot truly be termed 'statistically significant', and hence perceived worthy of a CSF title, if generated using samples which themselves could hardly be considered representative.

The initial phases of this project, too, perpetuated the belief that such CSFs could be hunted down. It was soon realised as the field research progressed that this would be unlikely to produce results of true value. Firstly, it would have proved similar to looking for the treasure at the end of the rainbow, since what was deemed 'critical', a subjective measure, constantly changed with the ever increasing pace of change of the business environment. Indeed, the list of factors seen to be 'critical' increased at a faster rate than company visits could be found! The project seemed to be turning into mere journalism - yet all of the CSF variables *were* important. In order to have taken all of these variables into account with co-variant and multi-variant proof of statistical significance, it would also have taken a far larger effort than the individual, time and resource constrained projects characteristic of academic research. Furthermore, it seems of little use to the managing director of an enterprise that what caused the downfall of the empire was not considered significantly relevant in statistical terms.

B - Rational Thought and Holistic Thinking

The approach taken by almost all examples of the literature has been to take one area of interest in isolation, and investigate its relevance to the machine tool

[2] An example of the use of the term and its abbreviation is the DTI publication 'Manufacturing in the Late 1990's' of 1994.

market, usually by some sort of standard questionnaire which has then been statistically analysed. Even those works such as that of Sciberras and Payne, which discuss a multitude of areas, seem to take this reductionist[3] approach, discussing the various areas in certain isolation. Hawking (1988) confirms this to have been the case not only in his field of theoretical physics, but also for 'science' per se:

> "The eventual goal of science is to provide a single theory that describes the whole universe. However, the approach that most scientists follow is to separate the problem into two parts....It turns out to be very difficult to devise a theory to describe the universe all in one go. Instead, we break the problem up into bits and invent a number of partial theories. Each of these partial theories describes and predicts a certain limited class of observations, neglecting the effects of other quantities, or representing them by simple sets of numbers. It may be that this approach is completely wrong. If everything in the universe depends on everything else in a fundamental way, it might be impossible to get close to a full solution by investigating parts of the problem in isolation."
>
> (1988, p.12-13)

Increasingly, such an approach to the analysis of problematic situations is coming under fire and is being criticised not simply for the quality of the results generated, but for the validity and appropriateness of the approach itself. The area of Chaos Theory grew from a desire to depart from the fragmented thinking of the traditional physical sciences (Gleick, 1987). The originators of this new science quoted such fragmentation of approach as the hurdle to the furthering of knowledge and understanding. The fundamentals of Chaos Theory have now begun to gain acceptance in the business world, with the various publications of Stacey (1993, 1992) and Sterman (1988), Mosekilde & Larsen (1988) being just three examples.

[3] The term 'reductionist' will be used a great deal in this research. In its usage within Systems Science, reductionism has a negative connotation. It describes the reduction of a complex situation or entity into its constituent parts. This is usually done in order that the situation may be better understood, since in its entirety traditional approaches have been unable to cope with complexity. Rather than address this as a flaw in the approach, such reductionism has become an accepted analysis tool. The result of reductionism is the inability to comprehend, model and exploit the interlinkages and interactions that exist both explicitly and implicitly between the 'units' that are separated. Holism and Systems Science are the opposite of reductionism. These schools of thought acknowledge the fundamental importance of these links to the success of the situation, organisation, entity or 'system'.

Indeed, many areas of society and industry have now found themselves under attack from an area of research challenging the very lynch pins of understanding and knowledge. Perhaps the most significant silo of this battery has been the body of scientists from the Santa Fe Institute in New Mexico, of whom Caulkin writes:

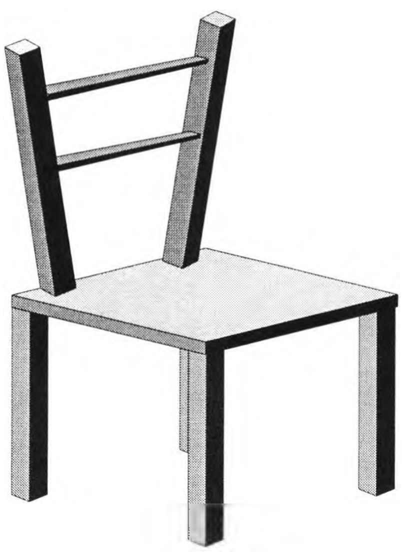
> "Their perception was that the 'loss of innocence' in discipline after discipline -mathematics with Turing and Gödel in the 1930's, physics with chaos theory in the 1970's, not to mention logic, language and philosophy - was not only coincidental, it might be explicable in common terms: in terms, that is, of the self-organising, emergent behaviour of difficult-to-model systems such as ecologies, economies and indeed life itself, which have done so much to destabilise the conventional sciences."
>
> (Caulkin, 1995 p.9)

Santa Fe is not the only source of protagonism. Presenting an argument from a more epistemological angle, Pirsig (1974) decries the rational approach evident in much of traditional scientific research, and indeed the whole rationale of science, as being self-contradictory, opening up more questions than it answers. Recognising the need for a certain element of reductionism in the evaluation of situations, Checkland continues by criticising traditional scientific method for adopting this as its *only* approach (1981, pp. 50). Ackoff's criticism of the 'Machine Age' takes a similar stance, and convincingly translates the argument into organisational thinking. Similarly, Deming called for an increased understanding of and 'appreciation for a system', the system not only of a single business, but of business itself, and of its inextricable interdependence with society and the whole environment (1986,1993). For Deming such a change in approach would open a window on a 'Profound System of Knowledge', offering potential for improving not only business systems, but personal and societal ones too. Einstein is quoted as having followed a "dictum that you should make things as simple as possible, but not more so" (quoted in Ridley, 1995). Unfortunately it is increasingly the case that 'things' have indeed been over-simplified.

B.1 - On The Existence of Problems

The criticism stems from the very perception of the nature of 'a problem' and the ability to solve it rationally. By accepting that such an entity as 'a problem' exists, it is also accepted that it can be broken down - rationally - into constituent parts, for ease of comprehension, and that these parts, once understood, may be reassembled to create a whole which is itself also fully understood. Ackoff and Pirsig illustrate the folly of this approach and its obsession with definition. Building upon Vestor's work (Guntram 1993), figure 4.1 can be used to explain the argument.

FIGURE 4.1



What is shown in the picture, what is its purpose? Traditional analysis would break the object down to its components leaving a set of shapes, some wooden, some metallic and some plastic. It cannot be concluded from these shapes what the purpose of the object is. This can only be understood when the components come together. It is their physical interaction which in this case gives the object its use, its quality.

By freeing the object from a reductionist analysis, by stepping out from the problem, rather than going into it, the purpose of the object which stems from the interaction of its component elements is fully appreciated. Having adopted this holistic approach to the solution of the problem, it is also necessary to free the analysis from definition. With no preconceptions as to the object's normal function, the answer to the original question could well be 'something to climb upon' (a ladder?), 'something to burn' (firewood?), 'something to put things on' (a shelf?), or 'something to sit upon' (the chair).

If this appears a flippant example, it is perhaps because of the wide recognition of 'a chair'[4]. The answer to the problem 'what is this object?' is governed by the preconceptions of those faced by it. It is therefore a moot point as to whether 'a problem' is an entity, or whether it is simply a situation which is viewed as problematic.

Holistic thinking and the avoidance of strict definition are fundamental to the still developing areas of Chaos Theory and Systems Science. They also characterise the approach adopted in this research which has as its underlying approach those belonging to the latter of these new 'sciences'. Key to these areas is the system - a set of purposeful elements and interactions[5]. In this respect, the machine tool industry is a system, as is the chair above or the weather systems of oft-quoted chaos examples (Gleick 1987). In its analysis of the machine tool market system, the literature to date has broken it into its elements, and has ignored these elements' interactions. Since it is this interaction which will be shown to produce quality and value in a system, it is argued that such approaches in isolation cannot be of use to the long term success of the system[6].

The acknowledgment of business as a system, rather than as a set of discrete functions is now widespread. It is not only a concept used by academics or pundits of such management fads as Total Quality Management or Business Process Reengineering. It is widely recognised that flows of value creation and addition are dependent upon cross-functional, inter-departmental co-operation, and that such flows are inhibited by functional barriers and delineation (Carlisle and Parker 1989, Shapiro et al 1992, Cole & Mogab 1995).

[4] This 'recognition' is what Locke describes as primary quality (quoted in Kanji, 1995 p. 66). The full quality of an object is also determined by its secondary quality, the experience or emotion arising from, for example, its use or consumption.

[5] A full definition of what is meant by the term 'system' is given below.

[6] As will be described in the second part of this chapter, it is accepted in Systems Science that all systems have an implicit purpose. The successful system is one that manages to move with time towards achieving this purpose.

It is therefore argued that the study of functionally related, isolated aspects of the business system and its markets cannot produce a true picture of the markets themselves, their systems or their enterprises - let alone their products and in turn the products' quality[7]. What is needed is an approach that is able to capture the complexity of these systems, and which can offer ways in which they may be optimised for the good of all elements of the system. It will be seen later in the discussion how an overbearing concentration on certain elements, as would seem to be the advice offered in parts of the literature, can be detrimental to the other constituents of the system.

Systemic optimisation is similar to economic pareto efficiency. This measure is one of the softer elements of economics, and is defined as the state where 'it is impossible to move to another allocation which would make some people better off and nobody worse off' (Begg et al 1984, p.325). Working to identify distinct CSFs is argued to be dysfunctional and self-contradictory. Through sub-optimisation it leads to pareto inefficient situations where certain elements of the system under examination appear more important than others.

The methodology presented below which has guided the research is a route towards not only the understanding of systems and their interactions, but also one which can lead to their optimisation - a situation where all CSFs through interacting *together* produce quality and value.

[7] Cole & Mogab (1995)take this argument one step further. It is firstly acknowledged that functionally oriented structures preclude the realisation of synergies between functions. Moreover, the rationale behind this organisation, scientific management and the division of labour, has such an inherent cost focus that any improvement or change will tend also to be focused on narrow cost improvements rather than wider process based learning.

C - Systems Science and the System

The above discussion presented the case for a new approach to the research of the business system. The requirements of this new approach, identified as lacking in work to date, are as follows:

- The ability to appreciate dynamic and detail complexity
- The ability to adopt an holistic approach
- The ability to reach definitions which are either common to the perspectives of all elements of a system, or which are loose enough so as not to produce sub-optimal preconceptions

This second part of chapter four will introduce Systems Science and some of its fundamental concepts. This is followed by the introduction of the methodology to be employed. To begin with, the nature of a 'system' as a generic concept is discussed.

C.1 - On the Nature of the 'System' as a Concept ('Systems World')

This research adopts a 'systems', or systemic view for the analysis of the machine tool market. In order for this to occur, and to aid the reader, the following discussion will analyse the meaning of the word 'system' as understood here and indeed within Systems Science. The abstract nature of this discussion will later be seen as necessary as it is re-applied to the more practical aspects of the field research. The reason for the presence in the title of the term 'systems world' in parenthesis will become apparent to the reader in section B below when the methodological approach is explained. In the context of the methodology, it will be seen to complement the similar title in chapter six, *'On the Nature of the 'System' as a Commercial Entity ('real' world)'*.

C.1.1 - Definition of the Term 'System'

As a word in the English language, 'system' is highly ambiguous. The Oxford English Dictionary offers some six variations of definition:

- A set of connected things working together
- An animal body as a whole
- A set of rules or practices
- A geological term relating to rock formation
- A method of classification
- Orderliness

Vernon (1993) offers a slightly tighter 'systems nomenclature'. Four types of system exist; arrangements, networks, schemes and true systems. Each type builds upon the preceding one. Thus, arrangement systems have parts arranged in order, networks have arrangements connected together, schemes are related networks, and true systems are schemes relying on each other[8].

Common to all of these descriptions is the notion of a multiple of elements which in some way together form a set. For the purposes of this study, it is the above classification of true systems in which interest is shown, although by definition this encompasses all other subordinated types.

The elements of a system interact. It was mentioned above that the traditional approach to the analysis of situations has been to ignore, or suppress these interactions through reductionist 'problem solving' techniques. The dangers of this have been discussed. Also of importance in the nature of the system is, however, *purpose*. As well as having a number of elements and interactions, a system is said to have purpose. This purpose unfolds and is fulfilled or otherwise within an

[8] For examples of these classifications, along with diagrammatic representation of the nomenclature, see Vernon, 1993, p. 207.

environment. The environment can have indirect influence upon the fulfillment or failure of the system to achieve its purpose.

Necessary to the comprehension of a system are, therefore, the awareness of the elements which constitute the set, an appreciation for the interaction of the elements, the purpose of the system and the nature of the environment within which the system exists. Hence Dunderdale (1994) describes organisational systems as comprising both the explicit 'definable structure' and a more latent structure of 'human interventions'.

C.1.2 - The Contents of the System and its Boundaries

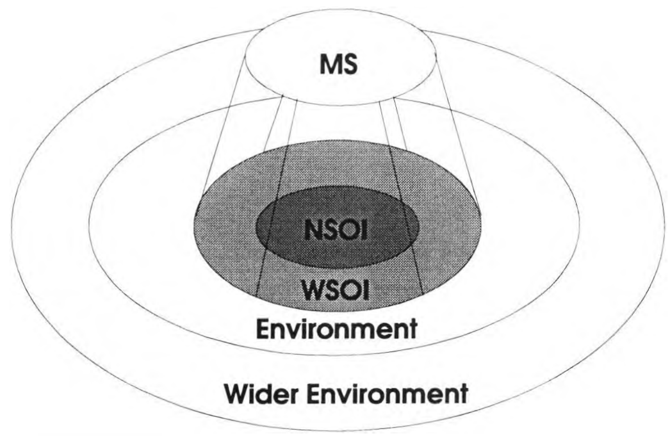
If a system exists within an environment, there must be point, on a boundary, where the system 'touches' the environment. Much consideration has been given to the criteria to be applied to the positioning or perception of an element as environmental or systemic (Flood and Carson, 1993, Checkland 1981, Jones 1982, Vernon 1993). One general principle that all tend to agree on is Flood and Carson's first rule:

> "Be suspicious of recognized boundaries or apparently obvious ones."
> (1993, p.71)

Flood and Carson (1993) illustrate the relationship as three-dimensional in their 'sombrero' model, depicted in figure 4.2 below.

FIGURE 4.2

Definition of a system's boundaries : "The Sombrero"
(Adapted from Flood and Carson)



KEY : MS - metasystem
NSOI - narrower system of interest
WSOI - wider system of interest

Four entities are shown. The first of these is the environment. The remaining three are systemic[9]. The 'NSOI' (narrower system of interest) is that set of elements and interactions in which the primary interest is shown. For the purposes of this research this is the machine tool market, or at times the machine tool manufacturing organisation. Surrounding this is the WSOI (wider system of interest). This is the set of elements which, subjectively do not belong to the NSOI, but where there nevertheless exists reciprocal influence upon the success of the purpose of the system. The NSOI and the WSOI together form the SOI, the general system of interest.

The last entity is the metasystem. Flood and Carson (1993, p.15) describe this as a control system - a system which in some way controls the actions of the NSOI in its pursuit of the systemic purpose.

These definitions use comparative adjectives, and subjective opinion in the definition of the systemic boundary. This is not by way of coincidence. Systems boundaries are 'fuzzy', temporary, indefinite and dynamic. What belongs to the

---

[9] The term 'systemic' being used to mean relating to, or belonging to the system.

centre of the NSOI is generally understood, but what exists in the WSOI will depend upon perspective and situation. Again there is the notion of the existence of problematic situations, dependent upon perspective, rather than fixed problems.

To summarise the various opinions offered, an element considered a part of the environment should actually be considered systemic if there is:

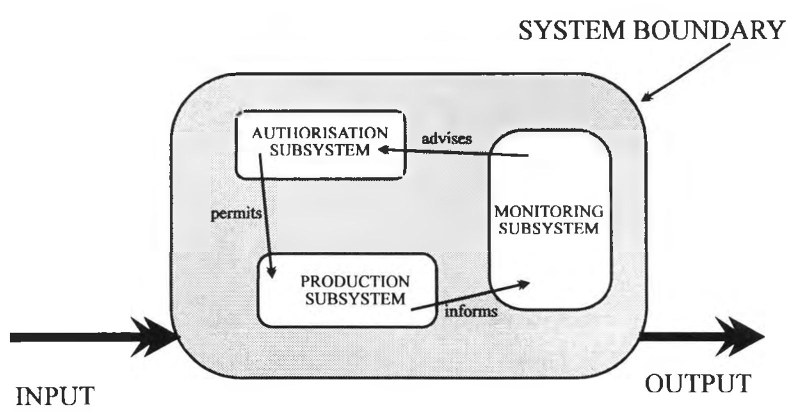
- reciprocal influence on activity between the element and other systemic elements, or
- reciprocal contribution to the success of the element and other systemic elements, or
- an element of control between the element and other systemic elements.

No element which both influences and is influenced by the NSOI can exist within the environment, but must be brought into the WSOI for systemic consideration. It must, however, be realised that this influence itself is dynamic, and inclusion in the system at any given moment is no guarantee that this must always be the case.

Vernon (1993) also illustrates the concept of the boundary to systems. In this case, a more process-oriented view is taken, where the system is a transformation process, accepting inputs and outputs from, one presumes, the environment. A diagrammatic representation is shown in figure 4.3.

FIGURE 4.3

Vernon's System Process and Boundary



Relating this back to Flood and Carson's approach, Vernon's system only represents the NSOI. Since the quality of the input influences the efficiency and/or success of the transformation process, and the acceptance of the input affects the success of the preceding process whence it came, a WSOI must be apparent, but is not considered by Vernon. This reciprocal influence, *interdependence*, will later be seen to be of crucial importance to the optimal management of systems in the business environment.

An important aspect of Vernon's descriptive view of the system is, however, this view of *process*. Flood and Carson offer a structural view which can *also* encompass interaction, transformation and throughput, but need not. This might easily be overlooked, leaving a view of the system as being simply a set. Vernon's view is a reminder that the systemic purpose is achieved by the quality of the transformation process. In the discussion of the methodology, the concept of transformation will be highlighted. It is the interdependent transformation process that opens the possibility of emergence, a term with which the reader will soon be made acquainted, and is therefore key to systemic success.

A first step on the route to the analysis of the nature of supply will be an attempt to define the system, its boundaries, elements and processes. This will follow in chapter five and constitutes the first stage of the chosen methodology described below. In so doing, the above criticism of definition has been kept in mind. The definitions given are therefore considered accurate at the time, able to be updated (indeed they should be) and take into account as many perspectives as possible by use of the methodological steps. The very process of assimilating such definitions should in itself generate greater understanding of the system, which is arguably of greater, longer lasting importance than the resulting definitions themselves.

C.1.3 - Generics of Systems

It will have become evident to the reader that the concept of a system is being treated as a generic concept. No attempt has been made to draw distinctions between possible types of system. Through observation in the literature of Systems Science certain generic properties are accepted to be existent in a system, the variation stemming from the nature of the systemic purpose (Flood and Carson, 1993, Checkland 1981, Senge 1990, Stickland and Reavil 1994, Vestor, quoted in Guntram 1993).

All systems, no matter what their purpose, are taken to exist within a boundary, and that boundary opens onto an environment. This boundary is dynamic. These are not the only generic properties of a system, more are listed below, but the list is not exhaustive[10]. Those items listed below are those which have been seen to have particular relevance to this particular project. It will be seen how the successful achievement of the systemic purpose will rely upon the management of these generics, be it conscious or not.

C.1.3.1 - Complexity

The idea of complexity has already been touched upon. It must now be further honed into two types, detail and dynamic. Detail complexity arises from the multiplicity of elements within the system and their possible relationships with each other. Dynamic complexity arises from the propensity of these elements to change their purposes, perspectives and effectiveness over time. Although complexity may well seem to be an aspect of the system that is to be removed, this proves a trap for the unwary. It *cannot* be removed, it is inherent, and therefore needs to be managed (Dunderdale, 1994). Indeed, it has been argued that a system

[10] For a concise and well defined list of these generics, see Flood and Carson (1993)

can only realise its purpose if it possesses a certain 'requisite variety' (Ashby, 1956).

Although it is accepted that there do exist generics to systems, there are certain types of systems that will exhibit these generics more than others. The difference between soft and hard systems is one example of this pertinent to complexity. Here the distinction is flexibility and adaptability[11]. Hard systems are generally inflexible and unadaptive. Soft systems, the reverse, are constantly changing, subjective and are capable of adapting to the environment. Of extreme 'softness' are human activity systems[12], where the nature of man's interaction with man - 'him'self a complex system - makes for complexity of ever increasing dimensions.

The efforts of Systems Science are not directed at the reduction of complexity - quite the reverse. The attempt is made to acknowledge its existence and understand its causes via the use of the Systems tools at hand. Only through such understanding can the purpose of the system be achieved (Dunderdale 1994, Clewer 1995 [a] & Clewer 1995 [b])

C.1.3.2 - Hierarchy and Feedback

Hierarchy is another important concept in the generics of systems. Each system exists within others, and contains in turn systems within itself. The set of resolutions that these systems create forms a hierarchy of systems. Within the machine tool market system are organisational systems on a higher resolution. On the 'next' resolution are, for example, functional departments or cross-functional project teams. The next resolution being the individual. What one takes to be the NSOI in the course of analysis will depend upon the particular hierarchy taken to

[11] The differences between hard and soft systems are well charted. It is not intended here to duplicate this effort. For a full definition of the two concepts and their differences see, for example Flood & Carson, 1993, or Checkland, 1981.

[12] The concept of human activity systems is covered by Vickers, 1970 (quoted in Flood & Carson 1993) and Checkland, 1981.

be central to the study, it is a purely subjective measure. Chelsom & Clewer (1995) illustrate this hierarchy, and discuss the importance of both vertical and horizontal interactions in the hierarchy to systemic success. Vernon (1993) also illustrates how the existence of the hierarchy ('nested systems') can be put to use in the management of complex situations.

The interactions that occur within and between systems produce feedback. As a resultant flow from an interaction, feedback in organisational analysis generally pertains to information flows, but in the physical sciences also encompasses more tangible or measurable flows of energy.

Senge (1990) discusses at length the importance of feedback and makes distinctions between reinforcing and balancing feedback. The first are similar to Arthur's positive feedback systems (1994) which explain the seemingly illogical and irrational acceptance of certain products in the market place. These are just two examples of work covering the importance of feedback in soft systems. In the area of hard systems, or more accurately the traditionally harder end of the spectrum, there is the attempt to model feedback to model the system itself. An example here is Forrester's work at the Massachusetts Institute of Technology, and other research in the area of system dynamics (Forrester, 1969, Lane & Sterman, 1994).

C.1.3.3 - Emergent Properties

It has been stated that the disaggregation of elements of a system in order more easily to understand them is sub-optimal due to the inability to comprehend the related interactions. No justification has as yet been given for this. This justification is to be found in the concept of 'emergence', and, similar to the preceding generics, this concept will prove of prime importance to arguments in the body of this research. In that it is an occurrence *between* systemic elements, it is similar to feedback, but pertains to the systemic output, rather than the functioning of the process.

Emergence, or emergent properties from systems, is the ability of the elements of systems to work together to produce an output greater than the sum of the physical products involved. These emergent products can be generated between all levels of resolutions in the system. Languages are full of idioms that describe our sub-conscious acceptance of emergence. Examples from English include ‘two heads are better than one’, ‘a problem shared is a problem halved’, or ‘the whole is greater than the sum of the parts’. Team synergy, group dynamics and general debate also rely upon it.

The disaggregating approach of rational thought, justified by the apparent inability to analyse without it, removes the opportunity to maximise these emergent properties. By ignoring the meaning of complexity, in fact seeming to be scared of it, the full potential of the system to achieve its purpose is foregone.

C.1.3.4 - Self-organisation

Systems themselves are generally governed by their place in the hierarchy; superordinated systems contributing to the nature of the metasystem as described above. Although open to influence and control from other systems and the environment, the various elements of the system can organise themselves. Hence clouds form, crowds gather, fashions and styles evolve, technologies and products gain acceptance - and there can sometimes be no logical, rational explanation for the ‘why’, ‘where’ and ‘when’. Other formations might have been more ‘rational’, but were not deemed suitable to the system’s purpose. Arthur (1994) gives examples of this in modern day life, and Stacey (1993) builds upon the idea. The elements of soft, adaptive systems can learn from the feedback of their interaction and use this experience to organise themselves.

In achieving their purpose the elements of systems ought therefore to be allowed certain freedom to self-organise in an environment or atmosphere of non-recrimination, in order that learning may occur[13]. The power of Arthur's 'positive feedback' or Stacey's 'chaos frontier' can only be harnessed if this is the case.

C.1.3.5 - Entropy

Four broad generics of systems have already been highlighted relating to their interactions with each other, their resolution in relation to other systems, the potential arising from the combination of these interactions with such resolutions and their ability to organise themselves for such potential in given circumstances. Entropy, the last of the generics to be discussed here, is a more negative one.

Entropy is defined in the Oxford English Dictionary thus:

> "A measure of the disorder in the molecules in substances that are in contact with each other, indicating the amount of energy that (although it still exists) is not available for use because it has become more evenly distributed instead of being concentrated."

Although a rather abstract definition, entropy is accepted as being generic to systems. Of importance from the definition are the phrases 'in contact with each other' and 'become more evenly distributed'.

Entropy is the tendency of systems to disintegrate, to collapse - perhaps even to lose their purpose. Through the interactions of the system, if left alone and without constant input of energy in some form, the system will not succeed. Flood and Carson (1993) quote the example of a droplet of ink let into a flask of water. As the molecules interact, the pure ink 'system' diffuses into the water. Gleick

[13] For discussions into the nature of learning in an organisational and systemic context see Senge (1990) or Garvin (1993)

describes the universe as being 'ruled by entropy, drawing inexorably toward greater and greater disorder...' (1987).

Whilst relating the concept of entropy to the existence and nature of black holes, Hawking (1988) also manages to describe entropy in rather more 'every day' language:

> "The non-decreasing nature of a black hole's area was very reminiscent of the behaviour of a physical quantity called entropy, which measures the degree of disorder of a system. It is a matter of common experience that disorder will tend to increase if things are left to themselves. (One only has to stop making repairs around the house to see that!) One can create order out of disorder (for example, one can paint the house), but that requires expenditure of effort or energy and so decreases the amount of ordered energy available."
>
> (1988, p.113)

Hawking continues to describe how entropy has been evident in all systems of all resolutions through all periods of time. Perhaps more importantly than its presence is the tendency of entropy to increase, explained by Hawking through the 'second law of thermodynamics'. This means that not only will systems tend to dissipate, but that the rate and extent of this dissipation will also increase.

From an organisational perspective, the concept of entropy is also observable with time. Well thought through strategies or projects which begin according to plan simply run out of steam - for whatever reason. The solution lies with 'management'. With reference to this project in particular, Ford's original product development meetings in the organisation's early years involved engineers, designers, marketers and suppliers. As time progressed and systems grew, they tended towards disorder and these activities became distinct functions, not concentrated together, but distributed - just as the generic definition prescribes. But is it unavoidable, inevitable?

C.1.4 - Fitzgerald's 'Life on the Edge' - Tying the threads together

This question of inevitability is an important one in the analysis of systems. Does the system have a choice in its future, and if so, how can it best exercise this choice. In other words, in what ways can the system carve its own route towards its purpose? If it were found that a system is doomed to the negative forces of entropy, what would be the point in further study of its nature instead of the speed and direction of this fall? The answer is in fact hidden within the above description of the nature of systems. Due to the depth entered into, and the necessity to state the diverse views and parlance adopted by Systems Theorists, this may not have been apparent. In order to make the message clear, the work of one author has been chosen that covers all of the concepts and issues raised above. The author is Laurie Fitzgerald. As will be seen, systems are subject to entropy, but this need not always mean their unavoidable demise.

Fitzgerald's article bears a similar name to this section, and ties together all of the arguments discussed above in relation to their implications for management and organisational strategy, and addresses this most important question of the route to success[14]. As such, no apology is given for using a similar title, for this summary of her observations. This summary will serves the following purposes - firstly, it will aid in the translation of Systems parlance into more commonly used 'management' terminology. It will secondly assist in the formation of an understanding of the Systems approach from the somewhat lengthy and varied discussion above. These first two factors will assist the reader to follow the argument into the realm of market and organisational systems of interest in the chapters that follow.

[14] Fitzgerald, 1994, p.19-23

C.1.4.1 - The Roots of Scientific Management

In common with Cole & Mogab, Fitzgerald begins the discussion with an attack on what is called traditional scientific management (SM) and its founder, F.W. Taylor. This style of management is accepted to lie behind the structures of Western organisations. SM has as its fundamental philosophy the Cartesian logic of the machine. Déscartes perceived the universe to be a machine able to be controlled by man. There exists an inside to the man of 'I am', and an outside which 'I can control'.

Accepting this Cartesian logic as a philosophical paradigm as it, and much of traditional scientific research did, SM regards the organisation, its capital, equipment and labour, as a machine of production which is to be controlled by management - a separate entity from the machine. This machine can be engineered for cost benefits and efficiency and also to facilitate its control. Hence SM builds upon Adam Smith's ideas of the division of labour to work towards the perfect job design. Once again, it seems that the paradigm was to 'divide and rule'. It was thought that through functional prescription there could be a prediction of success. Thus the employee became part of the machine, separated from others by functional delineation and later further still by union demarcation. As a part of the machine, the human employee became a mechanical component that can also be engineered, turned on, off or up and that is characterised by relatively predictable behaviour.

Through the observations of the Chaos and Complexity theorists in the literature and the bitter experience of business managers, this is proven to be a strategy for stagnation and decline. On a common theme to the above exploration of the (non)existence of problems, Fitzgerald ponders the existence of an 'outside' world, since it is 'in reality' only a part of one's world view, governed by one's consciousness. The 'outside' is therefore inextricably connected to the 'inside'. The success of the organisation is seen as a function of the sum consciousness of all its employees. Indeed, much of the area of organisational learning has as its aim the alignment of the employees' mental models, paradigms and values, as a magnet might align the poles of ferrous fragments.

Functional separation produces barriers that prevent the power of connectedness in the combined consciousness of the worker. Fitzgerald says:

> "Every time we erect a barrier between people, whether it be a department, a title or a division, we diminish the strength and quality of the whole."
> (1994, p.21)

The belief in the existence of objects and organisations as separate from the actions and perceptions of the humans involved in them is a major flaw in Western culture. Holistic thinking and the Systems perspective attempt to bring them back together.

C.1.4.2 - Properties of Systems and Systems Architecture

Fitzgerald continues the argument by discussing the nature of systems, again with regard to organisations. Concerning boundaries, connectedness once again is quoted. There is no boundary existing between the employee and the organisation, or the organisation and its customer or supplier. Each is merely a resolution of the other, the order of the resolution depending upon the individual perspective.

Looking at the properties of systems, once again generic properties are described. Although these are classified in different terms to those of Flood and Carson above, the meaning is the same. The five following properties are outlined:

Consciousness - All systems exist within the consciousness of the individual, and are affected by it.

Connectivity - All systems are connected, interrelated and have interdependence.

Complexity - No system can remain stable. A position of unstable equilibrium equilibrium will tend towards complexity, either through the number of interrelating elements (detail) or the nature of their interactions (dynamism). Once 'the edge' of complexity is reached (hence the title) the tendency will be either towards a 'higher order of complexity or death by stagnation'[15]. This path is non-predictable. At best management can analyse trends and be aware of their effects on the system, and be ready to adapt.

Dissipation - The path towards the 'edge' is a path of dissipation. After a certain growth, the system will tend towards entropy. This is a similar argument to the concept of a product or technology life cycle. Fitzgerald does make the point that, through observation, the organisation has the *choice* of moving to the higher order of complexity and survival, or stagnation. *The latter is not the inevitable outcome.*

Referring back to the discussion in chapter two of the technological development of the modern machine tool, the UK was seen to have encountered a 'competence destroying' technology in CNC. Tushman and Anderson's term here seems to ignore this issue of choice. According to Fitzgerald's argument, had organisations in the UK been aware of the move towards CNC - the higher order of complexity - and had the alignment of the organisation's consciousness been in tune with this higher order rather than with acceptance of defeat, the organisation could have adapted to it. Instead, the barriers which existed between markets and organisational functions prevented this being the case.

Threesome of Sustainability - Fitzgerald's final property concerns two of Flood and Carson's generics which were stated to be of prime importance to the current research, emergence and self-organisation. This is the property of sustainability. Systems are once again taken to be emergent entities. Recognising this, Fitzgerald makes the following telling statement:

---

[15] This edge of complexity equates to Stacey's Chaos Frontier.

> "Studies of a multitude of systems throughout the universe, with the single exception of the business enterprise, have failed to identify an 'executive' cell or molecule that tells the other cells or molecules what to do. And yet, organisations as we know them are rife with managers, directors, bosses and others who perform this directing function as a matter of fact."
>
> (1994, p.22)

This over-abundance of control is seen to stifle the potential of emergence from the system - the product of the systems elements. Management as control rather than guidance is seen as a remnant of the Cartesian paradigm. What is orderly is seen as good, what is left to its own devices will produce disorder and is therefore bad. Control will therefore lead to desirable, good output. The irony here, generated by the observations of the Chaos Scientists is that precisely this control can and does lead to disorder. Furthermore, within disorder, if left to the most part to run its course, there is inherent order.

Sustainability is the survival of a system through its emergence. The attainment of sustainability is, in turn, dependent upon three abilities of the system. The first of these is its ability to self-organise onto higher levels of complexity if allowed space to do so. When this concept is mixed with the property of connectedness, the concept of hierarchy is once again implied. The second is that in so doing, the system can self-replicate so as to create a system similar in nature to the original one. This it does through its ability to "develop in reference to a deeply embedded, implicit self-knowledge all by [itself]" (Fitzgerald, 1994). Hence the third ability is self-reference. Fitzgerald continues "The point here is that, given these...life-sustaining capabilities, not only does no system need a 'top manager' molecule, but the interference of such is potentially lethal to the system." In the references made below to Beer's VSM, it is precisely this issue which is addressed.

C.1.4.3 - Theory and Practice

From the discussion in her article, Fitzgerald makes the conclusion that the performance of the system is governed by its structure:

> "No enterprise can be expected to deliver greater or more prodigious outcomes than its architecture is capable of bearing."
>
> (1994, p.23)

The structural design will determine the ability of the elements to make use of the properties they all possess, and therefore will determine the emergence of the system. This emergence in common terms is output and quality, survival and success.

This point has been made by several others in their analysis of systems. Senge (1990) highlights that in excess of 60% of the 'problems' experienced by an organisation can be caused by its structure. In some of Deming's earlier observations, the 'causes' of up to 85% of 'problems' were said to be the impact of the structure and systems of organisations upon their activities. Dunderdale (1994) and Feigenbaum (1994) both look to the effects of the structure too, and address the issue of a latent, hidden structure existing within what is regarded as the formal, explicit structure. It is this formality which is seen to blind individuals to vital undercurrents and prevent flexibility.

To conclude this discussion on Fitzgerald, a quote from his work is offered expressing in no uncertain terms the last point made:

> *"So, what's behind our failure of will to*
> *change in profound ways?*
>
> *A world view so entrenched that most of us*
> *don't know we have it."*
>
> (1994, p.19, Fitzgerlad's italics and format)

C.1.5 Consequences for 'Management' of the Definitions and Generics of Systems

Above it was stated that a research project to analyse today's business environment had to fulfill certain requirements. These were embodied in Deming's 'appreciation for a system'. Having acknowledged what a system comprises, where it exists in relation to others and if not exactly why it exists, then certainly the fact that all systems have purposes, further generic properties of systems were discussed.

The acknowledgment of these generic properties is a powerful tool for the management of systems[16]. Fitzgerald argued that 'management' should be used to assist the system in achieving its implicit purpose, not to exact tight control. Management has the responsibility constantly to adapt the design of the organisational structure in respect of the requirements of its elements. In so doing, the complexity of the system must be appreciated in relation firstly to the varying perspectives of the system's elements or 'stakeholders', and secondly to the system's position in a hierarchy. In its processes, the purpose of the system will be more efficiently and effectively achieved if emergence is encouraged from the elements through their interactions. This in turn will be most likely to succeed if the elements are allowed freedom and flexibility in their activities, along the lines of self-organisation.

Whilst all this is guided by management, there must also be the constant input of energy, as much from the management elements as from the more operative elements themselves. Referring back to Hawking's description of entropy in section A.3.5 of this chapter, this input is what keeps the house tidy and in a good state of repair. In other words it is needed to navigate a route, driven by the dissipative, entropic tendency, through the chaos frontier or the edge of

[16] Once again this statement has highlighted an ambiguity in language. By 'management' the connotation of commercial (non-) profit making activity, is not intended. Rather the meaning of 'management' here is 'dealing with, coping'. Hence Flood and Carson's 'Dealing with Complexity', oft quoted here, concerns the management of complexity - one of the systemic properties discussed above.

complexity; a route whose direction is concurrent with the attainment of the purpose of the system. In more down to earth language this means that management is there to help the organisation find its own way out of a crisis through motivation and the creation of an adaptive structure. Once out of the crisis, however, this management must realise that the trend towards the edge will carry on relentlessly.

This summarises the perspective of this research. The hypothesis is adopted that supply is a system of many transformation processes, themselves flowing in a complex format through other systems at higher levels of resolution. That this is so will become evident not only through the use of the research methodology outlined below, but through empirical evidence. This, however, is not the key focus of the research - most organisations are now waking up the fact that all business is a system. The point of this research is to explore the true nature of this system. What exactly are the processes involved, and how efficient are they? How can their emergent properties be encouraged and optimised? Moreover is behaviour evident in the 'real' business world reflective of systemic behaviour, and if not how can it become so?

C.2 - The 'Toolbox' of Systems Science

As the set of activities engaged in the analysis of systems, Systems Science evolved from the 'hard' area of controls engineering[17]. The study of complex organisations, Systems Science has at is heart the generic concepts introduced above. Much of the activity of the Systems Theorist can be termed 'management', but again the connotation is 'dealing with' rather than commercial. The focus is on the analysis and subsequent modeling of the nature of complex systems, so that emergence may be optimised through *systemic* management.

[17] Once again, it is not the intention of the author to provide a thorough history of Systems Science. The systems related references quoted throughout already provide this, and offer adequate reference to further reading.

The growth of Systems Science and its application in academia, industry and society seems divided into two camps, although there is also a considerable amount of overlap. The first of these is research that analyses the nature of systems in their generics and metaphors (Stickland, Klir, Bohm, Jackson). The second area is that of analysis of problem situations using the systems approach (Vernon, Hitchins, Janes and Hammer, Senge)[18]. As an example of the overlap, the work of Fitzgerald offers itself as a prime choice - here the theory of the system is very much applied to the real world.

In this area of 'applied systems thinking', industrial and systems engineering have produced an array of tools intended to assist the analyst in either the conceptualisation and modeling of the system, or its subsequent 'management'. Examples of these are presented in work by Vernon (1993), Hitchins (1994), Boardman (1993, 1994), Hauser and Clausing (1988), Syan & Menon (1994) amongst many others. The acceptance of the systems movement in the industrial field is certainly growing. This could be confirmed by the volume of current research and publications on the subject, but practical applications, too, are on the increase (Caulkin, 1995).

Key to many of these approaches is the use of diagrammatic representation depicting not only functional structures but also processes and the interactions existing in the system. Flow charts and so-called 'fish-bone' diagrams are examples of this approach to the modeling of situations. Much of this approach owes its development to fundamentals of systems control from cybernetics. In some applications there is an attempt not only to model the structure of the system and its interactions, but also to model the influence of the interaction and feedback. Hence the use of influence diagrams and signed di-graphs in the analysis of complex situations such as the planning of the Thames Barrier or in the effects

[18] This apparent dichotomy in the development of Systems Science and thinking is described in Checkland & Haynes ,1994.

of manpower and recruitment policy (Senge, 1990, Senge & Sterman, 1994, Davis, 1994).

Many other tools have been developed from the Systems perspective. Some, like Beer's Viable Systems Model look to the structure of the system, its inherent complexity and the aspect of control (Beer 1979, Espejo & Harnden 1989, Espejo 1994)[19]. Others explore the nature of interaction and the physical environment in which it occurs to improve efficiency and effectiveness in the achievement of systemic purpose (Warfield 1976, Janes and Hammer 1990, Hammer 1995).

Confronted with such an array of Systems tools from the hard and soft area of analysis, a methodology had to be chosen to guide the current research. Certain criteria had to be fulfilled by the methodology to justify its choice. The first of these had to be the concurrence with, and foundations in, the Systems arena. Such a holistic approach is lacking from the analysis of the stated industrial sector. Secondly, the methodology had to be able to cope with an almost boundless complexity arising from the immense detail and dynamism of the human interaction. Thirdly, in its modeling of the system, it had to be able to allow for a mix of Systems Thinking as well as empirical evidence from current business practice. Having achieved this, there had to be scope for suggestions to be made for the optimisation of the system's performance, should there be a shortfall between the system's *ist* and *soll*.

A description of the chosen methodology, Checkland's Soft Systems Methodology (SSM) will be given below. In addition to this, however, the following paragraphs explore the possibility of choosing another approach, system dynamics (SD), and in particular one application of this, industrial dynamics (ID). It was initially

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[19] The VSM attracts much criticism due to its apparent 'mechanistic' concentration on structure rather than interaction in human activity systems (Espejo & Harnden, 1989). It will be argued in later chapters that where this proves to be the case it is more a fault of the actors in the system rather then the model itself. Where the pervading mental model of management is of a systemic nature (Cole & Mogab's CIF paradigm) there is an inherent focus upon the softer issues. In this case the VSM offers an insight into lean or efficient structure able to encourage and exploit the system's generics to the full.

intended to follow this approach, but another was found to be more appropriate in achieving the aim of the project. By describing some of the perceived short-comings of ID, a certain justification of the preferred method is implied. At the same time SD and ID can offer insight to the system, as will be seen, and aspects of the approach will be adopted in later stages of the research - indeed this is recommended by the SSM approach.

C.2.1 - System and Industrial Dynamics

System dynamics is an approach to the analysis of situations akin to the influence diagrams and signed di-graphs mentioned above. Flood and Carson define SD thus:

> "System dynamics is concerned with a...control system representation and is used for simulating structured socioeconomic processes, although more suited for harder situations, for instance a technological system like coal excavation."
>
> (Flood & Carson, p. 162)

SD models systems, and originally was concerned with the quantification of flows in the system, their direction and rate and the stocks involved. It is this quantification which caused it to be found at the harder end of Systems practice.

It was from these hard beginnings that ID evolved at the Massachusetts Institute of Technology (Forrester, 1969). ID was intended to address the failure of the traditional operations research-based approach to organisational analysis. This failure was seen in the inability to embrace interaction and dynamism as described above. Forrester defined the approach thus:

> "[ID is] the study of information feedback characteristics of industrial activity to show how organisational structure, amplification (in policies) and time delays (in decisions and actions) interact to influence the success of the enterprise."

ID was a step towards holistic thinking in the arena of engineering management, its study of interaction intended to assist decision making. The disaggregation advocated by management theorists (later to be supported and formalised by Michael Porter) lost much of the importance of interaction. As its basis, ID instead attempted to integrate all functions and elements of the organisation. This it does by the assumption that each activity consists of five common flows - those of money, materials, orders, personnel and capital equipment. These five process flows are coordinated by an information framework.

Since these characteristics are generic to each functional activity, and indeed the same flows run through them all, there is no worth in the reduction of the functions to separate entities, but rather the value lies in the analysis of interactions and of the effects of one activity upon another via these flows. In order to do this, certain assumptions are made, one of which is non-linearity.

C.2.1.1 - Non-Linearity

Much of management analysis before the advent of ID - and indeed subsequently - has assumed the need or requirement to create mathematical (statistical or algebraic) models of industrial behaviour which can be used as a package for all occasions. The formulae therein were in general linear of nature, presumably since non-linear functions were considered too complex for the task at hand. Hence a stimulus was assumed to cause a simple, traceable effect which could be quantified and predicted - furthermore it occurred in isolation from other events.

ID attempted to depart from this linear thinking. By doing so a much richer picture is developed and accepted, whereby, through the five flows earlier described and the framework of information, almost all areas of activity can be affected by one stimulus in a non-linear, multi-directional fashion; *ceteris non paribus*.

C.2.1.2 - Modeling in ID

Much of ID progressed into the activity of modeling the patterns of non-linear actions. Having outlined a problem, the flows in the organisation were measured and plotted, from which equations could be constructed.

The result of such modeling is the clear realisation and confirmation of the existence of positive and negative feedback in industrial systems. Forrester gives numerous examples of these, and defined a feedback system as follows:

> "An information-feedback system exists whenever the environment leads to a decision that results in action which affects the environment, and thereby influences further decisions."

Examples are given illustrating how production demand can greatly fluctuate when customer demand is stable, or why, despite improved production processes, consumer demand cannot ever be satisfied in certain cases[20].

C.2.1.3 - The Strengths and Weaknesses of ID

In its approach to modeling, ID was quantitative and experimental. This is where weakness is perceived in its possible application to the current research. It greatly improved upon prior approaches in its inclusion of the analysis of feedback, dynamism and interaction. This is why it was considered useful, but it stops short of the creation of a true rich picture of the system and its environment. In particular, ID did not give enough attention to the importance of human interactions in the system, and the existence of variety in the perspectives of the systemic elements in their perception of 'the problem'.

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[20] It is from this approach to the analysis of systems that the MIT devised its 'Beer Game; as described in Sterman, 1988, Senge, 1990 or van Ackere et al, 1993.

In ID the importance of the soft 'human factor' is left unaddressed. A far greater level of sophistication in modeling is required to quantify and predict the highly complex industrial systems described by Forrester than were apparent in ID. Whilst it was an improvement to study flows and dynamism, and to acknowledge non-linearity in the connectedness of the elements, it must be understood that these are not only caused by the structure of the system, delays and amplification, but also by the human interaction with other humans.

The issue of the human factor is what the subject of soft systems analysis begins to tackle, and is what represents the initial differentiation from ID. The need to model rates and quantities is postponed until the system can fully be appreciated in its true complexity. It is exactly this that the current research does through the use of Soft Systems Methodology.

In defence of SD, the activity has seen a great deal of 'softening' in recent years. Indeed, Forrester himself has now softened his approach with a refined definition of modeling:

> "In system dynamics models we look upon managers as information converters to whom information flows and from whom come streams of decisions that control actions within an organization. Much human behaviour might be viewed as the conversion of information into physical action."
>
> (Forrester, 1994, p.52)

No attempts are made in this research to quantify rates and flows, or stocks and delays. Certain elements from SD and ID are nevertheless 'borrowed', such as the non-linear nature of the flows, and their constant dynamism. The emphasis of the work will be seen, however, to be far more concerned with challenging entrenched perceptions of the nature of the industrial system, the greatest change arguably being the extension of the system away from Forrester's 'enterprise' to a far wider ranging concept.

It may well be that this research will serve as the basis for future research from the SD camp as softness and sophistication are increasingly incorporated into modeling packages[21]. Indeed, this would be welcomed. Nevertheless, it is vital before more effort is expended in the analysis or management of industrial systems that the governing paradigm of these systems is more accurately perceived.

D - Checkland's Soft Systems Methodology and Reasons for its Use

As stated, space can only be afforded to a limited volume of system tools and approaches. It is not implied that those presented are better than those not given attention here.

One well tried and tested example of a tool or methodology of Systems Science is that of Checkland's Soft Systems Methodology, or SSM (Checkland 1972, 1975, 1981). This is the key methodological approach adopted in the project at hand. Whilst not in itself presenting a way of arriving at solutions, SSM represents an approach which can guide the analyst to conclusions that highlight where the system is not fully optimised, and through the use of other systems tools (one of SSM's strengths), how this optimisation can be achieved. The following section, part three of this chapter, presents a summary of the nature of this methodology and its constituent stages. It also discusses the reasons for the choice of this as a guiding methodology and why its use represents an improvement upon research conducted in the field to date.

[21] Such approaches can be found in Morecroft and Sterman, 1994 or Davis, 1994.

D.1 - On the Nature of Checkland's Soft Systems Methodology

It is not intended to go into great detail about the *development* of SSM in this work. Its development has been well charted in the literature both by the creator (Checkland 1972, 1977, 1981) and by others in the Systems field (Flood and Carson 1993, Jackson 1982, 1993, Flood and Jackson, 1991). Should greater detail be required regarding individual stages of the methodology than is offered here, it is recommended that the reader refer to these texts.

In essence, SSM is a set of stages recommended in the analysis of a situation. Thinking similar to the above discussion of the misleading perception of the existence of problems has been instrumental in the creation and use of SSM. Checkland acknowledged the importance of complexity and dynamism embodied by Ackoff's concept of a 'messy' situation. A methodology was needed which could tackle a plethora of elements and relations. Also given consideration were the implications of the messiest of situations, human activity systems (Vickers, 1970 quoted in Flood and Carson 1993, Checkland 1981). Along with the ability to learn and improve, the new methodology would also have to have an inherent ability to adapt, and through iteration be able to build upon its past findings.

Hence SSM attempts less to find concrete solutions than to offer an approach which is able to embrace complex situations and address the totality of a system's elements along with their interaction. So doing, it can enhance understanding of the nature, purpose and functioning of the system itself. The pretext here being that through a greater understanding a more accurate 'mental model', or paradigm, is formed. This more accurate paradigm will lead to a better match of behaviour to systemic purpose[22]. Through the recommendation of iteration in the process, the ability to learn and the avoidance of analytical sclerosis are inherent parts of SSM, as will be demonstrated below.

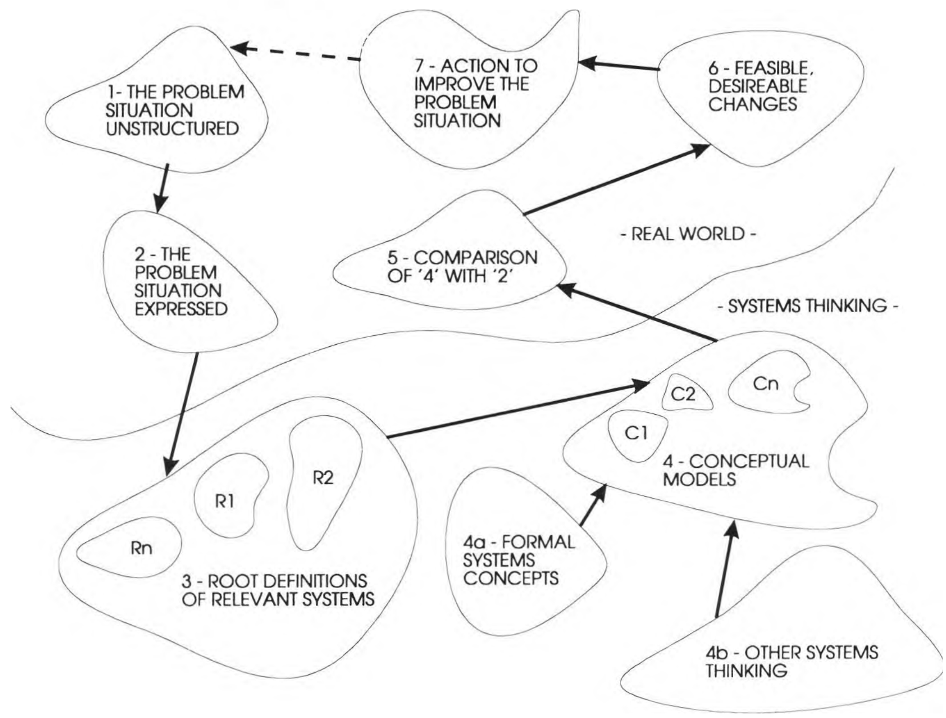
[22] For further discussion into the links between paradigms, mental models and behaviour, see Senge, 1990 Garvin, 1989 or Cole & Mogab, 1995.

D.2 - The Structure of SSM

SSM consists of seven numbered 'stages'. These are displayed in figure 4.4 below.

FIGURE 4.4

THE SEVEN SEQUENTIAL 'STAGES' OF CHECKLAND'S SOFT SYSTEMS METHODOLOGY (1974)



Checkland is at pains to stress that this sequence, although set in logical progression, need not be adhered to and that the enlightened analyst will be most successful when performing different levels of the methodology concurrently. In relation to this research such a multi-layered approach was definitely adopted; the field research (stage five) was performed concurrently with the creation of the root definitions (stages one and two). The logic becomes of importance when drawing conclusions as to the nature of the system.

The seven stages will now be described in more detail.

D.2.1 - Stages 1 & 2

The first two stages are interested in real world affairs. They encourage in-depth knowledge of that which is to be analysed in its entirety with an avoidance of pre-conceived structures or methods.

The first step is concerned with those elements which influence or affect the system. No attempt is made initially to structure the system, but simply to lay out in an *ad hoc* fashion those elements which are known to exist. This activity is often performed by the creation of a 'rich picture'. This will be explained in more detail in chapter five. Within this representation are to be found all items which are deemed important to the development of the system. Certain lines of influence may be shown in an attempt to introduce the idea of complexity, but no attempt is made to add direction or alignment to this influence. Nor is there any attempt to place system boundaries as yet.

Stage two is an exploration of the problematic nature of the situation. What are the initial causes of worry, the visible or tangible signs causing concern?. For the purposes of this study the statistical data shown in chapter two serve the purpose of stage two. From these data can be ascertained that the problem situation is one where one of a nation's key industries is in decline, and has been for some time. Not only is this a characteristic of one nation, however, but of many nations who are similarly engaged in such manufacture. The problem situation is this decline and the task presented is to analyse the system in which this has occurred. From the discussion of the nature of systems above, is this a process of entropy? If so into which areas does 'management energy' need to be injected to stabilise or improve the situation?

D.2.2 - Stage 3

The third stage of analysis brings the research into the realm of systems. It begins to acknowledge holism and the fact that different areas of human activity - perhaps different organisations or different cultures - will have varying views of what 'the system' really is, why it is there, and which purpose it serves. Again this allows for the fact that no one concrete solution can be offered which satisfies all possible perspectives in the long term. Hence, within the shape which represents stage 3 there are other, smaller 'sub-shapes' which show these varying opinions. From each opinion stems a definition of the system and of its purpose. By careful aggregation and consideration of these definitions, a 'root definition' can be found which describes not a solution to the situation, but the purpose of the system from the perspective of as many elements as possible . To arrive at such a root definition, Checkland advocates the use of a CATWOE analysis, each initial of the mnemonic representing one group of perspective. The CATWOE analysis as performed in this research is shown in appendix A4.1.

Caution must be exercised in arriving at a root definition by the CATWOE approach, and questions are raised at this point which must later be addressed. For instance, can the customer (C) be usefully described? Since the elements and the industry are so dynamic, and are subject to complex feedback, each element is constantly both supplier and customer. Various resolutions are at any one moment of importance, each with a variety of 'customers' present. Definition of what one element is at a given moment detracts from the acknowledgement of this feature.

Reducing the process to find an 'owner' (O) can be dangerous. Flood and Carson define 'owner' as that element or human group which could abolish the system. One of the points of the ensuing work is that *any* element is capable of the destruction of the system, if an action sets a disadvantageous positive feedback process into play[23].

[23] The term positive, when applied to feedback does not relate to the quality of the outcome, rather to the nature of the process. Positive feedback, or self-reinforcing feedback (Senge, 1990) accelerates or multiplies a process, whereas negative or balancing feedback will tend to revert the process back to a state of equilibrium.

Nevertheless, the CATWOE definition provides a sound basis for analysis of the system. Although the process of creating this definition is not described in detail until chapter five, the resultant statement is given below:

> *A system which exists to supply machinery encompassing all organisations or groupings that are involved in physical and non-physical input into the process and the consumption or appropriation of its output. It must recognise the importance and value of all of those directly or indirectly employed or engaged in all of these stages; these being active in the process of satisfying their customers. Ignorance of this could cause any part of the system ultimately to destroy or severely damage the system's performance. The satisfaction of the customers of each element or actor takes place within substantial dynamic environmental constraints.*

Despite the concerns expressed above, the definition does illustrate that the system affecting the success of the machine tool industry is far wider than that which has been accepted and discussed in the literature to date. The notion of the organisation as only a part of a process is addressed, as is the ambiguity of the nature of the customer and the fact that the destruction or demise of the system can come from a variety of elements. The importance of the human element in the system is also given attention.

This 'root definition' does, to a great extent, serve the same purpose as other models to be introduced below such as the hard models of circuitry, and the use of Flood & Carson's 'Sombrero' as described above, and demonstrated below. The improvements offered here, however, are the concentration on human and organisational influence, the fact that all stages are interconnected, and that consequently each has an influence on each other. It also recognises the existence of fuzzy feedback flows, and of the importance of dynamism in the environment.

D.2.3 - Stage 4

The remaining stage of the systems realm encourages the use of other systems tools to aid the mind in arriving at ideas to which it can compare the 'real world'. Examples of this will be seen in chapter six with the analogy of electrical circuitry. It will be shown how such modeling was the first 'round' of analogy - its shortcomings will be described and used for reconstruction. The importance of them is that they provide the basis from which further, more detailed analysis stems - again illustrating the power of iteration in SSM. Thus in later discussion other models and approaches will be introduced to represent situations on a higher resolution. These include the Viable System Model and failure analysis, used as a comparator to empirical data and structures found in industry, as well as elements of the SD/ID methodologies described above.

D.2.4 - Stages 5, 6 & 7

The return to the 'real world' is the attempt to draw meaningful comparisons which can highlight areas of conflict or difference between the *ist* and *soll*; that which 'is', and that which 'should be'. This is the stage which will begin the criticism of extant models of the supply system[24]. Although constituting the final stages of analysis in the logic of SSM, the process is by no means complete. Successful application of SSM sees a continual re-evaluation of the process since the system itself will not stand still. In this justification of the use of SSM it is such iteration which is seen as a major strength.

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[24] To be more accurate, these models do not even acknowledge the concept of a system. The traditional model revolves around the simple linear chain concept. It is the shortcomings of this chain and the introduction of an alternative - a system - which will form the major conclusions of the research.

D.3 - The appropriateness of SSM as an approach to the current research

The potential of SSM in the analysis of complex situations has already been touched upon, and the description of the individual stages will have reinforced these views. It is felt necessary, however, to give more space to the justification of the application of SSM before continuing with a description of the body of the research.

SSM purports to be applicable to situations which are complex, soft or human-activity based, in a constant state of flux and where specific solutions do not necessarily prove as valuable as greater systemic awareness per se. It was its ability to embrace such situations which suited it to this research better than system dynamics. Can it, however, truly be said that these conditions are prevalent in the supply of industrial machinery, and therefore is the choice of SSM a valid one?

That the machine tool industry is complex is surely beyond doubt. Leaving the engineering complexity of the very products themselves aside, the organisation alone is itself a complex system. It consists of various functions, processes and employee groupings each with their own agendas. An insight into the complexity of the processes involved in the control of the supply process within one organisation is offered in appendix A4.2. This flow chart shows various stages in the development of an order and the control of its subsequent production along with possible revision scenarios. Each stage involves a different employee or employee grouping, each with possibly varying perspectives on the purpose of their work. When the multiplicity of possible customer and supplier groupings is introduced into the picture, the complexity increases[25]. Add to this the influence

[25] This complexity has two sources. Firstly, there are obvious interactions between customers of the organisation and its suppliers. Turnbull and Valla (1986, pp. 253-256) illustrate how the nature of these groupings will affect the degree of complexity they cause. Secondly, the customers and suppliers themselves are subject to increasing complexity within their own systems, and this feeds into the complexity of the 'total system', a concept to be expanded later. Cole and Mogab (1995, pp. 124-5) illustrate the increasing complexity of the automobile markets with reference to product

stemming from the ever increasing degree of competition and environmental influence[26], the elemental complexity and the ensuing complexity of iterations is beyond question[27].

Dynamism in the market was also discussed above. The market statistics are proof of this as are the seemingly endless technological innovations developed both within the sector itself or adopted and adapted from other activities in the industrial and academic fields indirectly related to the machine tool market[28].

The mixture of dynamism and complexity, or rather detail and dynamic complexity, means that the machine tool market is indeed in a state of flux, and concrete predictions as seen to have been made in the extant literature have proved of scant use to the market. Indeed, the majority of the individuals interviewed in the market were highly skeptical of the extant research for this very reason.

D.3.1 - SSM and PDC/SA

It would therefore seem that the situation under scrutiny matches what SSM regards as its most suitable area of application. This does not seem sufficient as validation or justification of the use of SSM as a methodology guiding a research project. Another observation linking it to a widely used and successful approach to 'problem solving' in industry may well, however, add weight to the argument.

Towards the start of this century in the USA, Shewhart began teaching what later has become known as SQC and SPC, and, through his teachings to Deming and Juran, began what developed into the quality movement (Neave, 1995). Key to

development and the need to build flexibility into the production of products to conform to customers' requirements.

[26] The word environmental here is used in its systemic rather than ecological sense.

[27] The exponential growth of interactions associated with growth in the volume of systemic elements is discussed by Hammer, (1995).

[28] Examples here being concurrent engineering or the use of integrated MIS and EDI.

such approaches advocated by the quality 'gurus' is the Plan, Do, Check/Study, Act, Cycle[29]. Putting paid to the oft-cited idiom 'if it ain't broke, don't fix it', the PDC/SA cycle introduces the concept of continual improvement[30]. Following the work of Deming, Crosby and Juran, quality, the drive to achieve fitness for purpose in a product or process (the attempt to achieve the purpose of a system?) is accepted as being a journey rather than a destination. Perfection is hard to achieve, if possible at all[31]. Moreover, by the time such a 'perfect' position has been reached, the nature of the purpose will most likely have changed. Continued incremental iteration in the attempt to achieve success has been seen to be more effective than step changes alone. As Vestor describes, the creation of walls out of which step change is the only answer is of far less value than opening up to the influences of the environment (in Guntram, 1993). The result of a step change being a fit to a situation which does not necessarily equate to the current reality.

This is not to belittle the need for step change. Incremental change can be subject to lesser and lesser gains, and will not *necessarily* promote technological development in product and process. When the system has been allowed to stagnate, step change may well be necessary, as in the recent case of the Ford 2000 process. Arguably, these are, however, simply incremental changes of a strategic nature, and only represent step changes to higher resolutions within the system. All levels of the hierarchy have the ability to adapt and improve. If there is only improvement at higher resolutions (low levels in the hierarchy) there will be an opportunity cost for the total system as a whole.

These incremental changes - flowing throughout the Kaizen 'environment' of continual improvement - are derived from suggestions from all areas of the work

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[29] Some readers may be familiar with PDCA as the mnemonic, others with PDSA. Although the distinction between 'check' and 'study' may well be somewhat pedantic, the initials of both are used here to acknowledge both schools of thought. The process is described in Checkland, 1981.

[30] The inappropriateness of this as a guiding principle is mentioned in various examples of industry related research. For a concise discussion of the topic see Cole and Mogab, 1995, pp.120.

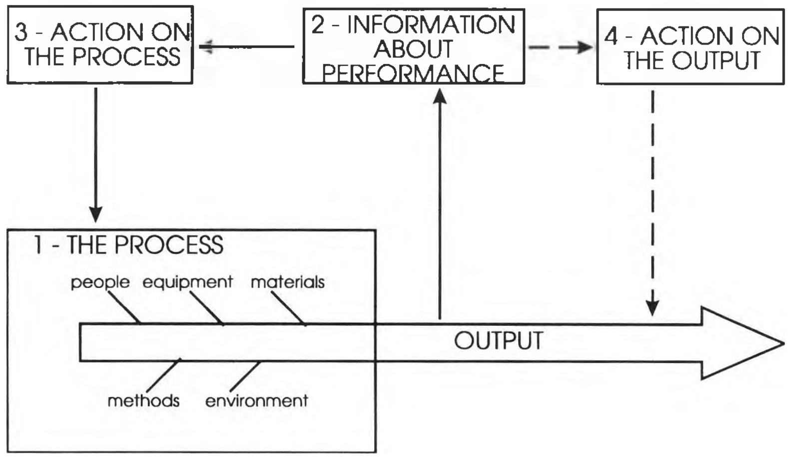
[31] Japanese automotive manufacturers have accepted that the closest to perfection they can arrive at through process improvements is 3 or 4 defects per million. The scope for improvement can never be eliminated.

process[32]. Through acknowledgment of the importance of every worker, all are encouraged and motivated to participate. Not only are they encouraged to make suggestions as to possible improvements, but they are also encouraged to carefully monitor their own work and compare the results with what is regarded as the ideal. This equates to the guiding principle of SSM; by firstly exploring which elements comprise the system an ideal can be formed to which the monitored real world situation can be compared on a continual basis.

Simply stating that SSM has similarities with an approach to the analysis of situations in industry is no validation unless proof is offered of the power and success of the latter. Instilling workers with the PDCA mentality has achieved successful acceleration along the quality journey; no-where is this more apparent than in Japan. The undeniable results of the Kaizen process are described by Rommel et al (1994) in a Japan-Europe comparison. When mixed with the enlightened personnel management policies of employee involvement, motivation and the devolvement of responsibility and accountability (themselves parts of the PDCA of personnel management), the PDCA process is the very generator of Kaizen[33].

FIGURE 4.5

A Process Control System



[32] Explanations of Kaizen and the 'continuous improvement firm' can be found in Cole and Mogab (1995), Imai (1986), Walker, (1993) or Hayes et al (1988)

[33] Once again this is the notion of hierarchies of systems. Within the 'continuous improvement organisation' the personnel function employs its own PDCA which interacts with the PDCA of the manufacturing employee - the latter being on a higher resolution (a higher level in Chelsom & Clewer's hierarchy of systems, 1995) than the former.

An example of how PDC/SA is used in industry is given in figure 4.5 above depicting a process control system (taken from Chelsom, 1996). The key is iteration in the system and the attempt to remove or reduce causes of variation.

As well as encouraging process improvements, the iterative process will be seen as an appropriate way of selecting and managing the supplier and personnel systems in the supply and manufacturing processes (should it prove at this stage still necessary to make distinctions between the two). It is, however, left until later in the body of the research to enter into greater discussion in these areas.

The ‘plan’ stage of SSM is clearly the stage of root definition and becoming acquainted with the system. The ‘doing’ is then the movement into the systems world where ideal situations are created which correspond to the root definitions provided. The ‘check’ and ‘study’ stages relate to the comparison of the systems world to the ‘real’ world, and finally the ‘acting’ part is action on the output of the preceding comparison.

As in industrial application, no concrete solution is offered. It is simply an approach to the analysis of a situation Through the use of SSM as a cyclical approach as in PDC/SA, the real world can be brought closer to the ideal world of systems thinking. Even where this proves not to be the case, or where changes are too complex and their lead times too long to be evident, it is beyond doubt that SSM can lead to heightened systemic understanding. This occurs through the use of CATWOE and root definitions along with the process orientation offered by the use of Systems Science in stage four. The resulting understanding will subsequently affect behaviour as mentioned above and in the works of Senge (1990), de Geus (1988), Cole and Mogab (1995, pp.xi) and Garvin (1993).

E - Industry Research

Thus far, much detail has been given on the theoretical methodology adopted in the research. Lest this detail be regarded as superfluous at this stage, it must be stated that the conclusions of this research will draw upon the realm of Systems Science to highlight the poor performance of the industry. Without a prior understanding of the concepts involved, these conclusions may not be fully understood or learned.

Nevertheless, a chapter outlining the methodology of the current research would not be complete without a description of the industrial research. It will be seen that the conclusions of the project draw upon the application of Systems Theory to industrial situations.

E.1 - Research into the Machine Tool Industry

The initial phases of the research were characterised by familiarisation with the industry under analysis. This began with secondary research in the media, and academic and trade literature. The result of this phase is outlined in part in chapter three and has been discussed. After a certain amount of desk research had been completed, a postal questionnaire was initiated. The response rate was, however, too low to be of use, although some important contacts were made.

A phase of company visits was therefore begun. Although a time consuming and expensive approach to research, primary visits seemed the only method of gaining information. Furthermore, more could be gleaned from an interview than from a questionnaire. Focusing mainly upon the UK sector for efficient use of resources, requests were made to major UK machine tool manufacturers for permission to spend at least an hour with middle or senior management discussing a variety of issues. A tour of the facilities was also requested. Although the targets of this effort were all UK based (with two exceptions), some of the organisations were in foreign ownership, bringing an international influence upon the opinions expressed. As was the case with the questionnaires, the doors of industry were not readily opened to visits. This was mainly due to time constraints rather than an anti-research stance, however.

A semi-structured questionnaire (shown in appendix A4.3) was used during each visit. Certain key questions were asked based upon secondary research into the company. Despite the use of this method, the target was always allowed to stray from the question should topics more pertinent to the research arise. Two general themes can be identified from the questioning. First, what the organisation is doing to monitor or improve efficiency. Second, what approach is adopted by the customer towards the organisation.

E.2 - Research into the customer sector

The interdependence of the customer and the supplier soon became apparent. As a result, research into the processes and attitudes of the supplier side alone was deemed insufficient. The primary effort was therefore extended to the major customers of the machine tool industry. The emphasis here was on the automotive industry, although the aerospace industry was also targeted. Here the majority of targets was UK based, but again due to the international nature of operations this was not perceived to constitute a major shortcoming.

A similar mixture of primary and secondary research was used. One difference arose in carrying out the customer interviews. The targets were either user engineers or purchasing personnel. The issue under analysis was the management of the buyer-supplier interface rather than solely internal processes, as had been the case with the machine tool supplier.

Summary

In preceding chapters an introduction to the current project and to the industry in which it is involved has been given along with the associated literature to date. Within chapter four the reader has been introduced to the methodology of the research. In order to do this a brief introduction to the world of Systems Science has been given, beginning with a discussion of the meaning of 'system'. Systems are taken to exhibit generic properties the understanding of which assists in their management and the achievement of their purpose. Due to the complexity of systems, the existence of 'problems' is disputed, a more suitable description being 'situations perceived by some as being problematic'.

The situation the machine tool market finds itself in is an example of this. Clearly, not everyone perceives its demise as a problem - in fact it is an industry of which many are oblivious. Nevertheless, for those elements involved in the system of the supply of machine tools the situation is a cause of concern. The research methodology chosen, SSM, offers a route towards the comprehension of this system, and through iterative comparison allows the analyst freedom to employ a wide range of tools to draw conclusions.

Chapter five concludes the background phase of the project. The first part explores the current paradigm of supply, that of the supply chain. A description of the development of the chain as a model is given along with some analysis of the work of Michael Porter who formalised the idea into an academic and business strategy model. Further adaptations and revisions of the chain are then presented. It is argued that this traditional model is reductionist and loses much of the potential of feedback. The second part of the chapter uses some of the systems tools of chapter four to lay the foundations of an alternative systems model. Subsequent chapters will explore the real world situation to confirm which approach, systems or chain, is the more appropriate.

CHAPTER FIVE - CHAINS, FORCES AND SYSTEMS

The melting voice through mazes running,
Untwisting all the chains that tie
The hidden soul of harmony.

'L'Allegro'
John Milton

Introduction

Until this point in the discussion of the current research, the machine tool industry and the extant literature have been discussed in isolation from the Systems parlance presented in chapter four. In chapter five these three areas are brought together. The traditional model of supply is discussed, and is shown to have arisen from the reductionist school of thought outlined above. It will be seen how this model of the supply 'chain' has been improved upon over the last fifteen years since its formal conception, but that these improvements are still characterised by many of the fundamental flaws contained in the original form. With reference to some of concepts of Systems Theory introduced in chapter four, the weaknesses of the traditional model from a purely theoretical point of view will be highlighted.

Chapters six and seven probe the industrial system in its reality. The focus of the research is upon process improvements; chapter six discusses company-internal processes, chapter seven inter-company processes. A wide array of process improvement programmes will be discussed as uncovered by the research. These will further challenge the model presented in this chapter. By providing 'real world' evidence in addition to that introduced in chapter one, the results of the phase of field research serve as input into stages of the SSM process as described in chapter four and performed in the opening chapter of part three. This latter section of the thesis applies Systems tools to the theoretical concepts of Systems and empirical evidence from the research in order to remodel the supply system in a manner which, it is argued, will more effectively promote efficient supply.

A - Porter's Value Chain - The Development Of The Common Paradigm

Whilst evident in the behaviour of certain pockets of management in manufacturing industry for quite some time, the general importance of purchasing and supply as a business process activity has only come to the fore in the last decade or so. Indeed, in some areas it is still an emerging topic. In the business oriented side of academia it is still subordinated to the major functional areas of study such as finance or marketing. Furthermore, much of what is taught is presented in isolation from these other functional disciplines.

Whilst the volume of literature and research from industrial application of new practice is ever-increasing, little has been done to explore or challenge the one pervading model of supply. It is widely accepted that models influence behaviour by colouring the way the world is viewed (the Weltanschauung). Without challenging the traditional model, or analysing its validity, it is possible that any related behaviour can endanger the system if the model is reductionist rather than systemic. It is exactly this that chapter five sets out to explore. This 'traditional' model was formalised by Michael Porter in the early eighties. In its common form of the supply chain it stems from Porter's publications relating to the value chain - both terms are in many instances interchangeable. The following is a brief history of its development.

A.1 - From Taylor to Porter

Chapter four devoted some time to the philosophical beliefs that underlie the organisational structures of traditional Western industry. Fundamental to this philosophy is the misleading separation of 'man' from the outside world. Such distinction leads one to try to control the outside world as much for protection and personal survival as to exploit control for competitive success (the distinction being the issue of necessity). It was argued that this belief has overrun into organisational thought, and has become the justification of strong corporate control over the enterprise. Within this enterprise, individual workers are under the control of the corporate heads, the latter giving little regard to the fact that the former may also exert control over *their* own environments. This failure to acknowledge the importance of the human factor was described as a source of competitive loss and as a factor contributing to the slow pace of change.

The perceived ability to control organisational activity implies an ability to control success, otherwise why control at all? Once the principles of scientific management had been built into organisations, (a period in the history of organisational behaviour accredited to F.W.Taylor) management began to look at ways to lock into the future of the organisation through control, and the discipline of strategic management and strategic planning (SMP) gained momentum. Despite enjoying several decades of prominence in the West, SMP as typically practised is now attracting detailed criticism, even from amongst its greatest one-time proponents (Mintzberg, 1994).

Stacey describes the apparent purpose of SMP, and in so doing outlines its fatal flaw:

> "[Approaches to strategic management] focus heavily on techniques and procedures for long-term planning, on the need for visions and missions, on the importance and the means of securing shared cultures, on the equation of success with consensus, consistency, uniformity and order."
> (1993)

The approach adopted by many practitioners of SMP was heavy, centralised budgeting along functional lines decided upon with reference to central, corporate strategy. Control was exercised 'top down' by adherence to these budgets, even at the cost of total long term organisational success[1]. The planning aspect of SMP failed to grasp the dynamic aspect of complexity, and attempted to foresee, even to preempt what the markets would be like in their detail far in advance.

The work by Fitzgerald (1994), as discussed in section A.4 of chapter four, addressed the issue of the necessity of heavy top down control. It is seen to

[1] This was the approach devised by Sloan which gained acceptance within General Motors and other companies in the post second world war period. The development of the Sloanist management practices within GM and the implications for the management of labour, and hence for innovation, are described in Chelsom (1996).

dampen the creative process and prevent the systemic emergence that can result from the management of detail complexity (if the latter were at all acknowledged). The attempt to control dynamic complexity has been argued by the Chaos Theorists to only create further disorder. This is the point Stacey carries on to make with the idea of the Chaos Frontier (1992) and complex feedback systems (1993). From an holistic perspective, the beginnings of SMP are seemingly self-contradictory. The attempt to control and create order only produces disorder. Evidence from many of the industrial organisations who have used SMP for decades would confirm this. Although their approach to management seemed correct at this time, the success of such monoliths as General Motors and IBM has been damaged seemingly beyond repair through the rigidity caused by traditional SMP[2].

In the late seventies and early eighties, work carried out by Michael Porter at the Harvard Business School sought to refine SMP and address some of the apparent causes of its failure. A string of publications has been the result of his work. Two of these, concerning competitive advantage and strategy, have become best sellers and are to be found on the syllabus of most management courses (for undergraduates and postgraduates) and in the minds of many management practitioners. In the opening paragraphs of Competitive Advantage, Porter outlines his potential audience thus:

> "This book is written for practitioners who are responsible for a firm's strategy."

It is beyond doubt that this target audience has been reached, if not directly to practising management then certainly to potential managers during education.

In Competitive Strategy (1980) the reader is introduced to a new form of strategic analysis, the '5 forces' model, which in its approach seems holistic in that it seeks

[2] Lynn (1995) describes the continued fall from favour of the 'big is beautiful' strategy following the breakup of ITT in June 1995 into more focused units able to concentrate on core competencies. An investigation into share performance before and after the break up of other such concerns shows a marked aggregate improvement of the smaller units after the split.

to take a wide range of influences into account. Having used this model for analysis, Porter compiled four 'generic strategies' of successful competition[3]. The second book, Competitive Advantage, began to outline how successful companies were achieving the competitive success that was the point of the analysis described in Competitive Strategy. A work based upon descriptive research became a prescriptive guide.

Acceptance of this second book saw a change of focus within the hard control of SMP. Porter argued that value, being what accrues to customers, is not created or added by top management, but by the individual workers themselves and by their groupings. The theme of Competitive Advantage was how these groupings, or Strategic Business Units (SBU) should be managed and audited to increase their individual efficiency.

> "Value Chain Analysis allows the manager to ***separate*** the underlying activities a firm performs in designing, producing, marketing and distributing its product or service. It is these activities from which competitive advantage ultimately stems."
>
> (Porter, 1985)

This approach offered improvements upon the SMP approach. However, the 'separation' or disaggregation advocated by Competitive Advantage, ironically presents barriers to the attainment of such advantage. It is to be argued here that these barriers are even higher if the manager's 'world view' is also influenced by the advice in Competitive Strategy. This labels suppliers, amongst others as a threat. Not only are they then to be separated from the organisation, but they are also to be viewed as a source of disadvantage. It will be shown below that the exact opposite can result from careful management - as long as this separation does not occur, and as long as the supplier is regarded as a strategic ally rather than an enemy of success.

---

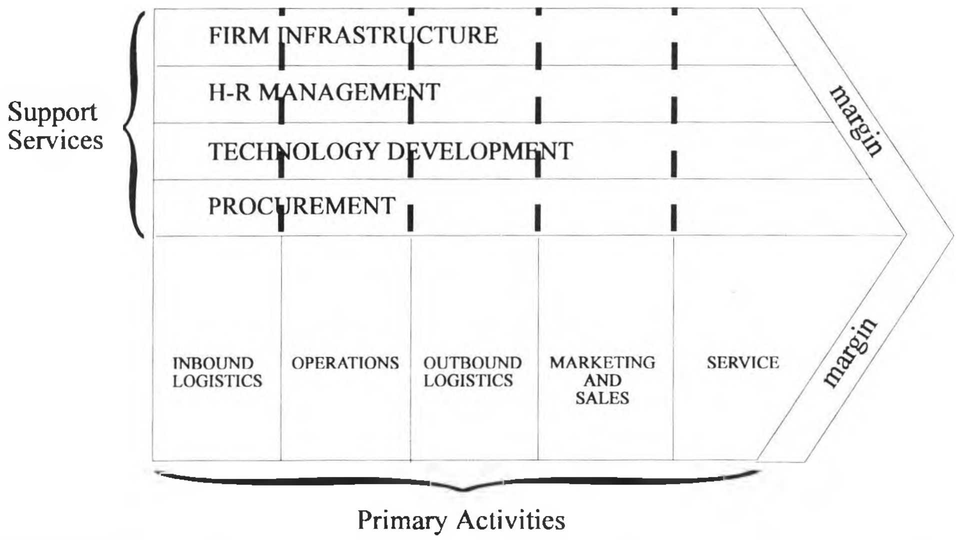
[3] Porter's 5 Forces of Competition and the four Generic Strategies are well known and used models, and need no further explanation here. For a more detailed outline, see Porter, 1980 or Mintzberg, 1991.

The difference between Porter's approach and that of SMP is in its emphasis not solely on top down corporate dictatorship, but the beginnings of an approach where bottom up requirements influence top down management and guidance[4].

Porter saw business as a process which delivers value to a customer that could be internal or external to the organisation. Again, this concept was a departure from the centrality of the SMP approach. Nevertheless, the functional orientation of business was maintained. The process is not continuous, but simply a set of distinct activities linked by a channel - the Value Chain. Porter's concept of a process runs into and out of the separate functions of the organisation, with various 'primary' functional activities being supported by other 'secondary' ones. The structure and relationship of these functions is shown in figure 5.1 below.

FIGURE 5.1

PORTER'S GENERIC VALUE CHAIN
(adapted from Mintzberg & Quinn)



Each functional unit is to be actively disaggregated from its up and downstream partners, in order that the internal efficiencies of its processes may be improved:

[4] The terms 'top down' and 'bottom up' refer to the concept of an organisational pyramid with the corporate executive being at the apex, befitting its perceived importance, and the lower ranks of the workers splaying out below. 'Top down' pertains to orders and control filtering down from the apex, whilst 'bottom up' has the sense of a more consensual, consultative approach where the 'top' forms opinions and strategy from the input of the 'bottom'. Elements of 'TQM' have been concerned with the 'inversion' of this pyramid to follow Porter's and others' advice of making the individual worker more important than higher management levels.

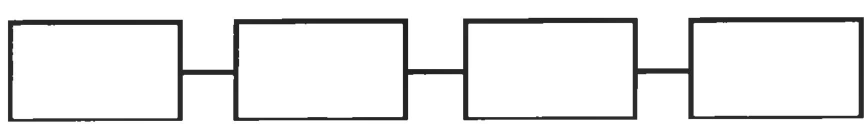
> "This book uses a tool I call the Value Chain to ***disaggregate*** buyers and a firm into the discrete activities from which value stems."
>
> (Porter, op cit.)

By doing this, the total efficiency of the process which flows from left to right is improved, or so it was thought. The increase in efficiency would lead to the attainment of lower costs or the ability to differentiate the product in line with the advice offered in Competitive Advantage.

FIGURE 5.2(a)

THE INTER- OR INTRA-ORGANISATIONAL VALUE CHAIN OF CONNECTED STRATEGIC BUSINESS UNITS

(from Porter, Competitive Advantage)

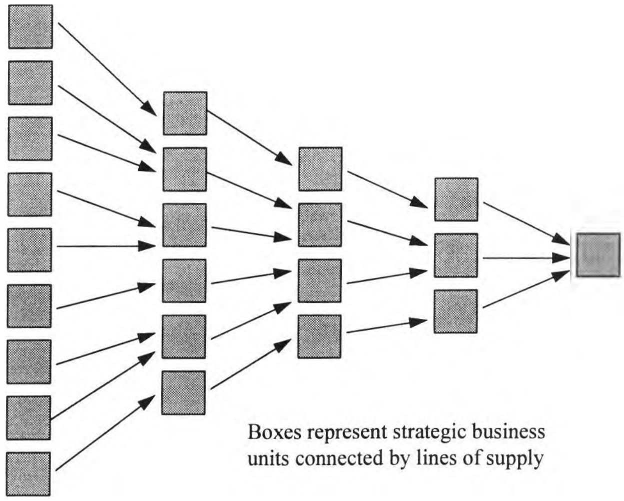


When the idea of the SBU is applied to the external environment, Porter's concept developed into the chain model shown in figures 5.2 (a), above, and 5.2 (b) below. The second of these representations is merely a widened version of the first, and although called a 'system', it is in reality little more than series of chains with one, final, common link.

The arrows in the diagrams are of interest. Porter was aware of a certain importance in the linkages between SBUs. He perceived an 'interdependence' between both internal and external SBUs. However, the models that are offered in the books only show single, simple connections and imply a uni-directional process flow through the SBU functions from left to right. Furthermore, the aim of the model is only that of internal process efficiency

FIGURE 5.2(b)

Porter's Concept of a 'Supply System'



A.2 - Beyond Porter

Porter's work has gained wide acceptance in industry and academia. It saw ever-increasing application through the 1980s and has become an unquestioned part of modern management thought. The value or supply chain's message is easy to understand and seems to make clear sense. From raw materials through to the customer, a process flows through a series of stages (SBU). These SBU (either firms or functions) form a chain along which value flows, is added to, or created. Efficiency is achieved by disaggregating this chain and focusing on its constituent links. The message is so clear that it seems beyond questioning - and few have. Many however, have adapted the chain model, 'improved' upon it, used it for further research or praised it. Some examples of these are discussed below. None has been found that challenges how valid the model is in 'creating and sustaining superior performance' as Porter's book promises.

As examples from the strategic management literature, Mintzberg & Quinn (1991) and Johnson & Scholes (1984) both use extracts from Porter's Advantage and Strategy to strengthen their approach to 'The Strategy Process'. Little commentary is offered on Porter's models other than their appropriateness and potential. Both texts have for some time been found amongst the text references of prestigious management courses in the UK.

Ironically, much research into the value chain has also been undertaken by an area relegated to secondary status by Porter, that of purchasing and supply (P&S). Quoted in Saunders (1994) the Purchasing and Supply Lead Body created a 'functional map of the purchasing and supply chain'. Within this is a definition of the purpose of the chain:

> "[To] provide the interface between customer and supplier in order to plan, obtain, store and distribute as necessary, supplies of materials, goods and services to enable the organisation to satisfy its external and internal customers."
>
> (1994, p.3)

This definition expands the idea of the interface of customer and supplier only touched upon by Porter's treatment of linkages[5]. It also repeats the internal-external customer concept. Through the mention of planning, there is a hint at the importance of information flow in the chain. The chain itself is, however, still regarded as a tool or a channel, separate from the organisation through which there is only physical flow. This view is reminiscent of the black box approach to technology described earlier and seen to be inappropriate to technological advance, and will be called into question below. Such a definition also perpetuates the concept of P&S as a support function to manufacturing.

In the body of Saunders' work itself, which adapts the SMP approach of Porter specifically to P&S, the chain metaphor is further built upon, but a far more systemic view is adopted, and the author alludes to the true importance of P&S:

> "Instead of a focus on the contributions of each subdivision of purchasing and supply management a more holistic perspective is adopted, which

[5] For Porter, the ability to 'exploit' supplier linkages was determined by the supplier's cost behaviour. This meant that the lower the relative price, the greater the scope for exploitation and the attainment of low unit purchase cost.

> emphasises the contribution of managing the whole supply chain. Managing the added value at each stage, as well as reducing wasteful activities (non-value added activities) contributes to the meeting or exceeding of customer expectations in the end product market. Expectations of different customers may vary with regard to priorities in relation to quality, delivery, price, flexibility of services etc., and it is the task of purchasing and supply management and the organisation as a whole to be sensitive to them...The need for continuously improving supply chain performance is also seen to be vital, especially if most of the value added is created by upstream suppliers."
>
> (1994, p. 19)

This greatly expanded view of the purpose of the chain and its management shows the need for integration in the process. Not only should P&S to be integrated into the organisation, with the implication here that it is *not* merely a support function, but also that P&S management ought to integrate across the organisational interface. Furthermore, there is the recognition that the efficiency of the chain can improve through a constant drive on its efficiency and its effectiveness. In many ways, Saunders criticises the 'traditional' approach of Porter's Chain[6]. However, little attention is given to the reasons why the traditional model fails, other than its ignorance of interaction. Why is interaction important? What is it about the 'business process model' that really constitutes an improvement? Although constructive criticism is offered to build upon Porter's model, the failure to address and answer these fundamental questions prevents Saunders' models from being truly systemic in nature.

The issue of customer demand is introduced in the above quote as well. Rather than a process pushing value 'left to right' at the customer, Saunders acknowledges the importance of customer demand pull, and conformance to these requirements. Furthermore, these requirements themselves are recognised as dynamic. Such dynamism makes adherence to a 'generic' competitive strategy rather risky.

[6] A quick reference list comparing the traditional model to the business process model is given in Saunders, 1994, p.50-51

Saunders also describes the inputs into the chain (1994, p.5), as listed below:

inputs to production
capital equipment
consumables
goods for re-sale
services

Rather than a generic approach to business, Saunders illustrates that supply is not always supply, that inputs will vary, and that this demands varying types of management. The management processes required will change from one type of physical supply to the next, and from one stage in the supply *or development* of a good *or process* to the next. This will be revisited below. Each input will also command a varying degree and nature of information and skill from the human side, but 'skill' and 'information' are not given the status or importance of an 'input into the process'. They are relegated to a secondary status similar to that of P&S in Porter's original view.

If the customer is positioned to the right of Porter's model, and there are countless internal customers throughout the 'chain', why is the marketing research information gleaned from them not depicted in the model? Why is this not accepted as a valuable process input? Without it there can be little guarantee of matching product to demand. Saunders' is not the only research to have ignored this point. Despite attacking some highly sophisticated aspects of the strategic management of supply in the body of his book, this fundamental flaw in the general paradigm is not addressed. The model is too simple.

After a lull in its interest in the manufacturing sector in the late eighties, the British government has once again begun to promote its domestic industry, apparently having realised its strategic importance to the wealth of the nation. The DTI is the governmental body responsible for much of its research, training and guidance to industry[7]. The importance of purchasing and supply has seemingly been realised within the ministry, and the DTI is doing much to promote regional supplier networks. The advice it offers is, however, still based upon the Porter Chain. In its 'Manufacturing into the late 1990's' publication, this is evident in the two models shown below in figure 5.3(a) and 5.3 (b)[8].

FIGURE 5.3 (a)

'Lines of Supply Model'

Source : DTI, 'Manufacturing into the 1990s'

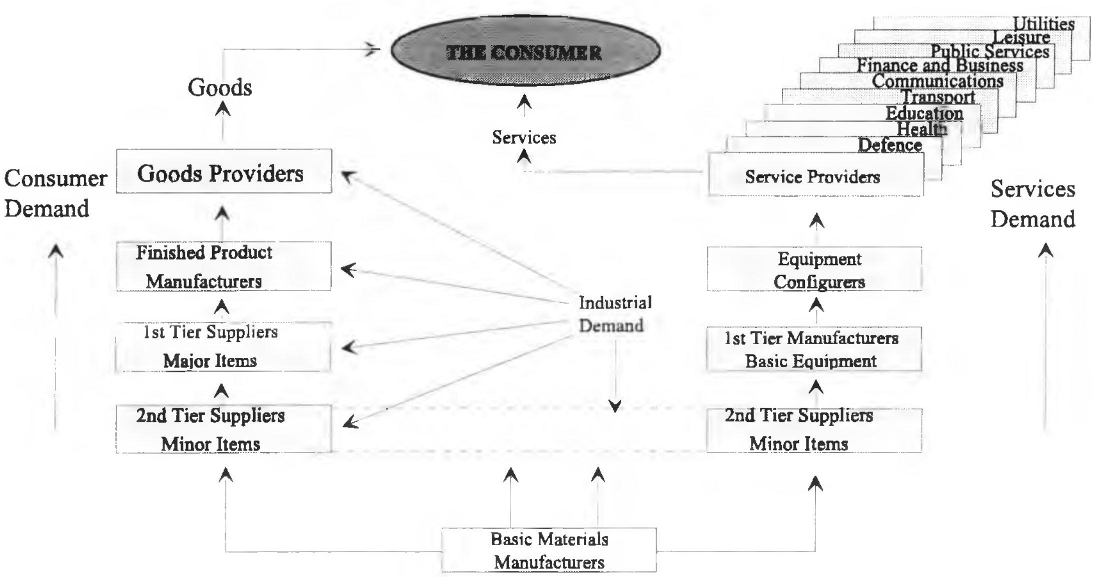


Figure 5.3(a) is intended to assist companies in competitive positioning - in a similar fashion to Porter's Competitive Strategy work. The positioning helps 'in terms of potential sources of demand...and potential lines of supply.' (1993, p.53)

Although the advice is centred upon qualitative issues and uses consumer demand as the driver of the process, there is still the persistence of disaggregation. The model shown even separates service providers from providers of physical goods. Both lines of supply only coming together at the point of delivery to the final customer . The accuracy of this particular refinement must be questioned in view

[7] More accurately, the DTI oversees and coordinates much of the contracting out of these activities. The DTI relies to a great extent on academia, independent bodies and industrial input for its research.

[8] This publication was compiled in collaboration with the PA group, which is the reason for the apparent similarity between figure 5.3(a) and the PA model in chapter one.

of the level of service provided to manufacturing organisations themselves, and indeed in view of the level of service activities the latter still provide in-house.

FIGURE 5.3

'Typical Supply Chain'

Source : DTI, 'Manufacturing into the 1990s'

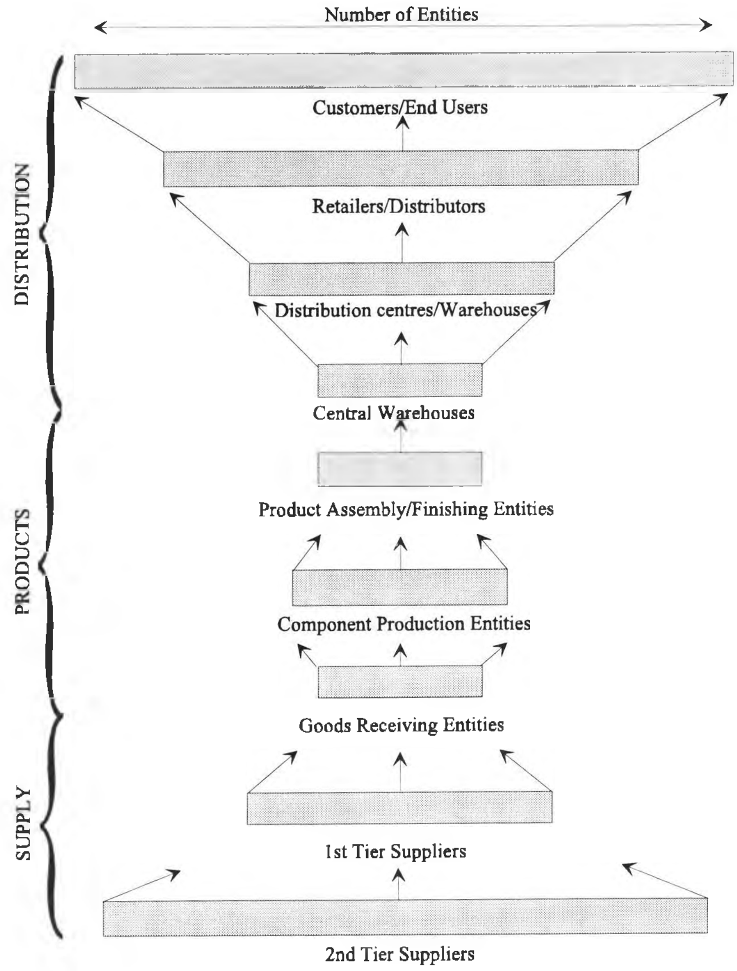


Figure 5.3(b), above, shows what is, undoubtedly, a 'Typical Supply Chain'. The advice offered is:

> "Developing an integrated logistics strategy requires a clear view of the entire (and often complex) supply chain. Knowledge of the supply chain must be overlaid with a clear view of both the variety and demand characteristics of the products, components and materials flowing through it."
>
> (1993, p. 117)

An improvement upon Porter's original theme, this example addresses the issue of organisational concentration and tiering towards assembly, and the subsequent divergence of distribution. It also makes an important step forward in illustrating the continuous nature of the supply process - the internal/external chains concept is broken.

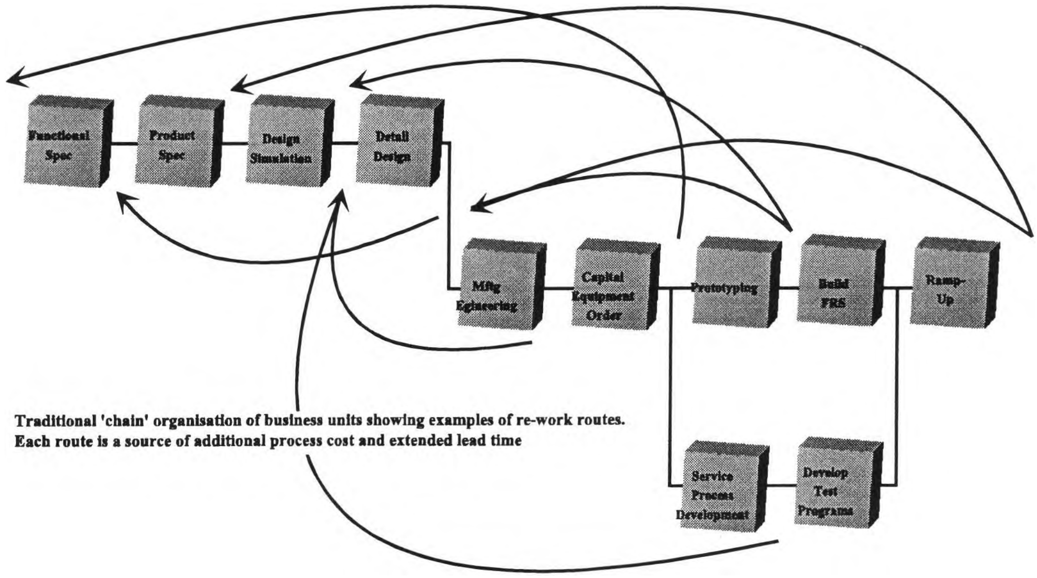
No feedback is shown, however, and only physical product is acknowledged in the flows. Without feedback the true nature of complexity has not been realised. The absence of feedback and the existence of solely material flow illustrates the continued ignorance of the importance of the human factor in the process. Furthermore, the model's definition of 'supply', 'products' and 'distribution' seems rather hard to justify. Surely an organisation in the first tier is equally engaged in distribution , and distributors are equally engaged in supply. The model is not only a typical chain, but is also a typical example of the reductionist view of organisational theory.

The disadvantages that can arise from preventing, or ignoring feedback in the system are shown by Hartley and Mortimer (1991, p.5). The reductionism of the chain approach leads to behaviour commonly termed 'over the walls engineering' (OTW). A description of this was given in chapter one. OTW has no proactive feedback. Products are passed along the chain in the usual direction and functional separation prevents adequate communication or information exchange. The result of this process, ironically is enforced, rather than self-organising feedback, in the form of re-work. The suppression of self-organising flows reduces process efficiency (the potential for reaching the systemic purpose) by adding to lead times and increasing cost; in short, decreasing quality. The re-work feedback is shown below in figure 5.4.

FIGURE 5.4

Backtracking with 'Over-the-Walls' Engineering

Source - Hartley & Mortimer



Phase 0 Requirements	Phase 1 Concept	Phase 2 Detail	Phase 3 Quality	Phase 4 Ramp-Up

Along with government advice, the 'chain' model has become the cornerstone of a modern day panacea - TQM. Once heralded as a cure for all ills, the TQM literature uses the chain concept to break down the issue of quality into stages of internal customer-supplier relations, in a similar fashion to that described above. An example of an improvement upon Porter's original work from the TQM school of thought is offered by Cesarotti & Visconti (1995) from a study of practice in the automotive industry of southern Europe. The model presented, the 'quality chain', is an example of how entrenched the supply chain has become in the formulation of TQM strategies:

> "The basis of the Quality Chain model is the internal/external Supply Chain model, that is the well known conceptual model that identifies two different supply chains within an industry: the external one between customer and suppliers, and the internal one between customer processes (or activities) and supplier processes (or activities)...On the basis of the internal/external Supply Chain model and the dynamics of the quality creation process...we have formalised a model that can be defined as a TQM-based redesign of the Supply Chain.
>
> (1995, p. 185)

Later it will be seen that this last statement is a contradiction in terms, since total quality (assumed to be the aim of TQM) cannot be achieved by behaviour consistent with the chain alone. The concept of two distinct chains, as originally formulated by Porter and perpetuated explicitly here, will also be directly challenged.

The improvement offered by Cesarotti and Visconti is, however, once again the inclusion of a greater level of feedback in the functioning of the 'chain'. Having recognised the importance of the customer/supplier relationship, the authors criticise the quantitative emphasis of many TQM projects. The model they promote is an attempt to splice qualitative factors (the "vision of quality") into the process. Two different sources of this 'vision' are identified, one stemming from the customer, the other from the supplier - a perspective that will be seen, both in this chapter and in chapter seven, to increase in importance. Above it was outlined how these two 'voices' have already influenced industrial behaviour with the example of Ford. The inputs into the chain create feedback loops which affect the satisfaction of the customer, the latter at times being the supplier[9]. The authors recognise the vital contribution these loops play in achieving quality in output, and quite rightly depict them explicitly in their model. The result, however, is hardly a 'chain', but rather a network[10], a welcome move towards the appreciation of a system. This being the case, the authors' continued use of what in this current research is decried as linear terminology must be called into question.

A further improvement upon Porter's model is that the external supplier has input not only into the 'inbound logistics' of the organisation, but into all functional areas engaged in the process. Here is the true importance of purchasing and supply. The supplier can directly affect the quality output of all functions, and the management and development of the supplier interface is primarily the role of purchasing and supply.

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[9] A supplier can 'buy' process improvements from a quality customer in return for higher quality supply.
[10] Once again the terminology of Vernon as introduced in chapter four is used here.

Referring back to the PA model shown in chapter one, (figure 1.2), this fact is shown on a broader scale. If the quality of the output from one stage in the diagram is dependent upon the input into its processes (since this will affect the efficiency of the transformation process), then it is machinery and equipment input as well as lower tier input per se which affects the quality in any one particular tier. This lower level tier's output is, however, itself also dependent upon the input of its machinery and equipment manufacturers. The ramifications of supply (good or bad) multiply up through the tiers not only through constant new input but also by the effects of existing factors of production. Even if those firms in the tier closest to the, for example, car assembler customer use no machinery at all, their output is nevertheless dependent upon the quality of machine tool use within more distant tiers. Brittan's discussion of Scott's work, as introduced in the literature review of chapter three, also touches this point:

> "A second and bigger reason [for believing that the return on investment much understates the true 'social' return from capital] is what he calls the 'learning externality'. By this he means the benefits of investment by one form spill over to benefit others. For instance, innovation may for a time lead to abnormally high profits. Even if these are eliminated by competition, the benefit to the customer of cheaper and superior products remains."
>
> (Brittan, 1993)

Also in chapter three, Edson Gaylord decried the tendency of Western managers to justify expenditure on capital and equipment by financial payback assessment alone. The inadequacy of this method is seen here. Expenditure on machinery may well seem nominally high for the output of the individual supplier, but in quality savings further throughout the system the expenditure might be easily justifiable. The payback will not be results that are directly quantifiable in advance, but will tend towards higher quality output from the system as a whole and therefore increase the potential for continued business[11]. Those organisations that need to

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[11] In chapter seven this topic will be revisited. The statement above makes some important assumptions. Firstly, there must be an awareness of the existence of an inter-linked system which Porter's model does not promote. Secondly there must be a readiness on the behalf of the customer to award long term business on the basis not of nominal cost alone, but also using criteria which

invest in machine tool technology ought to be able to communicate with their customers in order to avoid the 'guns or butter' trade off. Such communication could well result in the customer organisation making allowances for supplier investment in the prices it accepts. This would depend upon the supplier's ability to offer improvements in the future as a result of the investment that otherwise would not be possible. In other words the customer acknowledges the importance of development in its own suppliers due to the contribution this has in the customer's own development[12]. The inability of the linear chain paradigm to incorporate such long term feedback precludes the potential for world class quality in product and process.

Having made clear the multi-interface nature of supply, and including feedback loops in their model, Cesarotti and Visconti fail to realise the implications of their model, since they carry on to argue:

> "...an activity is necessary only when it is the only activity that can achieve what the customer wants and...an activity is useful when it adds value higher than its cost, or when it helps reducing the global costs of the business."
>
> (1995, p.187)

They have not realised fully that activities can be 'useful' in the long run despite increased initial cost. Indeed, investment in training for quality can improve quality output and reduce cost - but requires an initial input of funds with no quantifiable promise of results. Although not necessitating injections of funds per

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show potential for quality supply. Once chosen, suppliers should only be switched in accordance with all of these criteria. The criteria themselves, and their weightings will depend on the type of supply. Evidence of both 'old' and 'new' behaviour has been found in industry, although seldom has one organisation been characterised solely by one form.

[12] Two extra points must be made at this juncture. The first of these is that the development capacity of the supplier is increasingly becoming a criterion of supplier selection as will be seen to be the case in chapter seven. Substantial, sophisticated feedback loops of information exist between buyer and supplier organisations *even before contractual flows of physical goods in the 'chain' begin*. The second point is that improvements need not necessarily cost anything - quality can be free. The point made here in the text is that quality can be achieved through capital investment, which is expensive. It is not meant by this that such expenditure is the only method of nearing the quality objective.

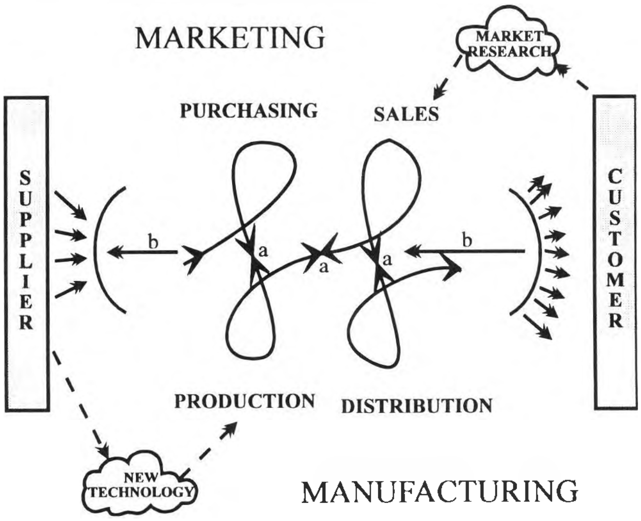
se, the initial stages of a concurrent engineering exercise are similar in nature, as will be described below in chapters six and seven.

In the context of the above quotation, the customer is the internal one. It is arguable whether the internal customer can always be expected to know *exactly* what the final customer wants, and how that connects to the day to day activities of each individual involved in its supply. Certain activities are 'necessary' for stages further downstream - a far more long term, systemic view of value engineering is needed than is described here. Furthermore, can an activity not be useful if it contributes to supplier satisfaction? It is argued in this current research that the satisfaction of quality suppliers is equally vital to the attainment of quality supply and technological advance as the satisfaction of customers is to the continuation of the business. Indeed it will be argued that both customer and supplier satisfaction are mutually dependent.

One final model is to be discussed in this section This was formulated by Deming and has recently been quoted as being the 'spark that ignited Japan'[13]. Although the model itself appears in Deming's 'Out of the Crisis', figure 5.5 below shows it in the form used by Carlisle & Parker (1989).

FIGURE 5.5

Deming's View of the Supply System
(adapted from Carlisle & Parker)



[13] This reference pertains to the Deming Lecture given at the First World Congress on TQM, Sheffield Hallam University, April 1995.

In showing Deming's *system*, a departure has now been made from Porter's model. Despite all of the refinements and adaptations of the other authors described above, they all have as their basis the chain as a paradigm. What Deming perceived to be representative of the process of supply can hardly be called a chain. Although it has some characteristics similar to the chain, Deming's model is a step into the realm of Systems

There is still the notion of the customer sitting on the right hand side, and the supplier on the left. Hence the primary flow of physical product is left to right, shown as 'a', the uni-directional flat line. However, the multi-directional non-linear function 'b' is equally, if not more important. This equates to supplier input in the form of new technologies (product and process) and customer input in the form of new requirements (form and function). These processes flow freely through organisational functions in such a way that the old functional 'chimney stack' organisation with a structure based on lines of reporting and control has little relevance in the modeling of business strategy. To show the interactions would require a model too complex for 2-dimensional depiction. That manager A *reports* to manager B is not important. What information the former passes on, and where it came from is, however.

As an aside, on the subject of the perception of the structure of the organisation, it is perhaps the acceptance of the hierarchical organisational chart that serves as one source of the perpetuation of the value chain approach. Since the 'chimney stacks' are sequentially placed anyway, it is 'easy' to show how one function's activity seems to pass on to the next. Hayes et al. (1988) describe the negative aspects of this approach to structure as being 'divide and conquer' and 'responsibility equals authority' amongst others (pp.98). Management gained respect and status through the divisions advocated by Porter amongst others, and would in fact try hard to create fiefdoms with as many subordinated 'serfs' as possible. Indeed many reward systems indirectly encouraged this behaviour. This would result in greater responsibility and therefore authority over the organisation - forming one great vicious circle.

The approach to the organisation of manufacturing product and process development offered by Hayes et al. is that of functional mapping, where interactions and linkages are depicted by circular rather than linear groupings of functions. Having begun to soften the hardness of Porter's approach, it is easier to imagine the existence of non-linear process flows. The 'creation of a learning organisation' involved in 'dynamic manufacturing' sees no chains at all[14]. Indeed, in later parts of the book, the chains of traditional manufacturing layout are broken into cells - this issue will be covered in chapter six in more detail. The point made by Hayes and supported by the current research is that the perception of the organisation depicted by a reductionist, hierarchical model contributed to reductionist, separatist behaviour. Greater awareness of approaches such as Hayes et al. or the systemic approach of this research could in time reverse the damage that disaggregation has done. Chapters seven and eight below use a systems tool, the Viable Systems Model, to offer a multi-dimensional approach to the structuring of complex organisations in a manner that can promote emergent properties through the encouragement of feedback.

Returning to Deming, given a chain with four disaggregated SBU labeled A - D, the product of the chain must be[15]:

$A+B+C+D.$ [16]

In Deming's system the feedback allowed through the multi-directional flows means that synergy is achieved through information exchange (i.e. not necessarily physical product flow) between any 'SBU' as and when it is needed. The resultant output (the emergence) therefore is *non-predictable* and will depend upon the

[14] The two phrases singled out here are from the title of Hayes et al. 1988.

[15] A word on the inclusion of a mathematical function in this formula. Since no interaction can occur in this model each stage adds to the value of the previous stage. In that this stage might negatively contribute to the chain output, the contribution could be regarded as a subtraction from value creation. This is nevertheless a negative addition, and the '+' function still applies. The phraseology used in texts on the chain is generally centred on creation and addition of value, and little attention is paid to negative aspects.

[16] This method of labeling organisational units and their interactions taken from Neave, 1995

quality of interactions (both human and physical). One *possible* product could be represented by the function[17]:

$$AB+CD-AD+BCD-AC+AB$$

In the dynamics of the process envisaged by Deming (long before Porter came to formalise the chain model), the route of the flows constantly changes. Here again the chain model falls down, since the links would have constantly to be broken and re-forged. Is Porter's model showing itself to be as rigid as the SMP approach it attempted to improve upon? Why did Deming's message receive such early acceptance in Japan and other emerging Pacific Rim nations, whereas in the West reductionist thinking still dominates even today? The reason for this is argued to lie in the Cartesian philosophy outlined above - a philosophy not prevalent in these former areas. The accepted existence of a division between self and environment leads the individual to perceive 'self' as more important than environment. The fundamentals of Deming's system subordinate 'self' to environment and, moreover, to the system, a concept which would arguably still be quite alien to Western thought today..

A.3 - Weak links in the chain

The above two sections have traced the development of the Value/Supply Chain approach as formalised by Michael Porter. Various adaptations of his model have been described. These stem from the academic management literature of various disciplines, the DTI, and industrial 'umbrella' institutions. With the possible exception of family background and society, these three groups of education, industry and government are surely the greatest sources of influence upon management. As such, Porter has achieved his aim of reaching practising strategists. The extent to which behaviour reflects this remains to be seen below. Remaining on an abstract level for the moment, this section will collect the weak

[17] In this formula, the functions are expanded to depict *more explicitly* positive and negative contributions as well as non-linear addition.

links from the above adaptations so that the their 'strengthening' is incorporated during the creation of the systemic model in later chapters.

A.3.1 - Non-linearity

A critique of the linear approach has already been given above and in chapter four. One stimulus does not produce one immediate reaction in a complex human activity system. The feedback effects are non-linear and are subject to delays. The simple chain model with linear connections does not address this fact.

A.3.1.1 - Non-linear feedback and the metaphor of light

The advantage of the use of metaphor in the study of systems has been discussed in chapter four, and has been illustrated by discussing the work of such authors as Fitzgerald and Hawking. A study into the nature and theory of light has been found which, it is argued here, offers a useful metaphor showing the importance of non-linearity in systems. The conclusions of work performed by Dr. Allan Snyder in Australia (Anon, Economist 1995) bear surprising similarities to the arguments presented here in the current research. It will be argued here that the system of light transfer and processing has much in common with the systems inherent in supply.

Traditional theories of light are founded upon linear mathematics, with Maxwell's original equations explaining light in terms of electro-magnetic fields. The article describes how Maxwell devised his equations "in a vacuum", ceteris paribus, as it were. Snyder argued that this condition is of little use, since modern science has shown how in space true vacuums rarely exist - nature abhors them. Deepest space itself contains gases and quantum particles (Hawking 1988). The passage of light (itself now regarded as consisting of particles rather than simply an electro-magnetic wave) is always obstructed by other materials which refract and diffract the light.

The following paragraph of the article is of particular relevance:

> "For most purposes Maxwell still does as well today as he did a century ago; the non-linearities do not matter much. But when light is used to send information, non-linearity starts to matter a lot. Thick glass distorts, and an optical fibre that crosses an ocean is an extraordinarily thick piece of glass. Non-linear approaches are also needed if optics are to be used to process information, as well as transmitting it; large effects from small causes are typical...and necessary for building the switches without which information processing is nearly impossible."
>
> (1995, p.121)

As has been stated in the current research, there may be situations in supply where a product, its processes and its markets are developed and where the chain model, like that of Maxwell, is appropriate. This situation rarely occurs. Rather, supply is a complex process of information transfer and processing, and just as is the case for light, non-linear effects are the result of the process. Small stimuli do create larger results, as was discussed in chapter two with reference to Senge's feedback systems. Not only does light possess such unpredictable properties, but it may also fragment through interference with other matter, producing multi-directional effects similar to those to be discussed in the following section.

Just as thick glass distorts, so do organisations due to their complex structures and plethora of human interactions and perspectives. Empirical evidence of 'chain' behaviour may be found in simple, static 'snap-shots' of supply, but not in observations over time. Even if it were, it would not prove 'best practice' in a comparative bechmarking exercise with an organsiation displaying more systemic behaviour.

Much of the work on the chain has been directed at the right hand side of the model - i.e. value addition towards the customer. For light the case was similar. Snyder's non-linear models of light now enable engineers to produce signals which will more reliably, efficiently and effectively reach their target. To produce these results, Snyder's team had to "look at the problem from a different perspective: backwards." In the current research the 'backwards' perspective (in the chain model, one which looks to the left) of supplier management is of similar importance, and it is argued is a pre-requisite of truly understanding the business process.

A.3.2 - Multi-directional feedback

Not only are the feedback effects of stimuli non-linear in nature, they are multi-directional. Just as the refraction of light reduces the intensity of light received at the target, so the passage of information and physical product through an organisation can become distorted. Such distortion, via inappropriate inputs or other low quality work will reduce the perception of quality of the customer compared with the achievable ideal. Much of the work into the chain approach can neither accommodate nor model flows which, depending on the situation involved, touch a variety of elements repeatedly, *and simultaneously*. Through this omission they cannot accurately model the human interactions of modern-day processes. The chain approach stifles emergence from the system through the inability of process feedback to self-organise. The discussion of earlier chapters, especially that of Fitzgerald's work, highlighted that such control was not only unnecessary, but would lead to the negative effects of entropy.

Non-linearity and multi-directional feedback are aspects of complexity that the chain model has failed to embrace.

A.3.3 - Cost Focus

The problems arising from a focus on cost have been described above. Porter's approach was originally designed to depart from the financially based approaches to control of Sloanist SMP through concentrating on 'process' efficiency. Indeed, 'Analysis' does explore some of the areas of diverse supplier selection criteria that will be outlined in chapter seven, and which have been seen by the current research to impact positively upon process efficiency. The underlying selection criteria are, however, still price and cost.

Apart from the disaggregation which precludes the awareness of the total process, two further contradictions exist which prevent the above aim being achieved. Firstly, in its bias towards improvement, Porter's work seems to have adopted a transactions cost approach. The disadvantage associated with this, described in Cole & Mogab (1995, p. 36-7), is that the focus is on 'cutting out' or eliminating aspects of the current process that are unnecessary. The following statement is typical of Porter's approach, mixing the transactions cost focus with the advice of the five forces model..

> "Identifying the lowest cost source may lead to lower unit purchasing costs in the long term if the firm can exercise its bargaining powers."
> (Porter, 1985)

This constant downwards pressure on suppliers will affect their ability to invest in product and process R&D, and will impact upon their future quality, thereby impacting on the future quality of the customer's own supply. Such a link between procurement and technological development is not realised.

Another danger is inherent in Porter's disaggregation. Purchasing is regarded as a support function, and therefore does not create value. By thus regarding the function the link of purchasing to the manufacturing process is destroyed and forgotten. That lowest unit purchasing cost does not necessarily mean lowest unit process cost, or lowest cost of quality, lowest cost of conformance etc. is left unaddressed by Porter. Chapters six and seven will, however, demonstrate the importance of this in much of modern-day industrial practice. Far more than being a support function, purchasing manages a vital interface, matching supplier developments and abilities to manufacturing and end-customer requirements.

The more systemic approach is one of 'value engineering' where elimination of cost is not the sole criterion. The effort is directed towards improvements in the quality of the process which can, in time, reduce its cost. This in itself casts a critical light on Porter's dichotomy of cost leadership or differentiation. Quality and cost can go hand in hand and lead therefore to cost leadership *and* differentiation.

An improvement system which is based on cost will look to reduce cost at the expense of quality. Returning to a human metaphor, Porter's approach can be equated with dieting, value engineering with exercise. By exercising the system it can be improved from within rather than starving it and reducing it artificially.

A.3.4 - Drivers of the System - stability or development?

This introduces the question of the purpose of the system. Porter paid no attention to purpose. The Chain was simply a black box tool of logistics, SBU being of sole importance. With recent acknowledgment of the quality issue, the importance of the customer in the business process has been unveiled. Hence the Purchasing Lead Body's 'purpose', in section A.2 above, gears the whole process towards the satisfaction of the customer, both internal and external. This is achieved by introducing customer requirements into the chain. Rarely is this actually depicted as a reverse feedback flow, however.

Meeting customer requirements is necessary. If the existence of the internal customer is recognised, this can even touch all elements in the system. However, further inadequacies exist here. The internal customer-supplier relationship is seen as a linear chain. By ignoring the importance of complexity as above outlined, the existence of certain internal customers may well be forgotten or ignored. No effort is expended to find the complete portfolio of those affected by the process.

Furthermore, why simply 'meet' the requirements perceived by the customer? If compliance is the aim, then by the time the product is supplied the requirements will at best already be in the process of satisfaction by competition or will themselves have changed. If customer requirements are as dynamic as Saunders believes, and they certainly are, and competition is tight, then supply should be aimed at exceeding these requirements This requires advance both in product and process - this in turn requires technological and managerial change. That such change is not exogenous to the firm has already been discussed in chapter four. The Chain model, however, seems geared towards the supply of established product - the simple transferal of product along from one SBU to the next. Value is created within these SBU in isolation. This is not the case in reality.

Value is created, added to, or developed by interaction of inter-organisational elements with others - both in the organisation and outside of it. The driver of technological change is commonly named 'The Science Base', and consists of interactions between both the industrial and educational systems.

What drives the system therefore is the attempt to attain its purpose, that of the satisfaction of the elements of the system - which include the customer - on a long term basis. This satisfaction is the constant mixture of technological 'push' and customer market 'pull'. Although it could be argued that technological change in itself is only aimed at customer satisfaction, and that the converse is hardly true, neither may be allowed to outweigh the other. The structure of the system must be able to promote market-driven technological change.

In Systems parlance, market-driven technological change is simply emergence that fulfills the purpose of the system. In order for the structure to promote such emergence, it must acknowledge the System generics. Dynamic complexity in non-linear and multi-directional feedback, and detail complexity in the inclusion of, and interaction between, customers and suppliers. Self-organisation is important in allowing the complex feedback freedom to flow throughout the system. If the structure is geared towards systemic behaviour in this way, it will be prepared to move towards higher and higher levels of complexity as the market adapts to environmental influence - again stimulating the need for market-driven technological change. If the system is stifled by reductionist thinking, the negative effects of entropy will ultimately destroy it.

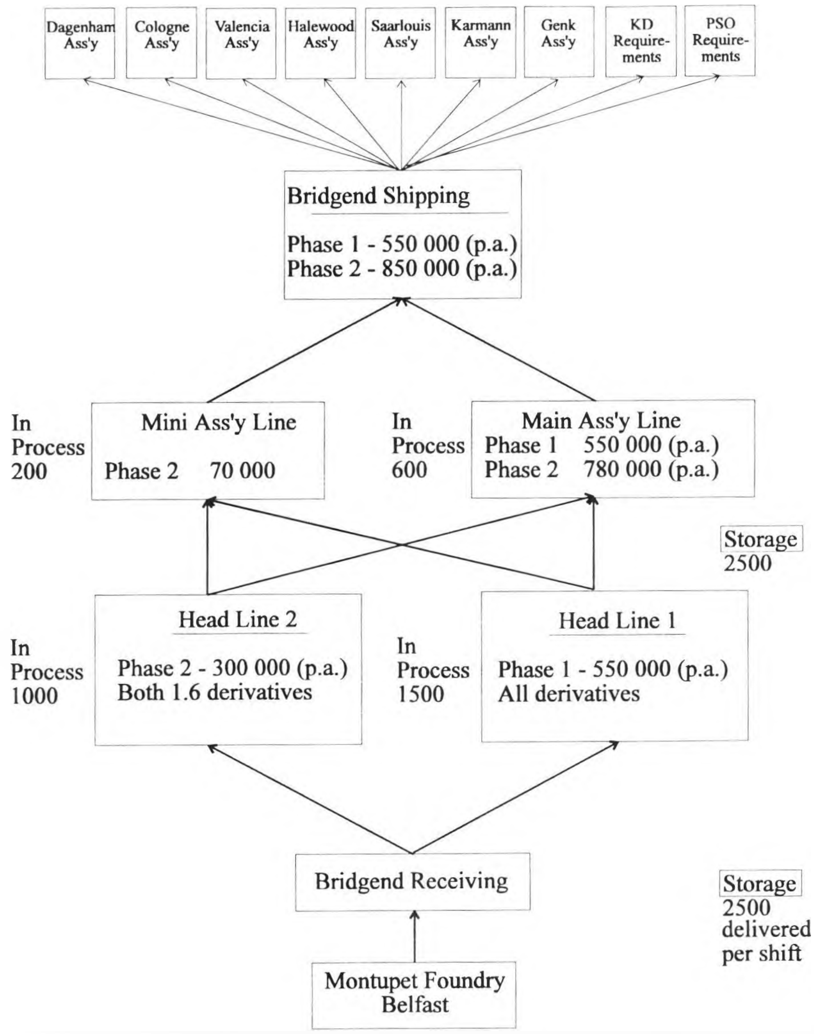
A.3.5 - Case Study - The Ford Zeta Engine Programme

Although much of the field research (SSM's real world investigation) has been reserved for the following two chapters, one short case study is described below. It has particular relevance to the current discussion of the appropriateness of models. It shows a reductionist strategy which leads to the sub-optimisation of a process. Non-linear, multi-directional feedback is ignored and a unit cost focus leads to a situation which, for Ford, could have proved far more than 'problematic'. The quote from Porter's work of 1985 given in section A.3.3 above will be seen to be not only misleading, but to present a great threat to the success of the strategy.

Figure 5.3 (b) above resembles the model used by Ford in planning its 'Zeta' engine operations, the first phase of which was implemented in 1991 as described in Chelsom (1996), and shown in figure 5.6 below. A two stage project was decided upon for the production of the engine and its expansion into the European continent. With regard to the cylinder head, as referred to in figure 5.6 below, phase 1 would produce 550 000 heads annually, phase 2 a further 300 000. Castings would all be supplied from Belfast, and machining would take place at Bridgend. From Bridgend, the heads, now part of an engine, were transported to final vehicle assembly areas all over Europe as shown at the top of the figure.

FIGURE 5.6

JIT Plan for the 'Zeta' cylinder head at Ford, Bridgend



Derivative Complexity

Phase 1	Phase 2	J.I.T. Objectives
1.6 2V		
1.8 EFI H/L	1.6 EFI	- Direct flow of material, no interim stocks
	1.8 EFI H/L	
	1.8 MED EFI	- Overall plant inventory, 5 days wall to wall
	2.0 EFI	

The decision to centre all Zeta head machining at Bridgend was based upon comparative 'piece price' analysis, that is, the cost of the materials, labour and overheads that were attributable to the manufacturing and shipping alone. Other plants were not able to achieve the low piece prices offered by Bridgend.

Having accepted this as a suitable and credible model upon which to base its materials, production and logistics strategy, changes were necessary before the introduction of the second stage. It had become apparent that the model failed to take certain aspects into account. These aspects relate to the ignorance of two things. The first of these is the issue of process costs, the second that of the influence of the WSOI. (For Ford the narrow system of interest is not the machine tool organisation as was the case in previous chapters, but Ford itself. In this case it was even narrower, in that many decisions were centred on individual factory locations). The chain model works towards the efficiency of each stage, and in isolation such efficiency was thought to be achievable by working towards lowest unit purchase costs and economies of scale. This was to be achieved through concentration on one plant - Bridgend. In reality, such concentration proved sub-optimal.

The foundations of phase 2 had been laid in Wales. Plant and equipment were all in place. A labour dispute occurred, however, which gave Ford management cause for concern. The model in figure 5.6 shows how in theory expansion of supply into the European continent could have been achieved from the UK. Feedback from the wider system, in this case national union intervention, had not been considered, however. Phase 2 was therefore moved and placed in Köln, the head-quarters of Ford's German operations, closer to two major user locations.

Many of Ford's previous strategic decisions concerning the Zeta engine had been based upon the cost of the output of British facilities. Yet the reasons for not placing all production in the UK were not solely cost based. Even after the dispute, the piece price could still have been low, but potential interruptions in production could not be accepted. Two lines were planned, one in each phase. Much of the product of these would be exported to continental Europe. Why not produce in existing plants on continental Europe? As well as spreading the risks associated with industrial relations, this would reduce direct transport costs and associated costs of inventory and even-out the imbalance of importance being placed upon Bridgend (cultural issues were not insignificant).

In-bound logistics were also to be positively affected. No longer was Montupet the only source of castings, but Brühl, near Köln sourced the castings needed for German processing. For some classes of supply, volume purchase contracts could achieve favourable buying economies[18], and hence one sole supplier would be retained, but would be required to supply to the UK and Germany locations. The extra cost of splitting plant-bound material into two from the supplier (e.g. administrative) being offset by qualitative as well as quantitative improvements. In other words, not only was outbound supply an issue, but inbound supply was also taken into consideration. This means that employees', suppliers' and customers' perspectives were being considered.

The chain approach as typically used and perceived, as shown in the original plans for both Zeta phases, does not take into account the ramifications of supply strategies upon the wider system. The WSOI in chapter four was explained to comprise elements exhibiting reciprocal influence or control over the system. In this example, this quite clearly means employees, customers and suppliers, from whom feedback stems, which has a significant influence upon the success of the system's processes. It may well be, once a structure has been established that takes all perspectives into account, and where a product and process have been co-developed, that the chain does accurately describe what occurs. As a way of perceiving the environment in which the system is to exist, and as an approach to development and improvement, the simple chain is not suitable.

It is neither known nor intentionally implied that Ford's Zeta decisions were a result of Porter's models. It is a matter of fact, however, that the Zeta plan is an example of a supply strategy that used strict disaggregation (down to the resolution of the plant and the piece price) to determine strategy. A wider, process-oriented view has resulted in using locations with higher piece prices, which in turn allow lower process costs. The cost of the head after machining is lower than the cost of

[18] A prime example here being raw materials.

it by the time the final car is purchased! This issue will be re-visited in the next chapter in the sections concerning measurement.

Summary

Chapter five has explored the nature and development of the traditional model of supply. This model, that of a supply 'chain', is argued to have such acceptance that it has become a 'mental model' or paradigm affecting behaviour. The roots of this model, Porter's Value or Supply Chain were seen to be in the world of prescriptive strategic management and planning. There is a certain irony that Porter's original intention of freeing organisational analysis and policy making from the shackles of the SMP approach has resulted in its being locked in chains.

The chain model is too simple. It is beyond doubt that it accurately reflects certain situations where supply is continuous, predictable and stable. Such situations rarely occur. The issues of feedback, complexity and synergy are ignored in favour of an implicit cost focus that leads to a stagnation of competitive performance rather than what Porter's two books quoted here promise in their titles.

These criticisms as they stand are based to a great extent upon fundamentals of Systems Theory. The research must now move to explore the nature of the system in the real world. Does industrial behaviour reflect the Supply Chain? If so, to what extent and with what results? If not, what characterises the behaviour and in what way are there distinctions to the currently accepted paradigm? What can be derived from these distinctions as to the nature of the Supply *System*? This is the content of the next two chapters.

CHAPTER SIX - INTERNAL PROCESS IMPROVEMENTS

To find the source of this evil
look better at things on this Earth
before you look to things
unhuman

Rebecca, in
The Crucible
Arthur Miller

Introduction

The preceding introduction to this second part of the current research gave some history of the challenge from Japan to much of Western industry - the machine tool and automotive industries being no exceptions. This chapter explores ways in which UK-based machine tool companies have attempted to rise to the challenge from new competitors by becoming more efficient in their work processes. An outline of individual process improvement programmes is given along with what these programmes mean in terms of feedback.

A - Benchmarking

As the Japanese spread their sales efforts and production into Europe and the US, they began to test the standard of EU and US suppliers. The low impression they received had two results. First, Japanese industry retained its concentration on its own suppliers. Second, it made clear to Western suppliers that if they wanted business from Japanese manufacturing organisations they had substantial ground to recover. At the same time, the Japanese were confident that the 'front edge of Japanese competition' would move forward faster than the 'rear end' would be recovered by competition. This is embodied by the following quote from the head of the Kanosuki Matsushita, head of the Panasonic Corporation in 1979:

> "We the Japanese shall win and you, in the West will fail. The reasons for your failure are within yourselves. With you the bosses do the thinking while the workers wield the screwdrivers. We know business is now so complex and difficult that to survive depends on the day-to-day mobilisation of every ounce of intelligence. For us, the core of management is precisely this art of mobilising and pulling together the intellectual resources of all employees in the services of the firm."
>
> (taken from Towers, 1994, p.12)

As a result Japanese industry began to offer advice to the West. This occurred both directly through tuition and indirectly through what has become known as 'benchmarking'.

Benchmarking is the activity of looking at a product or process which has direct or indirect similarity to one's own, assessing which is the best (relative to more than functional cost) and establishing it (for example) as the benchmark to match or beat. The similarity here to the PDCA cycle mentioned in chapter four is easily recognisable.

Although much benchmarking was initially performed between Japan and the West, much has also now begun within the West itself. Benchmarking has led to the adoption of such phrases as 'world class' and 'best practice' as norms within industry, these being the targets to achieve, or the status achieved. A large proportion of industrial organisations are now highly active in the comparative analysis of performance and procedure - many of which can be found in the UK. The UK government's initiatives and assistance from independent organisations have greatly aided industry's efforts in this area, especially small and medium sized companies[1].

The CBI has, since 1993 published an annual survey of benchmarking practice with the Coopers & Lybrand management consultancy. Although the results of the survey have been encouraging in that they show an increase in benchmarking, and benchmarking success, they have also highlighted that despite some years of effort, only 2% of UK companies can with confidence

[1]Two examples of initiatives to assist companies benchmark and improve are the DTI's M90s programme and the CBI's Competitiveness Forum. The former aims to "spread good practice to every part of UK industry", the latter is "a programme designed to help companies learn from each others' business practices". The programmes are targeted at a range of business activities including design, procurement, manufacturing etc. A host of regional supply networks has also been established by these two institutions in conjunction with local authorities. Initiatives also exist whereby managers and other employees are sent to Japan, either as a one way secondment or on an exchange basis. The two publications 'Manufacturing Bulletin' and '90s news' from the CBI and the DTI respectively (from which the above quotes originate) are, to a great extent, devoted to the topic of benchmarking initiatives available to industry and the success of current programmes.

call themselves "world class". Similarly, a large proportion of those companies now engaged in 'quality management' programmes is disappointed to find that their achievements are not yet approaching best practice when they come to study the requirements of the Malcolm Baldridge Quality Award (Chelsom and Clewer, 1995, p. 229).

A start has been made, but some ground has yet to be covered. In the meantime, the competition from the East (now expanded to the growing Pacific Rim economies of South Korea and Taiwan) is steadily making further progress. The following discussion will outline some of the programmes found in existence in the UK within industrial organisations. Although they are, necessarily, discussed in isolation, all programmes feed into each other and influence the efficiency of the business process.

B - Process Improvement Programmes

The result of benchmarking has been a drive to improve efficiency in product and process. The following is an outline of the various process improvement programmes found to be under way in machine tool organisations visited in the UK. They have been categorised into the following five sections:

- 'Muda' initiatives (management of waste elimination)[2]
- Financial management
- Human resource (HR) management
- Information exchange and management
- Benchmarking and measurement

[2] The term muda is Japanese for activities leading to the elimination of waste from a particular environment. The term waste pertains to non-value added activities rather than simply to the unwanted or spent physical product.

Such classification has proved useful in the consolidation of arguments to be presented later in this, and following chapters. To a certain extent the boundaries between the classifications are, however, quite artificial. For example, successful, efficient implementation of the production smoothing policies found in the 'muda' section will depend upon the extent to which issues found in the section on HR have been addressed.

Having discussed each of the five sections, some time is devoted to the 'environment' in which they exist - that of quality and continuous improvement (kaizen). It will be seen within this environment how all the programmes do, indeed, hang together.

Before continuing with the discussion of these programmes, definitions of both efficiency and effectiveness are given.

B.1 - Efficiency and Effectiveness

The process improvement programmes described in this chapter and chapter seven are intended to achieve process efficiency and process effectiveness. Dictionary definitions illustrate the similarities and differences between these two terms:

Effective:

productive, or capable of producing a result

Efficient:

functioning or producing effectively and with the least waste or effort

The end result of effective effort in the supply process is to continually surpass customer requirements, which when done efficiently occurs with the least possible waste and effort. This means with the least energy (since waste is simply energy that does not contribute to the result).

Some of the programmes increase effectiveness by gleaning ever more accurate and timely market information. Others are efficiency programmes, aiming to achieve the effective result with the least amount of energy expended. Most programmes have the simultaneous aim of achieving effectiveness through increased efficiency.

B.2 - MUDA

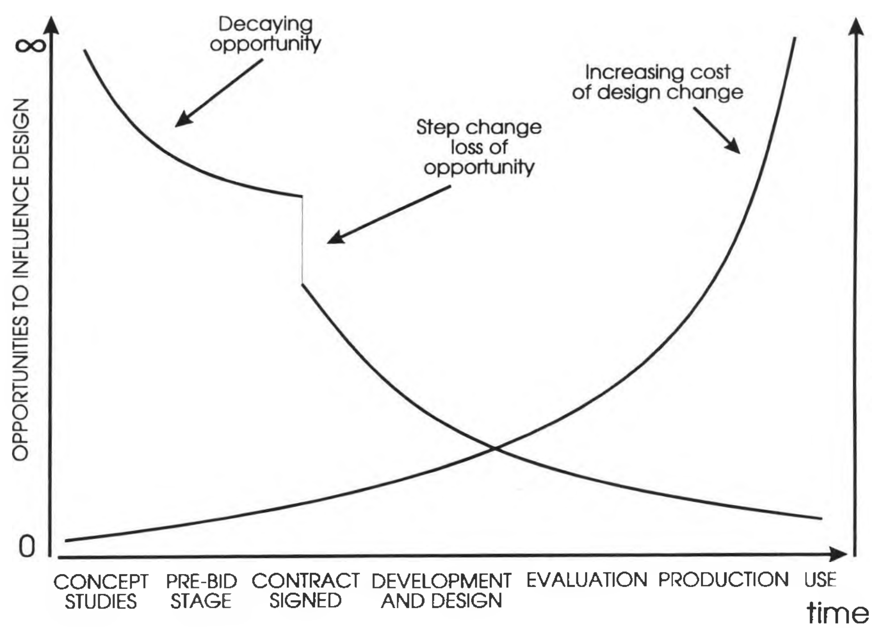
'Muda' is a Japanese term which can be translated as the elimination of waste (Imai 1986, Walker 1993). This section of chapter six looks at programmes primarily associated with the 'shop floor', but which have also begun to spill over into administrative 'white collar' areas. Three areas of waste elimination are described; design, inventory and production. Once again, here, an effort is made to show the overlap between these three areas. One of Senge's principles of "The Fifth Discipline" (1991) is that cause and effect are rarely connected in time and space. Hence, whereas muda may be initiated within the design activities of the organisation, it can have knock on effects on production, inventory and logistics. For the purposes of this chapter, at this stage, it will suffice to treat them separately; the connections between the programmes will be drawn later.

B.2.1 - Muda in Design

Once the concept of the linear, disaggregated chain as evident in Porter's work had begun to show flaws, those industrial organisations moving further towards process orientation noticed a surprising relationship between the direct cost of the design process in manufacturing and the costs it commits to the later stages of the project. This relationship is illustrated in figure 6.1 below, taken from Chelsom (1996).

FIGURE 6.1

The Opportunities and Costs of Changing Design



Although itself only costing up to some 10% of the total process cost of a project, the lion's share of the remaining costs of the project are written in by the design stage. Changes in design are significantly cheaper, easier and quicker if determined and performed at the design stage rather than once the project has progressed onto the shop floor. Several 'tools' exist for the management and performance of design that can help to ensure that design is right first time (RFT). Together with scheduling techniques, the design-related process improvement programmes to be described below correspond to the Japanese concept of jidoka, which translates as production smoothing techniques. Although performed at the design stage, these techniques aid in the smooth flow of information and value addition through the various functions and teams that together make the process, and help to prevent energy being diverted from the process in the form of waste. Jidoka is the removal of variance from both the part and the processes. Wherever possible the process should be smooth with few breaks or delays. The product produced in the process should also have as many commonalities as the conformance to customer requirements permits. In other words any variance should be customer-driven not design-built.

B.2.1.1 - Failure Mode and Effects Analysis (FMEA)

FMEA was employed by several of the target companies visited. It is a method by which various alternatives are evaluated by their possible failure modes (the ways in which something can go wrong) and the ramifications and likelihood of such failure. FMEA is performed as much for a component, sub-assembly or system (design FMEA) as for the manufacturing process the component must go through (process FMEA). Ford Motor Company defines FMEA thus:

> "In its most rigorous form, an FMEA is a summary of the engineer's thoughts as a component, system or process is developed."
>
> (Ford Internal Manual, 1988)

Another definition given below comes from one of the machine tool assemblers visited, and alludes to the advantage of using FMEA:

> "FMEA is initiated in the product and process development phases of the product development cycle. Proper application of FMEA can diminish the workload in the design or manufacturing engineering process because it is a logical and progressive potential failure analysis technique which allows the job to be performed more effectively. FMEA is one of the important and early preventative actions in design or manufacturing engineering which will prevent failures and defects from occurring and reaching the customer."

When untangled, it can be seen from this definition that FMEA is a way of increasing the efficiency of the process, whilst also making it more effective by reducing the defects that reach the customer[3].

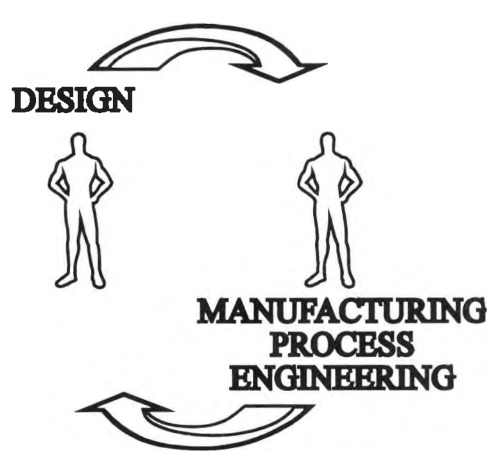
[3] The term 'customer' here not pertaining solely to the final consumer, but to any individual or group that receives information or physical product in the process.

The decision making function of FMEA is achieved through probabilities of risk of occurrence and weightings of seriousness and likelihood of detection. The combination of seriousness and risk create a ranked list for prioritising preventative actions.

The use of further statistical techniques affords FMEA its role as an early warning indicator. Once the product and process have been decided upon, the possible outcomes of an event in the manufacturing process will still have a given distribution. By pre-testing the outcomes of the process over this spread, the engineer can predict what might go wrong at various possible stages throughout it. This allows tolerances to be created beyond which the process may not deviate. Even within these tolerances, FMEA allows the engineer great insight not only into the various functions and components of a process, but also into the way in which these are interrelated, and the connectedness of the process to its component.

FMEA is, in essence, a feedback process as illustrated in figure 6.2 below.

FIGURE 6.2
FEEDBACK IN FMEA



Design engineers and production and service engineers create a process team that will sit together to decide upon the FMEA variables[4]. These are the possible outcomes, their ramifications and their risk and seriousness ratings. Although both groups will have certain limited knowledge of the workings of the other, it is only through such collaboration that the input of the most perfect knowledge can be assured. Such collaboration produces emergence from the system. In this case it manifests itself as the potential for RFT efficiency in design and the possibility for higher quality, more innovative design through the use of a wider range of perspectives.

The pooling of knowledge is not the only positive feedback effect that such meetings create. They promote early knowledge amongst production engineers of what is about to come onto the shop floor. The 'over the walls' engineering approach mentioned in earlier chapters can be avoided to a certain extent by the early inclusion of individuals who would otherwise have been brought in only when they were to commence the processing of physical product. The emergent benefits here are related to reduced lead times, and hence the reduction of process costs, as well as higher quality through fewer defects.

It is easy to see how the various stages of FMEA - consideration of alternatives, setting of tolerances - along with statistical process control techniques - tracking process actuals against designed capabilities - are comparable to the PDCA approach to the management of a system mentioned in chapter four.

B.2.1.2 - Quality Function Deployment (QFD)

QFD also has the reduction of lead times, the effectiveness of the production process and the satisfaction of customer needs as its aims. Lead times are

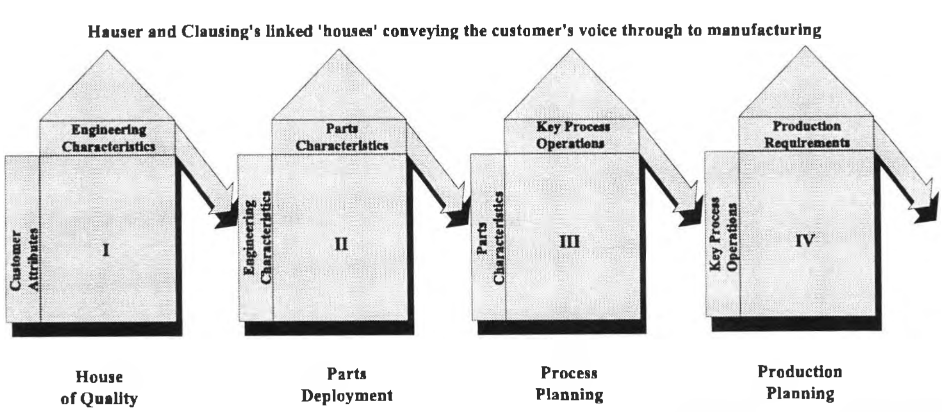
[4] These will be employees of various levels, including those who will be performing the actual production work.

reduced through the elimination of re-work, and effectiveness is ensured by building in consumer requirements from the concept stage onwards. Hauser & Clausing (1988) and Syan and Menon (1994) both describe the QFD tool. Through market research and analysis of warranty and service failures, customer requirements are gleaned, at times in the form of negative consumer experiences in the past, the connection to FMEA, or rather ineffective FMEA being evident. Also in common with FMEA, these requirements are given a seriousness rating determined by the customer's input. An effort is made to ascertain both the 'form and the function' of the problem, i.e. what the problem was, and how and why it was caused, and the range of additional customer needs and wants. Past failures may not be the sole focus of the QFD survey, rather it tries to ascertain the priorities of the customers' requirements through scaled questionnaires and consumer focus groups.

Having collated the market information, the results are fed from the marketing department back to the design activity of the organisation. Parts and processes are then designed either to correct the perceived product failure or to build in the hitherto unrecognised requirement. As in the FMEA process, QFD concentrates not only on the design of the product, but puts equal importance on the inputs into the product, and the process itself - both mechanical and human. The following diagram depicts the connectedness of product, process and system as approached by QFD (from Hauser & Clausing, 1988).

FIGURE 6.3

The Quality Function Deployment Process



(Source - Hauser and Clausing, 1988)

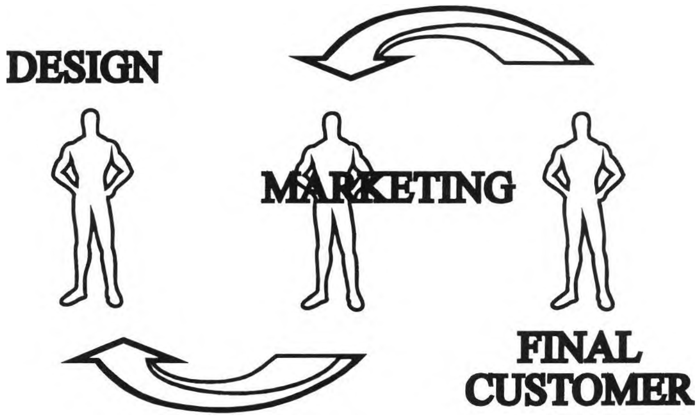
It has been described how the traditional 'over the walls' approach was caused by functional separation. One of the greatest functional distances created within the organisation was that between the marketing and design department. This is mentioned in the literature as a reason for poor competitive effort (Sciberras and Payne 1985, Parkinson 1984), a fact borne out by the field work of this current research. Designers have been criticised for wanting to create the 'best ever design' with little thought given to whether this design is what the customer wants[5]. Reference to Porter's chain model also gives evidence of this functional distance, but rather than criticising it Porter perceives this as natural and correct. The use and success of the QFD tool casts doubt on such a perception.

Once again, 'spin-off' advantages of feedback processes are created by QFD. Not only does it ensure that what is supplied and produced corresponds to, or surpasses, what the customer wants (rather than what the designer thinks all customers *should* want), but it also heightens awareness of the importance of cross-functional connectedness and interdependence amongst very different organisational activities. In terms of feedback processes, QFD can be represented by diagram figure 6.4 as illustrated below.

[5] Hence the term 'over-engineered'. Not only can QFD correct past failures, but it can also eliminate waste in the form of unwanted extras in the product. During an interview with Peter Stangl, Managing Director of Daimler-Benz Purchasing Co-ordination, the issue of over engineering was touched upon. Mercedes have realised that the inclusion of state of the art electronics in their interiors has caused greater process costs of rework than it has increased customer satisfaction. Within the machine tool sector, over engineering has been evident not only in the machines produced but also in the processes they employ - machine fault diagnostics being a prime example, often mentioned in interviews. Simplification of the work process has been the result, embodied by the Japanese concept of 'jidoka'. This will be covered again in further detail below.

FIGURE 6.4

FEEDBACK IN QFD



B.2.1.3 - Design For *XXX* (DF*X*)

DFX is related to FMEA and QFD. It stands for ‘design for any activity’ and is the umbrella term that has been coined for ‘design for assembly’, ‘design for manufacture’, ‘design for recycling’, etc. Once again, DFX has at its core the realisation that design activities have far greater process costs and quality and market ramifications than those at first apparent. FMEA and QFD are attempts to achieve efficiency and effectiveness in both product and process. DFX activities are mainly attempts to optimise the process, but often with the issue of human input in mind.

Design for manufacture (DFM), for example, is the attempt at the design stage to ensure that the manufacturing process designed for a product is simple. As will be described below, much of the success of the Japanese production philosophy has come from simplification. Many production and manufacturing processes in Western industry have been found to be excessively complex. DFM, when performed well, sees the creation of a manufacturing process that is not only easy and simple in its functions, but that is also easy for the production operative to perform. The benefit is the elimination of rework through mistakes caused by complex tasks, and the acceleration of the process through such simplification.

B.2.1.4 - Modularisation, Commonisation and Standardisation

These three terms embody some of the aims of DFX programmes. They are activities which all make production, recycling and assembly easier through the elimination of variance across projects.

During visits to machine tool builders, modularisation was observed as the breaking down of machines into sub-assemblies or modules. These might be the drive, the saddles, the controller, parts of the hydraulics etc. Having broken the machine down into these constituent parts, which can be sourced as subassemblies from suppliers, the machine tool assembler attempts to use the same modules across different jobs and contracts. Designing with such modules has several advantages. The first of these is consistency in assembly which assists the task of the production engineer. The second is the ability to make long term contracts with suppliers rather than constant supplier switching or changing of specification and tolerances. After-sales support can also be simplified.

Commonisation and standardisation are similar in nature to modularisation, but are not aimed necessarily at sub-assembly ‘modules’. Commonisation is again the idea that certain parts need not be different from one machine to another. The assembly process is aided by consistency, supply is also assisted and buying economies can be achieved. Through standardisation the drive for simplicity is achieved. One of the machine tool builders visited had attempted to make the most simple form of a given process its standard and had then begun to simplify all other related processes to match the simplicity of the benchmark. Substantial quality and cost benefits were expected.

B.2.1.5 - Design for (Total Productive) Maintenance

Often called just 'total productive maintenance' (TPM), this process can be aimed at the wider process rather than simply internal ones. However, as will later be seen, this research attempts to break down the walls perceived to exist between 'parts' of the process, and TPM is a good example of this, and as such has been given a separate section rather than inserting it into the DFX section above. TPM, as observed in the field work, is a set of procedures written by the machine builder's design and production engineers as a guide for the *customer's* production engineers as to how the machine or process is best kept in a condition that will prevent it from going wrong (see section B.2.2.2 on cellular organisation below), or what to do when things do go wrong. Since the supplier's engineers should have designed and built the machine they will be the best source of this information, rather than leaving the customer's engineers to search for faults themselves[6]. In this sense TPM is an extended form of FMEA involving inter-organisational feedback rather than internal feedback flows.

B.2.1.6 - DFX Feedback

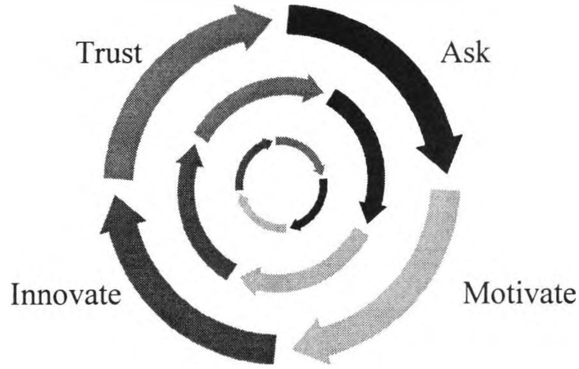
In terms of feedback, DFX programmes are a mixture of the feedback diagrams for QFD and FMEA. DFX can be seen as a subset of QFD, being the design effort that follows the input of internal and external customer informaiton. As was mentioned earlier, however, in the form found in the field work of this research, DFX is also related to human issues. It was found that by asking the operatives what they found difficult or time consuming in the process, certain advantages (again the result of feedback) were attainable. The first of these is the process improvement described above. The second is

[6]One customer organisation was visited where TPM had not been pursued, and where, as a result, several engineers had to be employed full time to ascertain how one particular machine functioned, and how it was to be maintained.

motivation. This issue will be covered again below, but in relation to DFX it was seen that employees are motivated by the feeling that their opinions are not only sought but are given serious thought and are, furthermore, used to positive effect. In chapter four the Cartesian view of separation of self from environment was discussed, and linked to the erroneous separation of innovation from the work-force. Process improvement programmes like DFX have shown that there is a link between the worker and innovation, and that the link is a mixture of trust and motivation, as shown in figure 6.5.

FIGURE 6.5

The Cycle of Trust, Ask, Motivate and Innovate



Where the individual is trusted by management, an environment of true empowerment can be cultivated. In such an environment, the individual is encouraged constantly to question the rationale behind routine work practices and processes. The authority to change this routine that goes hand in hand with empowerment increases the motivation of the individual to suggest ways to improve upon the status quo. Such suggestions, in turn, serve only to increase the base of trust that exists between the individual and management. Once this spiral has been established on an individual basis, it can be extended to groups and whole organisations - indeed whole systems.

B.2.2 - Muda in Production

The process improvement programmes described in the previous sector concentrated on the wider process effects of the design activity, but were seen to impact upon marketing, HR, and production policies. The following discussion focuses upon the elimination of waste from the production area, the shop floor, but similar feedback spin-off effects will be seen.

B.2.2.1 - Recycling

A policy that was standard practice amongst several bespoke machine tool builders visited was the disposal of much of the tooling, parts, fixtures and fittings that had been used to build a particular machine, or set of machines in a transfer line. One reason for much of this was the rigid specification given to builders from their customers precluding the reuse of certain parts across customers. More likely, it arose from the 'fat years' of machine tool and automotive production in the West when the ability to employ 'cost-plus' pricing meant that leanness and recycling were less of an issue than they are today.

Current conditions have put an end to this, as described in detail in earlier chapters as well as in the above introduction to chapters six and seven. One of the machine tool builders visited had found that by sorting through the left-over stock of a contract roughly one third could be either recycled[7] or reused in further jobs.

It would not be possible to put a figure on the savings achieved through this realisation, since it would change with every job. It is significant enough that the company had become aware of the need to reduce wastage and increase the process efficiency. In fact, the production management had never thought of the connection of what they threw away to the costs of inventory, work in progress and the costs of running the total business as a whole.

[7] All waste had always been sorted by material, and where possible was disposed of in a fashion allowing it to be properly recycled. The use of the term 'recycled' here means *sold on* for recycling, or re-used internally, i.e. not simply disposed of as waste.

B.2.2.2 - Cellular Organisation

In chapter two some of the results from a survey conducted by Ingersoll Engineers were presented. Ingersoll is a consultancy that arose out of the machine tool industry, and now specialises in the area of cellular manufacture (CM), a form of operations layout and management. Almost all of the machine tool builders visited had adopted the basics of CM and some had gone further to organise their whole factories according to CM or transfer line technology[8]. Since a total adoption of CM was rare, and is not appropriate for all machine tool builders, this section will discuss the benefits of 'cellular organisation' (CO), by which is meant the adoption of looser forms of group technology than complete CM.

As was the case for DFX described above, CO sees the marriage of worker to machine, and worker to process innovation. Empowering, i.e. assigning full responsibility and authority for the input, output and functioning of the cell to the employee, has proven to be motivational and helps to maintain the quality of the cell's output. This occurs not through the fear that because responsibility is easily traced any mistakes will be punished, but because mistakes can be learnt from. Where management still bases its policies on fear, CM will tend to be less effective than in what Cole & Mogab (1995) call the 'continuous improvement firm' where mistakes are a source of innovation. Empowerment is covered in section B.2.5.3 below.

HR related issues are only one benefit from CO, as experienced by the machine tool firms visited. Another important benefit was speed of throughput. This cannot, however, be wholly separated from the HR issue, as will be seen. Because one cell is responsible for more than one engineering function there is less distance for the product to travel in comparison to the traditional shop

[8]The extent to which CM can be used as opposed to transfer line technology will depend upon batch sizes, complexity and speed of production.

floor layout which is functionally arranged[9]. The distance travelled by physical product is also reduced through the elimination of stage by stage inspection stations. This is made possible by the empowerment mentioned earlier. The employee in charge of the cell 'owns' its problems and is responsible for the outward quality of it. Rather than sending the product to inspection for testing, the employee does it within the cell. Better still, through concentration on the process and on the quality of inbound materials, quality should be ensured from the outset. This not being the case, the clear lines of responsibility allowed through CO enable the causes of poor quality to be traced[10].

The empowerment which removes the need for testing, and thus saving time and cost has another spin-off benefit. During down time the cell's employee is encouraged to perform preventative maintenance on the machine. This is not unique to CO, but was observed to be an important contributory factor in the success of CO. Preventative maintenance means that the employee can use down time, scheduled or otherwise, to check over the process machines and keep them in good condition. Traditionally machines would have been maintained by a separate functional department that would only have been called in once problems had occurred. Preventative maintenance had gained great acceptance amongst several machine tool builders visited in the study, and the ability to perform it well is an important criterion for the customer when choosing its supplier, as will be seen in chapter seven.

CO reflects the feedback-cycle shown above in figure 6.5. Further issues are affected however, including a reduction in inventory and testing, and the reduced distance travelled by work in progress within the factory[11].

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[9] For examples of these forms of shop floor layout c.f. Bennet et al. (1988).
[10] Hayes et al describe the benefits of CO as the removal of check and test stations as well as the removal of the bottle necks and inventory that will inevitably occur through the distances travelled by work in process and the variance in capacity of disconnected stages of the process in the functionally organised factory (1988, p. 198).
[11] Reducing the distance travelled by WIP was seen to have different advantages in different organisations. Some viewed the benefits as being related to the time involved, others the rationalisation of the work flow and the removal of intermediate shelving and testing. Some even found significant improvements through being able to keep a better track of WIP - long distances had meant that parts often went missing.

B.2.2.3 - Auto*no*mation

The term 'auto*no*mation' has been taken from Imai (1986) where it is used to describe the Japanese word 'heijunka'. Heijunka has two sides. The first of these is automate only where needed. Automation should assist the human elements of a system and only perform those tasks too dangerous, or strenuous for humans or where the tolerances can only be achieved by computer controlled accuracy[12]. The human elements are far more important, since it is from these that emergent learning can occur, rather than the machines (even where mechanical experience leads to improvement, it is usually down to the human worker to translate the experience into improvements). The second side of autonomation is the built-in fail safe feature of the manufacturing process whereby a) each worker has the ability to stop the line should difficulties arise[13] and b) certain processes can only be performed if the component or sub-assembly is introduced at the correct time, place and angle[14].

Auto*no*mation is more evident within the automotive assembler customer of the machine tool builder due to their high volume and repeatability than in the machine tool builder. Nevertheless, certain aspects of it have been adopted by the machine tool assembler, especially the 'poka yoke'. For example, drilling machines used on the shop floor have a form of poka yoke whereby any variance in the tension or speed of the drill causes the tool to be retracted. Such variance could be the result of a bit breaking, blunting or overheating - all causing low quality work.

[12] This approach was seen in action at the Nissan Motor Manufacturing (UK) Ltd plant in Washington, Sunderland.

[13] An example here from the Toyota production system is the 'andon' cord. This is quite simply a rope that runs along the length of the production line. When a problem arises the line operative pulls the cord once to alert the group leader of the problem. Only once the operative, and possibly the group leader is sure the difficulty has been overcome, and is safe to pass on to the next operative, is the cord pulled a second time. Should the cord not be pulled the second time within the given time allowed for the task concerned the line automatically stops.

[14] This is usually achieved by using 'poka yoke' - small distinctive shapes used to prevent parts being inserted incorrectly into a machine or process.

Not only do the machine tool builders use the heijunka principles themselves in an attempt to reduce wastage, but they also design such auto*no*mative tools and stops into their machines so that their customers' process efficiency can be increased. Before the interdependency of both customer and supplier became known, as in the case of TPM, the supplier would have paid little attention to the process efficiency of its customer.

B.2.2.4 - 'Housework'

Perhaps the least likely subheading in this thesis, the issue of housework in the production area has proved to be of great importance. Once again, the stimulus for focusing on housework comes from the Japanese, where the concept is called seiso, one of the '7 S's and 3 M's' which lie at the core of the Japanese Kaizen manufacturing philosophy (Walker, 1993, Imai, 1986).

The meaning of the term housework in this context is the maintenance of the area of the shop floor occupied by an employee, team, cell etc. In common with the tendency of 'ownership' of cells, machines or projects, for example, the employee is encouraged to 'own' the space in which work is performed. The idea here being that through a sense of pride in the workplace the employee will tend to keep it clean, orderly and respectable. Orderliness, or 'a place for everything and everything in its place', along with tidiness, are aids to the worker - it is not simply a question of aesthetic effect[15]. Knowing where things belong, and replacing them means that time does not have to be spent looking for items when they are next required. Furthermore, accidents can be caused by low attention to housework of this sort.

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[15]Increasingly, manufacturing organisations are, however, analysing the importance of the aesthetics of the workplace, modern factories have employed drastic noise reduction techniques to help employees, and colour, sound and general ambience are also being explored.

Personal appearance and attitude at the workplace have also been addressed. Several of the organisations visited had attempted to change from the traditional image of the production worker - dirty, cigarette in mouth, stops to read the newspaper at regular intervals when the supervisor is not around - to a far more professional one. Again this is concurrent with the Japanese philosophy whereby respect and pride for one's work and those around in wider society can only begin with personal respect and attention to personal cleanliness and appearance.

Although an entirely HR-related issue, the issue of housework has led to benefits of increased efficiency on the shop floor. These benefits are motivation and morale as well as quality-related issues of fewer mistakes, less wastage of inventory and faster throughputs.

B.2.3 - Muda in Inventory

The above programmes associated with design and production have not been performed in isolation; they have impacted on HR and inventory, amongst other things. Certain programmes have, however, been directed primarily at inventory which have themselves, in turn, had further feedback ramifications on production and efficiency.

B.2.3.1 - Re-order Point Policy (ROP)

This programme had only been initiated by one of the machine tool builders visited, but was used by most of their customer organisations to positive effect as well. ROP concerns the re-ordering of component parts used during machine assembly; who orders them and where they come from.

An MSc project had highlighted that stock turns[16] were too low, and the associated costs of inventory at the firm in question, were too high - especially in comparison with Japanese competition and even with US sister factories. A pareto analysis was performed on the stock and, as is usual for manufacturing organisations, an 80:20 relationship was discovered[17]. This means that approximately 80% of the order volume constituted only 20% of the total procurement bill.

This relationship has increasingly led managers to realise that various types of 'supply' exist. Not only does procurement vary by lead time, geography and quality, but the criticality and risk associated with the bought-in part along with its relative cost also play a role. Hence procurement portfolios can be drawn up which connect certain types of procurement to certain types of management. Appendix A6.1 contains two such portfolios.

For the machine tool builder, the 80:20 relationship meant that responsibility for ordering 80% of the bought-in components could be devolved to the production employees themselves using a kanban system[18]. When stocks became low within the production cell, the employee sent a kanban to the stores from where replacements would come. When stocks in the stores were low they would be re-ordered directly by stores. Within this particular organisation this was done on an almost just-in-time (JIT) basis.

By so doing the purchasing department was freed from having to deal with low value, low risk items, and could concentrate on the other end of the portfolio's spectrum. This meant that the cost of processing an order transaction fell due to fewer departments being involved. Inventory costs also fell as the

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[16] 'Stock turns' being the number of times per year(usually) that the entire stock of the organisation has to be re-ordered. A stock turn of one would mean that enough stock had been purchased for the whole year's business, a figure of four would mean that only enough stock was procured for a quarter.

[17] This relationship is discussed in Clewer and Totzauer, 1993 and Chelsom, 1996.

[18] The kanban system of reordering, relying on the passage of tickets in opposition to the flow of goods, is described in Chelsom, 1996.

organisation moved towards JIT, and efficiency increased due to the necessity of RFT supply.

ROP is another example of the devolvement of authority and responsibility that was seen in the section on cellular organisation (B.2.2.2). Not only are there implications for inventory and procurement, but the empowerment and trust which are prerequisites to ROP are both highly motivational and allow opportunities for learning. In fact the ROP programme was key to the success of the CO programme mentioned above. In another of the organisations visited the stores were kept locked and employees not allowed in. Internal orders for components had to be signed off by supervisors and inbound logistics were not nearly JIT[19]. Apart from the increased costs of inventory and order processing, this policy created a power and culture distance between different groups of employees that channelled the productive, innovative potential of the worker into cross-functional tension[20].

B.2.3.2 - Supplier Relations

Since chapter six is entitled internal process improvement, a section on supplier relations would seem out of place here. However, in achieving process efficiency in inventory, the supplier organisations to machine tool builders play a vital role. The interface management of chapter seven will be seen to deal more with the treatment of the machine tool builder by its customer.

[19]In fact, the whole issue of inbound muda had not been addressed in this firm. Wide ranging efficiency improvements in production were therefore offset by poor inbound quality and, astonishingly, by delivered goods going missing on the shop floor.

[20] This point is described by Senge in a discussion of creative tension and emotional tension. The former will tend to result in innovative effort or creative, positive conflict, the latter in destructive, negative conflict. Establishing an environment of creative tension requires not only an environment of shared values and common mental models, but also of motivation and guidance to encourage emergence from the system (Senge, 1991).

The traditional view of business as a set of discrete functions sees inventory as a simple stock of product waiting to be processed - a store unrelated to the process. There are, however, costs of holding inventory which the whole business process must bear, and poor quality in inventory incurs further process costs in the form of re-work (see section B.6.2).

Many of the machine tool builders - but not all - had begun to involve their own suppliers in what has become known as concurrent engineering - the earlier than usual inclusion of all elements of the system, including suppliers in the development process (as described in chapter two). By this the supplier has input into the design and development of products and processes to be used by the machine tool assembler. This reduces the scope for poor in-bound quality due to imperfect knowledge. At the same time some machine tool builders are working to reduce the number of suppliers they work with to increase supply consistency which again, in turn, reduces the scope for mistakes and poor in-bound quality. In fact a reduction in the supply base volume is generally a prerequisite of CE due to the unnecessarily large size of traditional supply bases. One supplier had begun a strategy that would see the number of its raw material and component suppliers cut by over 50%.

By ensuring quality and integrity of in-bound supply (right first time, RFT) the amount of inventory held can be reduced. Often inventory is held in the form of buffer stock to reduce the risk of stock out due to the discovery of an unusable batch (Chelsom 1996). By removing the risk of poor stock quality no buffer stock need be held. The reduction of inventory that is facilitated by ensuring RFT supply is a spin-off feedback effect of high quality. As Cole & Mogab (1995) discuss, reduction in inventory (i.e. increasing the efficiency of the process logistics) can only occur once the issue of supplier quality has been addressed. During the field research of the current research, some machine tool builders had attempted to reduce inventory, but were still pursuing short-termist supply management based on conflict and competitive bidding - these are not consistent with the creation of quality suppliers and supply. Without attention to the supplier, internal logistic efficiency cannot be attained. Such observations are key to the modelling of the supply system in chapter eight which is the culmination of this research.

Outsourcing, the procurement of components, machinery or labour from outside the organisation rather than finding it within, has also drastically increased over the last decade. This point will be discussed in greater detail in chapter seven, but warrants mention here too. Many of the machine tool builders visited had begun to use outside contractors for, for example, the electronics of the machines, or for the hydraulics, in addition to a core of 'resident' employees. This meant that in times of slow business, the contractors would be lost rather than the directly employed labour.

Outsourcing has allowed a concentration on the core competencies of the organisation. No longer does the firm make all the components of the machine. In general the core competence of the machine tool builder is the design and assembly of the machine as a part of an integrated system. Alternatively, some design, co-ordinate, construct and install whole turnkey systems. The production of components should be left to the supplier whose real business it is.

The issues of CE and inventory, as well as the whole area of supplier relations will be dealt with in greater detail in the next chapter. At this point in the discussion it suffices to say that the machine tool sector itself is engaged in new forms of supplier management, whilst they themselves are also subject to a similar change in approach from their customers.

B.3 - Financial Management

The discussion of Muda in the preceding section was an aggregation of diverse programmes seen across the whole range of machine tool companies visited, along with some experience from their customers. This particular section, however, concentrates upon one particular organisation engaged in the supply of aerospace components and bespoke machine tools to the automotive industry[21].

The company concerned had been successful in both lines of its business, and had been in family ownership and management since its beginnings. Despite the success of the company, steady order books were not matched by steady earnings. As the financial performance of the company worsened, the departure of certain family members created the need for management and directors to be brought in from outside of the organisation (internal promotion was not deemed appropriate to board level). Graphical representation of some of the company's accounting ratios are given for the period in question in appendix A6.2.

The most significant of these appointments was a part-time non-executive director of finance from a London-based accountancy firm in 1988. Until this appointment no formally qualified accountant had been employed in the organisation, and financial management had been little more than bookkeeping. The issue of the efficiency of assets and investment had therefore received little prior attention. Changing this situation was to prove vital for the company.

[21] The organisation in question lent itself well to a case study on the importance of financial management because of the circumstances it found itself in. This is not to say that other issues were not of importance to the firm, as will be outlined below. Furthermore, financial management and planning was concentrated upon, and had been for some time, as a matter of course in all of the other machine tool builders visited. This company was picked for particular mention because the interview occurred soon after financial management had been successfully introduced.

That the company's turnover was healthy and steadily increasing is evident in A6.2(a). A6.2(b) shows, however, that the steadiness of turnover is associated with highly erratic earnings figures. The low correlation of profit to turnover is shown by A6.2(c). From this graph it can be seen that from 1989 onwards the ratio of earnings to profit improved - a fact which the managing director attributed to the appointment of the financial director in the previous year, and more efficient utilisation of assets that ensued. Finance was being managed in a way hitherto unthought of. Appendices A6.2(d) & (e) show this. An initial concentration and improvement in fixed assets was followed by an improvement in total asset utilisation into the 1990s.

By analysing the utilisation of assets the cash tied up in unused assets could be invested in technology or people[22]. These unused, inefficient assets included property that the company no longer used, but had retained. Buildings were rented to other firms, or sold, and greater use was made of the space available. Funds released from assets were invested in CAD/CAM facilities. In the opinion of the managing director the effect of the initial financial fillip was far greater than this. The total benefit was a heightened awareness of the connection of the finances of the organisation to the business process. Finance had been seen as a constraint rather than a tool that could be manipulated within limits to the advantage of the organisation.

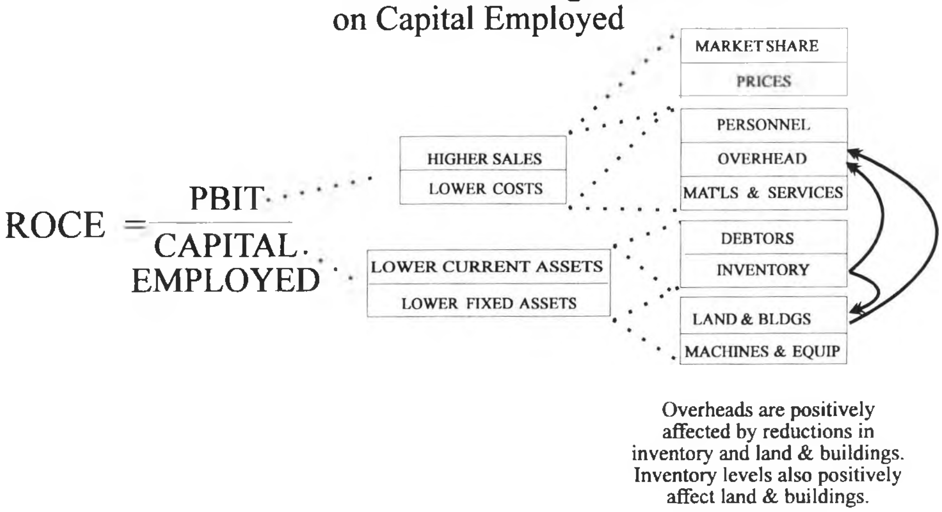
At the time of the interview the company was still in a learning phase. The MD regarded the period as one of total reengineering, not simply of business processes, but more importantly of the attitude of the company's management to financial structure and the success of the business. Evidence of this was the investment in CAD/CAM facilities following the asset rationalisation. The approach that would have hitherto been adopted would have involved this money being filtered off to the owners.

[22] In this sense, the attempt to improve the finances of the company could be viewed as 'muda in finance', since the initiative was intended to eliminate wasted investment.

Figure 6.6 below shows the relationship between the funds tied up in assets and the financial performance of an organisation[23].

FIGURE 6.6

The Effects of Materials Management on Return on Capital Employed



The illustration shows how attention to sales and process costs are only one way of improving the financial performance of the organisation. Although these are, in the long run, most vital for the survival of the organisation, attention to fixed assets can have the same effect. The diagram shows the knock-on feedback that reducing one variable can have upon others. Perhaps more importantly, it is also shown how any increases in the sales or costs side of the equation can be offset by the negative, balancing effect of inefficient use of assets. It was this that had weighed down the particular machine tool builder in question.

Most of the assets which had been rationalised are classified in the lower double block of the right-hand column in the figure - i.e. land and buildings/plant and machinery. During the interview a tour of the shop floor highlighted the need for attention to be paid to inventory and work in progress. The above section on efficiency in inventory (B.2.3) introduced the potential

[23] This diagram taken from Chelsom, 1996.

for efficiency improvement through reducing the amount of work in progress held on the shop floor and the raising the stock turnover rate.

At the time of the interview there were components in process on the shop floor worth in excess of £10,000 which would not be bought by the customer for at least 2 years, but whose processing had already begun. The lead time for completion was well below twenty four months. Here was another source of inefficiency that had not been addressed, but which through the new attitude to company finances was slowly being realised.

Once again, the connection between certain variables in the process - as in the inventory-production example mentioned in the above footnote - had not been fully understood.

B.4 - Information Management and Exchange

The functional, disaggregated view of business, managed by strict functional budgets led to 'walls' being erected between functions. The resulting 'over the walls' engineering has been described in both chapters five and two above. These walls presented barriers to both the passage of physical product and, more importantly, to information exchange. Impeding the flow of information meant imperfect knowledge within the functions of what other functions were doing or planning. Process improvement programmes like those described above involve a greater degree of information flow and sharing, which, when managed well, results in fewer mistakes, shortened lead times, improved quality and lower costs and, possibly, in innovation.

This section will describe how the machine tool builders visited were increasing the potential for information flow through the organisation.

B.4.1 - Information Technology

Almost all of the organisations visited had highly sophisticated CAD/CAM systems, or were in the process of installing them. The power of this software is the ability to transfer commands directly to the controllers of machine tools, cells or transfer lines. However, the software and technology used to transfer information through the human controllers of the organisation - the employees - was seldom as sophisticated. The applications of IT below do, however, show how the machine tool sector has begun to exploit the power of IT to its advantage.

All companies had management information systems (MIS) which managed the creation of the bill of materials (BOM)[24] and the ensuing procurement and accounting. Some had tied this in with scheduling packages to ensure that not only did the BOM drive the procurement and accounting activities, but that delivery could be achieved on time rather than ad hoc, as had often been the case before.

Several interviewees outlined moves to increase the utility of MIS by exploiting its reporting functions. Many systems were able to generate reports of performance, but the employees had been unable to exploit this due to poor training or the inability to understand the content of the report produced. Training, aimed at correcting this failing, was seen to be underway. Examples of the use of such reports include the ability to track desired delivery deadlines to actual delivery dates or matching billing dates to payment. Both of these variables had received little attention prior to the introduction of MIS due to the time consuming nature of information collation and comparison. The ability to have data collated automatically by the MIS was proving to greatly aid other process improvement programmes[25].

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[24] 'Bill of materials' - essentially a list of the 'ingredients' from which a machine is built, showing quantities and relations to other parts.

[25] The measurements described in section B.2.6.2. of contract administration are examples of how MIS can generate important information.

Another use of the MIS was seen in one particular machine tool builder that used it to trace employee improvement or corrective action suggestions. The traditional approach to management in the West, as described in chapter four, was to view employees as machines under management control, rather than as a source of innovation and improvement. Contrary to this approach, this particular firm had built an employee suggestion scheme into the processes of its administration. Since it is the employee that has 'hands-on' experience of the operations of the company and the realisation of design, it is there that improvement can come from.

A 'corrective action report' (CAR) was available to every employee. At the end of every working day these would be input into the MIS with a note of the source of the CAR and the target of it. The MIS would only erase the CAR once three individuals had signed it off - the source employee, the target employee and the relevant supervisor or project manager. In this way, the source employee was assured that action had been taken. The role of the MIS was to ensure that this action did occur. CARs did not simply sit in the system. The Board of the firm received a fortnightly report of CARs that had not been signed off. Target employees were required to explain and justify the delay. In this way the employee plays an important role in the quality plan of the organisation (see appendix A6.3).

Difficulties caused by geographic distance were also overcome by MIS. Many machine tool builders have more than one facility, and to survive in the global market place many are realising the need for international representation. Only one of those organisations visited was not internationally located. Such geographic dispersal presents barriers to information exchange not only through distance, but also through language.

Local area networks were used to link up the individuals of the company in the above BOM applications of the MIS. Investment in wider area networks was increasing amongst the target companies. Some even had dedicated transatlantic EDI[26] connections which had also been extended to continental Europe. In this way, designers, production engineers, buyers, management - indeed all elements of the organisation were able to pool information without having to rely on post or expensive, inflexible fax transmissions.

One of the organisations visited had augmented this by producing a dual-language system[27]. Employees in Germany were thus able to work simultaneously in the system with UK or US employees, the Germans using commands or standard text blocks in German, the UK and US employees working in English. The benefits of this not only being the ability to pool greater amounts of information but furthermore the removal of frustration and errors caused by translation difficulties.

EDI has begun to play an even greater role in the interface management that will be the subject of the next chapter. Geographic and linguistic differences do not only manifest themselves within organisations, but between them too. Increasingly customer organisations are encouraging their suppliers to invest in EDI systems compatible with their own so that information may be transferred between engineers of both the customer and supplier. Although rare within the target organisations interviewed, the two organisations with this capability talked of increased speed and efficiency in the concurrent engineering environment that relies on timely, accurate and freely flowing information exchange[28].

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[26] 'EDI' - Electronic Data Exchange, sometimes called CDX, or Computerised Data Exchange.

[27] This dual system was devised, installed and taught by the author of this research and the contract administration manager of the company in 1993.

[28] It must be stressed that acquisition of EDI, sophisticated MIS or other IT applications will by no means ensure the efficient or effective generation, use and transfer of information. The human input and interaction with IT still has more significance than the IT itself. Where the employees are not trained to use IT properly as a tool, but rather let themselves be run by it, the emergence from CE will be inhibited. *"Open minds are more important than open Systems"*

B.4.2 - Quality Plans and Procedures

The increased awareness of the business-process-oriented organisation has had the knock on effect of increasing the awareness of the complex system of internal customer-supplier relationships as described in chapter five. The 'andon' system discussed in section B.2.2.3 above is an example of this, where no Toyota 'member' (internal or external supplier) passes on work that is known to be of low quality to the next member (customer).

Within the administrative sides of the organisation the internal customer-supplier relationship also exists, but due to offices being dispersed and the flow between the two parties being paper work, it has often proved difficult to explain successfully the message of the relationship.

Four of the target organisations had, however, initiated programmes to address this issue. Some had attended courses run by external consultancies specialising in quality, others had employed quality experts to champion the programmes internally. All were characterised by the need to increase awareness of the internal activities of one function amongst those engaged in others - with a concentration on how work flowed through each function into, and out of, others. It was necessary to portray the workings of the employee - exactly what they themselves did, what they required from their internal suppliers and what they thought they should pass on to their internal customers.

The approaches to these programmes were diverse. Some involved all employees on monthly 'quality days', where presentations were made by certain individual functions to the others. Other firms relied on smaller, informal, cross-functional work groups to sit and discuss what their needs and outputs were. All had a 'quality-map' that formalised the procedures of normal work and corrective action, an example of which was already introduced in an appendix to chapter four (A4.2).

Both approaches had varying degrees of success. Two of the organisations involved in formal quality initiatives were experiencing difficulties due to lack of top-level involvement. Lack of director-level commitment is often stated as a reason for the failure of quality programmes, but the organisations visited went further to state that although the commitment was there, the directors and senior managers had not the time to devote to what they saw as mainly a middle management responsibility (they themselves already assuming their input to be widely known and of high quality). Involvement and participation are more important than simple commitment.

In the remaining two, director-level input into quality meetings and programmes was direct and frequent. The employees of the organisation drew motivation from the example set by their seniors, and from their openness. Where this was not the case, one firm was trying to introduce quality plans for the third time, and was experiencing low morale amongst the work force. Workers were sceptical firstly because they had seen it before and secondly because they lost faith in a management that needed to rely on what the workers regarded as aphorism.

Where the quality message had got through, the same benefits were being felt on the 'white collar' side as on the shop floor. Even in the two organisations described above where difficulties were experienced, advantages were being felt from the sharing of experience and the removal of interfunctional barriers.

B.4.3 - Internal Concurrent Engineering

The term 'internal' before 'concurrent engineering' would seem something of a contradiction, CE being the cross-functional *and* inter-organisational pooling of information and experience to develop and design processes and products.

Nevertheless, the change from functional orientation towards process orientation involves such a radical change in attitude that many organisations have tackled the internal issues of team building before looking outside the firm. The target companies visited were typical examples of this. Furthermore, inter-organisational CE requires substantial investment of time and money to establish exactly who the supplier partner/s are to be. The machine tool organisation in the West is still adjusting to being on the receiving end of this process as its customers acquaint themselves with CE. It was the opinion of the managers interviewed that once their customers had settled into the CE environment and once internal teams had been successfully built, and minds changed, that then and only then would it be appropriate to start the next stage of looking at the suppliers to the machine tool builder itself. Nevertheless, one of the firms visited had already made tentative steps towards supply base reduction and the simultaneous development of future plans. Although still in this infant stage, there is certainly much evidence of moves towards CE within the machine tool sector. The most evident of these is cross-functional team building.

Within the organisations visited all were increasingly adopting team-oriented approaches to problem solving in design and production issues. Almost all had also realised the advantage of adopting such an approach during the development stages of projects. With the relationship of direct costs to 'written-in' costs at the design stage as shown in figure 6.1 in mind, such collaborative development proves more efficient than isolated development followed only then by collaborative correction techniques.

Often names have been given to the teams in order to make them sound attractive to the participants. Hence some used the term 'wolf-packs' to describe the process teams involved in the design, development and production of machines. Each wolf-pack contains engineers from various engineering disciplines, and will also draw upon employees from finance and purchasing as and when needed. In essence the 'wolf-pack' approach was shop floor based.

Another had 'WAR' meetings, this mnemonic translating to 'weekly action report'. Rather than a collaborative attempt at development, the WAR meetings involved representatives from all functions of the organisation, not just the shop floor and design. Any issues relating to a number of projects were raised and any difficulties addressed in a consensual way. WAR meetings tended to be more formal than the 'wolf-pack', necessitating scheduled meeting times due to the diverse participants.

Where WAR meetings were the approach adopted to middle management tracking, and wolf-packs used to enhance shop-floor quality, teams were also used in the development of projects. Given the less attractive title of 'line-ups', these teams would consist of design and production engineers, as in the wolf-pack approach, but would address design issues. Line-ups tended to be the next step on from FMEA. Once the possibilities had been ranked and decided upon in detail, the line-up would begin to discuss the wider systems engineering issues of the interaction of the mechanical, tooling, hydraulic, electronic and materials handling elements of the machine or system. The focus here would be to match and improve upon any ideas or guidelines obtained from the customer organisation[29].

Despite the obvious commitment towards team oriented business, all target firms spoke of the persistence of particular individuals who preferred to work to their own agenda. This continued to present barriers to process improvements, since regardless of the abilities of these individuals the islands of knowledge they possessed were either of little use to the wider process, or would even prove damaging to it. Whereas some of the companies regarded this as a matter for continued training and encouragement, others were more

[29] Increasingly the rigid master specifications that were characteristic in the supply of machinery are loosening. The supplier tends to be given a functional requirement along with a target cost and guidelines as to size, position, volumes, schedules etc. From this the supplier will develop the 'form' of the machine to match the function with little interference from the customer.

fatalistic in their approach. The latter organisations were of the opinion that the remaining 'old school' were unlikely to change, and true, team based work would only occur as natural wastage removed the 'dead wood'.

B.4.4 - Portfolio Management

The programmes and behaviour described above tend to involve the closer collaboration of functional groups within and across the organisation. However, as was stated above, all but one of the firms visited have more than one location, many have international facilities. Even the one firm with no other facilities had two complementary businesses running under the same name.

From the research conducted in this current study it seems hard to imagine a machine tool builder that can compete successfully by having facilities in only one country - even if they do have international marketing capability. Indeed, the global nature of the organisation is one of the supplier selection criteria used by customers to be discussed in the next chapter. The machine tool business requires the management of portfolios - both geographically and of products.

The need for geographic portfolios is connected to the increased globality of the customer organisation coupled with the realisation that 'acting locally' for certain types of supply outweighs the benefits of global sourcing. It can furthermore offset the cyclical nature of the industrial world's economies.

Offsetting such cyclicality can also be one of the benefits of diversifying the product range. This was the case for many of the target firms. As well as machine tool assembly, one firm was engaged in the manufacture of aerospace components (partly with its own machines), another makes pressings and stampings for the automotive industry. This latter organisation described the pressings side of the business as what paid for working capital, any machine tool business was therefore where profits and earnings came from. Although something of an exaggeration, this is generally the trend many managers spoke of.

As well as the benefits felt through levelling cyclical tendencies, another major benefit from diversity is again that of the pooling of knowledge. Foreign locations, for example, have been beneficial to the organisation due to their acquaintance with foreign business cultures.

Perhaps more importantly, advantages have arisen from product diversification. The knowledge and experience gained in the press shop has, for one machine tool builder, led to improvements in the machines they build for the welding and handling of pressings and panels within the customer's facility. In other words, a whole system of panels and machines can be obtained which are completely compatible.

A similar situation was seen in another organisation building both machine tool transfer lines and 'body-in-white' assembly machines. Much of the knowledge gained from the former activity, the traditional one for that firm, had helped to build up the body-in-white side to an equally successful side of the business.

The feedback here is self-evident, and can only flow where there is freedom to exchange ideas and a team-based approach to business. Rather than the removal of waste which has been the focus of the programmes discussed above, efforts to improve the flow of information within the organisation have, in Systems terms, been attempts to promote emergence from the development system, and then to either reduce waste or continually encourage emergence from the production and administration system.

B.5 - Human Resource Management

The realisation that the labour force has for too long been an untapped source of process improvement technology, and a tapped source of competitive disadvantage has created new demands for the selection and management of the work force. In order for workers to be able not only to participate in the programmes outlined above, but furthermore to understand their vital importance, a new type of worker has become necessary. Efforts have been made within companies visited to create such a work force.

The 'old type' of organisation separated workers into functions that typically had little communication with each other. The more collaborative, team-built organisation requires workers that have the necessary interpersonal skills to allow information to flow freely and effectively between functions when and where needed. Often this has required a significant change in attitude from the 'knowledge is power' approach of the functional firm.

This flow of information, as has been outlined above, has increasingly been facilitated by the introduction of IT. This has occurred not only between associate groups, but also between associate and manager, and associate and the respective work station machines. Information is needed not only to track processes, but also to report upon progress and detect variation. The various IT applications used in the machine tool industry and its customer organisations have placed new demands upon workers that have required as great a change in attitude as the need to communicate verbally.

Such changes in working practice are not unique to the machine tool industry, nor are the problems associated with them. As in other industries, great resistance has arisen from the work force against what is seen as a threat to job security. This is perhaps justified from the workers' perspective since new, IT-based practices do often reduce the necessary headcount. The increase in outsourcing mentioned above has had the same effect.

The result of this resistance has been the need for changes to be made to the way that the work force is managed per se. At the same time changes have had to be made to training and education of the extant work force to meet the new requirements placed on the worker. Coercion and dictat has had to give way to motivation and encouragement. Selection and recruitment procedures have also had to become more sophisticated and stringent to ensure that the new intake of labour can meet these new requirements with less and less investment of time and money from the firm[30].

HR is an area of the business process which, rather than being regarded as a support function, should be seen as a primary source of improvements. Current best practice approaches to HR are, once again, a move towards the PDCA cycle of systemic management.

Before looking in detail at the findings of the current research in the area of HR management, an example from the Rover Group illustrates the potential of including the worker in planning, decision making, and process improvement drives:

> "At Longbridge, 82 people in the body assembly plant took a detailed look at their processes and layout, looking for ways to improve. As a result of their work they made huge improvements in their own efficiency, reducing their manpower requirements to just 58. This would not have been possible in the days when people felt their jobs were threatened. In those old days it would have taken an army of work study engineers, complete with clipboards and stop watches, six months to achieve a reduction of four people."
>
> (Towers, 1994, p.13)

[30] What this amounts to is an outsourcing of education. Rather than training the worker in-house, the organisation is devolving the responsibility for training into the various layers of the education system. This will be seen to be consistent with other changes in HR management and supply base management. The disconnect between the trend in training and these latter two is caused by the degree of collaboration evident between the firm and its suppliers and the firm and its existing employees. The degree of collaboration between the firm and the education system that should shape the content and structure of syllabuses is, in the vast majority of cases, non-existent. This is an important cause of competitive disadvantage in the UK - especially when compared with the approaches evident in Germany, Japan and the Pacific Rim countries.

That such employee involvement is still relatively new to Rover, and also to much of Western industry is validation of the opinions expressed by Matsushita at the beginning of this chapter. An important issue mentioned here by John Towers, chief executive of Rover, is that of fear and threats in the work place. The most effective and efficient improvements to the business process will be seen in this chapter and the next to occur in an atmosphere of encouragement and non-recrimination rather than threats and punishment.

B.5.1 - The Manager-Associate and Associate-Associate Relationship

This topic has been touched upon above with the discussion of the internal customer-supplier relationship. Improvements in HR management have included the drive to ensure that all human elements of the business process, or system, understand what it is that the others produce, require and expect. The 'Managing Personal Growth' (MPG) policy of one of the machine tool builders visited is an example of this. Co-ordinated by the HR department, responsibility for the programme was given to the management of the organisation.

Within MPG, or other similar programmes seen, it was management's role to find out the requirements of the work force, not only on a day to day basis, but also on a longer term basis. This meant both training and education as well as promotional prospects. It was also the impetus for the removal of layers of the management hierarchy. These layers were seen as superfluous to productive effort, erected barriers to the flow of information, and lowered morale. The success of these particular programmes was attributed to management commitment and participation.

B.5.2 - Training and Education

Having established the needs of the work force through participative programmes such as MPG, the HR activities of the organisation are once again used to co-ordinate the necessary training and education of the existing work force. Examples of this have been seen both within the organisation and outside of it. Internal training includes both on the job 'learning through doing' and special training centres. These centres are run by experienced production supervisors who run mock production situations for trainees.

External training has generally followed internal training in those organisations visited. On the shop floor side, external training has taken the form of commercial training at higher education institutions. Finance, project management, and linguistic and IT skills are examples of such training. On the administrative side, much external training occurs in addition to on the job training. Again, such training includes commercial awareness, languages and IT skills. The various principles of quality management have also been taught to the administrative areas of the firm, as well as middle and upper management. In very few cases were the production associates included in external quality training modules.

B.5.3 - Empowerment

Empowerment and employee involvement are two concepts that have come to the fore of HR management. In a discussion on the subject of empowerment in 'The Pursuit of Wow!', Peters quotes Terry Neill, managing partner of Andersen Consulting's change practice. He says of empowerment:

> "Empowerment...is not the things you do to or for people, it's the impediments you take away, leaving space for folks to empower themselves."
>
> (Peters [b], 1995, p.6)

Empowerment sees the responsibility of HR management resting not at the foot of the HR department, but with individual managers. The HR department co-ordinates training, recruitment and management programmes, but the responsibility for the execution of these programmes lies with the management of other functions.

The ideas that lie behind empowerment are similar to outsourcing. The employee working at a station has greater knowledge of the actual running of the station than the employee's supervisor, and is in a better position to correct faults or make improvement suggestions. As a result, the employee should have full responsibility and authority for the successful, quality output of that particular station. Improvements should not need the approval of several layers of management. Where output is of poor quality the employee should have the power to either put things right or stop the process.

Traditional approaches to business have not encouraged this from employees. Management and supervisors thought they had perfect knowledge, and therefore the employees did not need to attend to their processes. Furthermore, stopping production created high reset-up costs and lowered productivity figures. The wider costs of quality and rework not coming into the equation, the worker never stopped production and was rarely asked to contribute to technological improvement. Empowerment is the devolvement of responsibility for the processes within the system to those who perform and away from those who used to think they control through hierarchical power.

The results of empowerment are often hard to quantify, and are subject to long delays. However, the two machine tool organisations visited where the employees said they felt able to contribute to the development of the organisations had certainly begun to feel the effects. Increased morale, improved shop-floor layout, more specific training, as well as improvement to product and process, were all mentioned.

B.5.4 - HR Management and PDCA

Responsibility for the improvement programmes mentioned in this chapter lies with every employee in the organisation. By keeping workers - the human elements of the system - apart, and discouraging interaction, the scope for improvement suggestions to the product or process - emergence from the human activity system - is precluded. HR management within the organisation (co-ordinated by the HR department, performed by all management) should attempt to change this.

As stated above, the improvements to HR seen within the machine tool builders and their customers have mirrored the PDCA cycle. The requirements of the employees are found, as in QFD; new employees are selected, as in FMEA, or existing ones trained to meet these requirements; once employed, the 'empowered' employee's progress is checked, monitored, as in SPC. The similarity to PDCA and the management of production is obvious.

What had not been addressed in great depth within the machine tool builders visited is the Act part of the cycle. Organisations using empowerment policies must view mistakes as opportunities to learn. This is one of the principles of the learning organisation (Senge, 1991)[31]. Peters, too, sees value in error, albeit in a somewhat more informal way:

> When, oh when, will we learn to honor error? To understand that goofs are the only way to step forward, that really big goofs are the only way to leap forward.?
>
> (Peters, [b], 1995, p.4)

Where mistakes are made, the employee must firstly be able - together with the team or process leader - to find the reasons for the mistake with no fear of recrimination, and, secondly, be encouraged to find solutions to the situation.

[31] Senge builds this into the principles of the 'Fifth Discipline' through his assertion "there is no blame".

Again, here, the important word is encouragement. The role of management, once the system is designed and in process, is to encourage the emergent properties of the system to be realised through the employees. Unfortunately, too many of the teams in the firms visited were still pointing the finger of blame at 'up-stream' or 'down-stream' teams, rather than taking time - together - to find a common solution.

B.6 - Benchmarking and Measurement

Benchmarking and measurement have been important aspects of all the programmes discussed above. It was benchmarking against the Japanese, initially, and other competitors that opened a window on the reasons for poor competitive effort amongst areas of Western industry, including the machine tool industry. Measurement is inherent in benchmarking, and has also been seen of use in, for example, production smoothing techniques, or in inventory analysis. Increasingly, attempts are being made to apply quantitative measurement techniques to what are traditionally regarded as qualitative variables. A prime example here is the application of psychometric tests during HR recruitment and development. Within this particular section, two particular uses of, and approaches towards benchmarking and measurement are discussed which would not fit into the above classes of process improvements.

B.6.1 - Organising for Benchmarking

If the functional, chain view of the business system neglects the linkage between individuals, teams, functions and organisations associated with the process flows, it completely ignores the possibilities that can arise through 'lateral' benchmarking - that is benchmarking across the same tier of the process amongst units that are not necessarily associated with the same processes at all.

In Japan, the cross ownership of organisations, along with the less formal, but perhaps more important webs of influence that together form the kieretsu systems, have always fomented the exchange of information both within processes and across them. Major manufacturing organisations encourage the suppliers of the kieretsu to exchange best practice techniques of product, process, administration and management. Interviews with management of the machine tools builders visited confirm the statements found in the extant management literature that such lateral information exchange is not the norm in the West, and especially not in the UK.

Much of the efforts of the M90's programme and the Competitiveness Forum has been directed at the creation of regional supply networks. Consultancies have been created advocating the adoption of networking as an approach to organisational learning[32]. In the following chapter a change in industrial structure will be discussed which sees a move towards the Japanese model - but not total convergence[33].

That lateral benchmarking has slowly begun to occur was also confirmed by the interviews. The major hurdle to overcome in the move towards information sharing of this kind is similar to the difficulties encountered in HR management. For years, management has fostered the opinion that knowledge is power, and as such is to be retained and guarded at all costs. Models such as Porters' 5-forces enforced this view.

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[32] Examples here are Partnership Sourcing Ltd., Supply Chain Management Associates, and The Supply Chain Management Group.

[33] Turnbull et al , (1992) discuss changes in the industrial structure of supply, and address the issue of convergence towards a Japanese model. Western suppliers are relatively more powerful, larger and work with more customers than their Japanese counterparts who tend to be locked in to their kieretsu. The Western supplier has, according to the authors, an advantage as a result of this. From the findings of the current research it is evident that this advantage will only be realised if such power is only used to stave off the misuse of customer power, rather than to turn such abuse of 'power' around and direct it against the customer.

In fact, knowledge is of no utility unless it is applied, and such application is optimised through collaboration. Through a complex system of feedback and delays, even only loosely connected organisations can benefit from the sharing of such information. Lamming (1994) describes the need for such groupings (*kyoriokukai*) if the Western industrial system is to approach the success of the Japanese.

Almost all of the organisations visited were taking part in regional network meetings and panels. For many, once the initial concept of information sharing was overcome, the next hurdle, paradoxically, was to accept that one's firm often had more to learn than to teach.

In the case of one of the machine tool builders visited, an informal network of five local suppliers had been created. All in the business of supplying automotive components or machinery, the five had gained not only motivation from the efforts of the other four, but had also learned much from their experience. Of importance within this particular network was the ability to find out each other's experience at the hands of particular customers. Before entering into a contract with a new customer, or new customer area - even new individuals in the customer organisation - the arms of the network could be pulled to find out which approaches to business had been the most successful in the past.

B.6.2 - Measurement

Within the quality department of one of the machine tool builders visited, a wide ranging measurement exercise was underway. This particular firm was going through a radical transformation to try to gain both parts 1 and 2 of BS5750, as well as to improve upon its almost World Class competitive performance. Having paid attention to the areas described in this chapter, with varying degrees of success, the quality and contract administration department was now turning its attention towards the success of whole projects and contracts rather than their individual elements.

The impetus for much of the organisation's process improvements had been the benchmarking activity described above. For this particular organisation, Japanese competition had not been as much a threat as the polarisation of the markets for both its product and that of its customer. The impetus for the measurements described below came from the Crosby Institute where the firm's management had all undergone quality seminars.

One of the major points put forward by the Crosby Institute (amongst others) is the concept of the 'cost to own' of a project, as much for the customer as for, in this case, the machine tool builder itself. The cost to own, or process cost has been mentioned on several occasions above. The notion of process cost is that the price of a bought-in component, for example, is not equal to the proportion of the total cost of the final product that that component represents. There are costs of labour, machining, overheads etc. that are to be associated with that component that mean that the process costs are greater than the price[34].

Often the four common components of process cost - parts, facilities, overheads and labour - are not sufficient to describe the full 'cost to own' of a project, as was seen in the Ford Zeta example in chapter five, where the costs of labour disputes and stoppages amongst other things would have far greater implications on the system than their initial direct costs. The cost to own is a way of adding in the cost of delivery (and delivery mistakes), of finance, of extended lead times and rework.

The cost to own approach had been translated into eight measurements within the firm. These are as follows:

[34] An example of this applied to the use of laser printers is given in Anon, 1994.

Minor shop-floor changes - why arisen, from whom and what action needed
Major shop-floor changes (requiring design changes) - why arisen, from whom and what action needed
Life-cycle variance - the difference between lead time of scheduled start of design engineering and strip-down[35], and actual lead time
Floor time variance - the difference between scheduled time on the shop-floor and actual time
Installation period - scheduled against actual installation period
Cost of finance (past due date) - the costs of financing overdue work
Budgeted cost variance - budgeted programme costs against actual
Installation cost variance - budgeted cost against actual

Although more detailed programmes had been initiated and were yielding results, the performance of the whole contract - in effect the sum of the more detailed areas where improvements were in process - was still unsatisfactory. This poor performance was due to the existence of non value-added work in the process. For example, the interest costs of overdue work were at times in 1992 running at over $100 000 p.a.. The warranty costs for the organisation were on average $142 000 per month. By 1994 both these figures had been halved.

The success of these 8 measurements had been achieved through visible display systems (VDS)[36] and communication. Before the cost to own projects had been started, no attempt had been made to show the employee how work done in one area impacted on another. Even the internal customer-supplier programmes had not quantified the results in such a comprehensible form. By showing the

[35] Strip-down is the dismantling of a machine after it has been built and tested to the customer's satisfaction.
[36] Visible display systems are simply charts, graphs and displays throughout the shop-floor and offices of the organisation that depict statistics pertinent to the organisation. As discussed above, knowledge without application is of little use in business. The results of benchmarking and measurement are only of use when they are communicated to the employees responsible for the part of the system in question.

room for improvement on VDS as a function of everyone's effort, significant improvement had been achieved.

C - Internal Process Improvement as a System

Having discussed some of the process improvement programmes underway in the machine tool building organisations visited, there now follows a discussion of the concept of process improvements in Systems terms.

C.1 - Common Themes in Process Improvement

The improvement programmes outlined in section B were diverse, ranging from ways of improving inventory costs to financial management or employee training. Throughout the discussion the attempt was made to illustrate the importance of three things which in chapter four were seen as important in the study of systems. These three were feedback and information flow, self-organisation (usually referred to as 'as and when required') and collaboration, or interaction.

Without exception, the programmes involved a greater degree of information flow. The typical approach to business had created barriers to this flow. Moreover the flow is not depicted in the accepted model of supply, and is therefore not given the importance it deserves when systems are constructed.

Often the flow of information has required a greater degree of collaboration within and across functions into process or project teams. Of equal importance to this flow of information is collaboration and the ability to self-organise. Chapter four described the concept of emergent properties from a system. These properties are what are necessary if entropy is to be turned to the firm's advantage. What section B alluded to is the fact that production, inventory, design, financial and HR management are all systems that interact with each other whereby emergence can, if encouraged, occur. On a lower resolution, these systems in turn are the elements that interact in the organisational business system. On a higher resolution, each of these systems contains other systems - the groups or individuals that perform tasks.

Traditional approaches to management have not recognised this fact, and have treated them as separate entities, with varying management techniques. An analysis of the methods being adopted to improve process efficiency has shown that in fact the systems are all similar - they all display elements of the PDCA cycle. Efficiency is achieved through allowing elements to interact, communicate and learn on an informal basis, with certain elements changing their roles or importance as the project progresses.

The flow involved in the process is not simply that of the flow of value as shown by the chain model. The development of products, processes and people is just as important as the production of the product, and for this development to occur complex multi-directional flows are evident on various dimensions. It is the task of management to encourage these flows, and to help elements use the information they receive to full effect. Where this is not the case management's role is to help the worker to get back on track.

C.2 - Continuous Process Improvement - The Ultimate Feedback System

An important feature of the Japanese approach to business, as has been mentioned at various points in preceding chapters is kaizen - continuous improvement (literally for the common, or general good) (Imai, 1986). Putting paid to such phrases as 'if it ain't broke don't fix it', the kaizen approach to business (or indeed life) is characterised by the belief that perfection cannot be achieved over time. This is consistent with the Systems view of the world. Entropy in all systems along with the tendency for ever-increasing complexity means that a system will always contain scope for improvement.

The potential that stems from adopting the kaizen approach - which entails the encouragement of improvement suggestions from all workers involved in the system - is no longer a Japanese secret. All organisations visited - both in the machine tool sector and its customers - had introduced their own version of kaizen.

From a Systems point of view, kaizen is simply a feedback system, again akin to the PDCA cycle (Clewer, 1995 [b]). Having invested time and effort in process improvement programmes, benchmarking either internally, laterally or otherwise, is bound to show areas for continued improvement. Even if this is not actively pursued, suggestions from workers can often generate equally valuable results. This ‘P’ stage is then implemented as in the programmes discussed above (‘D’), the results monitored and learnt from (‘C’ and ‘A’). Each cycle is followed closely by another.

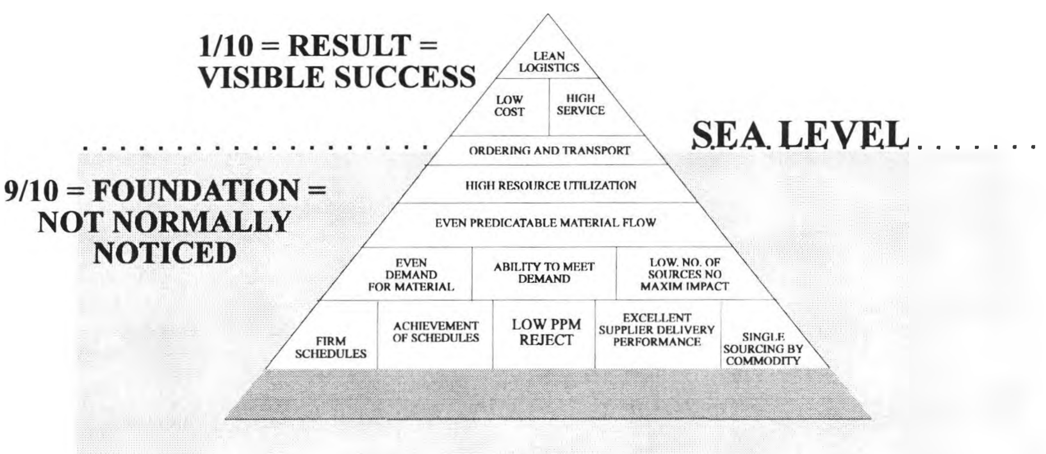
C.3 - Interconnectedness

Whereas the target firms were all vigorously following the principles of kaizen and striving for efficiency, they had not begun to draw the connections mentioned earlier between improvement systems. Each cycle of improvement will set off feedback of its own. To once again use Senge’s parlance (1991) this feedback may be reinforcing or balancing, each of these possibilities on occasions being desirable, on others unwanted - at times this feedback is essential for the success of the initial programme. Realisation of the interconnectedness of all systems within the total business system would greatly increase the efficiency and effectiveness of process improvement programmes.

The automotive manufacturer Nissan claims to have realised just this, and has attemped to incorporate it into the way it tries to achieve successful quality through lean management of supply and logistics. Figure 6.7 below shows how the 'visible results' of low cost, high service and high resource utilisation all depend upon other, less visible factors. Compared to the base of an ice-berg, these 'submerged' factors build upon each other in exactly the manner in which this chapter has described the interconnectedness of the process improvements found in the current research work.

FIGURE 6.7

Interconnected Prerequisites of Success in Lean Logistics - The Iceberg Principle



Within Ford, too, there is evidence of the recognition of the importance of interconnectedness. An example from a different area from that of Nissan above has been found in the management of Ford's 'make/buy' process. This is the decision process that determines whether a component will be built in house or supplied from outside of the organisation from the supply base. The necessities of the new Ford 2000 global reorganisation make this process critical. It has also been realised that the outcome of the process has impact upon the labour force. Changing from a 'make' to a 'buy' decision can mean wide-ranging changes are needed in the pattern of work, or indeed in the required volume of workers.

Trusting that these decisions are made for the good of both the Ford organisation and its suppliers, Ford HR, manufacturing and the unions have joined together to create a management matrix for the concurrent handling of both manpower planning and sourcing decisions. A similarity exists here with concurrent engineering - all those who will be affected by a process are involved from the concept stage to ensure that the process output is appropriate in the eyes of all customers involved. In this case the customers are both the organisation's suppliers and its employees.

In chapter five the case study from Ford discussed how manpower issues had not been taken into account in an example such as this. From past experience the importance of interconnected programmes has apparently been learned.

The existence and importance of interconnectedness has been recognised within certain areas of the major customer organisations. Within the machine tool sector, such recognition was far lower. In the following chapters it will be seen how the success of all elements of a system will depend upon the ability of all levels, or resolutions, to appreciate interconnectedness. In systems parlance this is called recursion. All resolutions of a system should exhibit similar behaviour. This means that HR and Supply should be similarly connected within a customer organisation as they are in a supplier. Despite all of the process improvements discussed in this sector, there is little recursive behaviour to be found in current industry. This forms part of the content of chapter seven.

D - Summary

In this chapter the issue of the efficiency and effectiveness of the business system has been discussed. From the perspective of the chosen research methodology, it has seen the research jump from the Systems World into the Real World. Comparison with a fundamentally new approach to business found in Japan highlighted reasons for poor competitive output in the West. The programmes implemented to rectify this situation have been classified into five areas in this chapter, but such classification is not intended to suggest that they are distinct - all feed from each other and are intertwined in a complex, multi-dimensional fashion.

The traditional approach to business of the West was seen to fail in three ways. It created barriers to the flow of information and communication, it tended to prevent collaboration, and through formality and bureaucracy prevented self-organisation. Through converging their approach to the management of the business system around a more holistic model similar to that found in Japan, and addressing these three variables (albeit often unwittingly) the target companies have seen lead times reduced, quality improved, morale raised, innovation encouraged and costs reduced. All of these results are emergent properties from the system generated through a management style that recognises business not as a chain of separate, disaggregated events, but as a system of interconnected elements.

More attention to the nature of this interconnection will assist the efforts of the organisation even further. This is the topic of the remaining chapters. Chapter seven remains in the ‘real world’ and extends the barriers of the System to its true boundary. Chapter eight then returns again to the Systems World where Systems tools are used to build up new models of the dynamics and structure of the supply system. These are then built upon in chapter nine, where a model is arrived at that is argued to depict the true nature of the system, and therefore that which can encourage efficiency and effectiveness in supply.

CHAPTER SEVEN - INTERFACE MANAGEMENT

Forget the competition,
We all win in the end.
Fill the space that is missing -
You've gotta give to get, my friend.
And remember while you're dancing,
About who you're dancing with.
Come on! Get yourself together -
To receive you got to give.

Got to Give
The Brand New Heavies

Introduction

Chapter seven is the second half of the discussion of the field work carried out during the current research project. In terms of the research methodology, chapter seven is the second half of the exploration into the 'Real World' of the machine tool industry.

Entitled 'interface management', this chapter explores the interface between the machine tool company as a supplier and its major customers - the automotive and aerospace industries. Having already established that the supply of machine tools is a complex human activity system, this chapter extends the boundaries of the system that have thus far been explored, and which receive the greatest attention in the extant machine tool literature.

Bringing the boundary into question brings a new perspective to the nature and number of elements within the system that can influence it. This influence will determine the extent to which emergent properties are encouraged from the system, and the ability of the system to move towards its implicit purpose. It will be seen that the internal process improvements that were seen to be useful to the machine tool builders are equally important to their customers (and suppliers). However, negative feedback can be generated in the system through mismanagement of the inter-organisational customer-supplier interface that has the potential to negate competitive advantage within the machine tool builder, and, more importantly, its customer.

Certain organisations were visited where this idea of 'reciprocal dependence' had been realised. Within these organisations significant change programmes were in process, aimed at moving to what, in this research, has been called 'systemic management'. Other firms were found who tended to display what will here be called the 'traditional' approach to interface management - that of short-term, antagonistic relations with suppliers.

This traditional approach to the management of supply and the buyer-supplier interface is characterised by the following behaviour:

- a concentration on purchase cost above other, more qualitative, factors
- the tendency to switch suppliers
- low levels of trust and a high power distance between the buyer organisation and the supplier organisation
- development of product and process within customer functions
- a large, uncoordinated supply base

The characteristics of emergent behaviour in industrial supply base management will be discussed in section B below, where the contrast to these five traits will become apparent.

A - Moving the Boundary

In chapter four the concept of the system was discussed. The elements of the system were accepted as being those in the environment which exerted influence or control over the NSOI, and which were, in turn, subject to some degree of influence themselves from the NSOI.

Chapter six discussed ways in which certain organisations were changing business processes, and were becoming more systemic in their management. An important aspect of machine tool supply mentioned, or implied, in all interviews but not mentioned in chapter six is the influence of the customer. Internally, processes may be as efficient as possible, but the company's efforts could completely fail due to the behaviour of customers[1].

[1] In separate interviews with two former managers of one of the UK's leading machine tool suppliers of the 1970s, the demise of the organisation was, to a large extent, blamed on the way they were treated by their one main customer. This seems at first to be an easy direction to pass the buck, but further discussion proved that customer behaviour and the breaking of promises put the organisation in such a position that internal efficiencies were insufficient to save it.

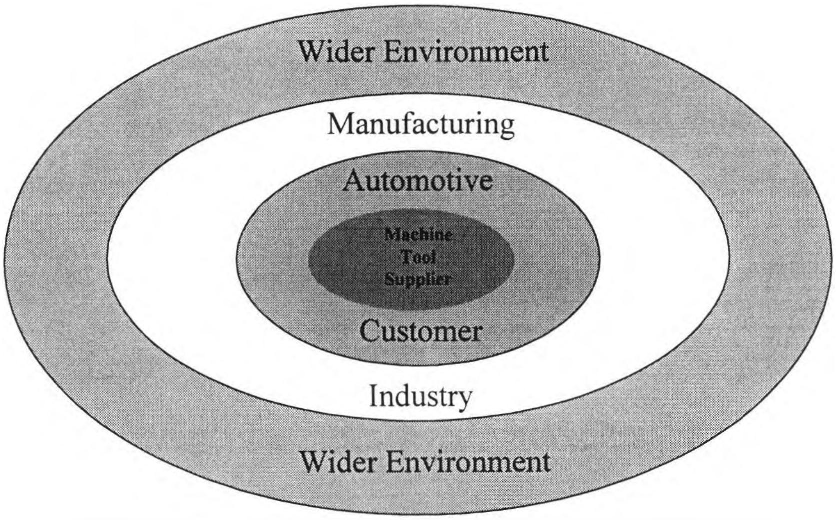
Much of the extant literature written about the machine tool industry has explored those factors critical to the success of the organisation. Only few addressed the issue of customer behaviour (Parkinson, 1984 Sciberras & Payne, 1985). Even when the issue was researched, it was not analysed in relation to other variables, such as those found in chapter six. Since the issue of customer influence is simply a feedback process, Porter's models of supply and many that have been spawned from them have ignored it - indeed, have actively discouraged it. As such, the 'system of interest' as accepted by much of the extant research is the machine tool builder itself. The customer exists outside the boundary, within the environment. It is argued here that this is a false, misleading paradigm. A quotation from Flood and Carson in chapter two, section A.2, is recalled:

> "Be suspicious of recognized boundaries or apparently obvious ones."

From the perspective of Systems Theory, customers and suppliers exist in the same system and both have the potential to move either towards the system's purpose or to stagnate. Represented as a diagram, the system boundaries resemble those shown in figure 7.1.

FIGURE 7.1

Shifting Boundaries - The Supplier as a Subset of the Customer
(An adaptation of Flood and Carson's Sombrero Model)



With the machine tool manufacturer/supplier as the narrow system of interest, the customer becomes part of the wider system of interest. Both are, therefore, a partof the same total system which exists within the wider environment.

A.1 - Barriers to Emergence

The need to broaden the narrow view of the system to include customers and suppliers is easily justifiable from the Systems perspective. This second part of the field work of the current research intended to find examples of industrial behaviour that embodied systemic and non-systemic principles. This was not an attempt to validate Systems Thinking, but rather to find and subsequently highlight its potential when practised.

In those cases where behaviour tended towards the non-systemic end of the spectrum, behaviour was seen to present barriers to emergence. Examples of this also exist in the literature (Carlisle & Parker 1989, Syan & Menon, 1994). Where suppliers and customers acted as separate units the resultant effort in the supply 'chain' was often characterised by extended lead times, re work, poor delivered quality and relatively high costs.

Examples of the benefits of what has here been called systemic behaviour are also described in the above mentioned two texts. Chelsom, in Syan and Menon (1994), for example, contrasts the two approaches in relation to the development of the Ford Zeta programme. More recent evidence found during the current research from Ford and Rover concerning the Sigma and K-Series engines respectively reinforces these views[2].

The reasons for the lack of emergence, as prescribed by Systems Theory, are considered in Carlisle and Parker. Lack of trust, short termism and antagonistic behaviour are mentioned as the causes. Two areas of prior research are used to justify this from a psychological perspective. The first of these is Alderfer's categories of needs (shown in appendix A7.1). Applied to the area of interest, Carlisle and Parker summarise the meaning of these categories thus, including a reference to an expert already quoted on several occasions above:

[2] This evidence arising from interviews with the engineering and sales directors and the business development manager of Lamb Technicon Europe.

> "If suppliers are being treated as though the only reason they wish to interact is because they want more money...then in fact that is how they will behave on the surface. (Note that Deming maintains 'your suppliers are what you make them'.)"
>
> (Carlisle & Parker, 1989, p.18)

In other words, if treated as an organisation only interested in returns rather than partnership, development and quality, then that is how the supplier will react and behave.

The second area of work used by the authors to illustrate their point is the 'Prisoner's Dilemma', or the 'red-blue game' (Carlisle & Parker, 1989, pp.46). This business game has been played many times with players from various hierarchical levels and from various areas. It shows that, in the long run, satisfaction with what on the face of it appear to be lower than normal rewards in order that partners may also survive, actually results in long term gain.

Put together, these two ways of looking at the business of supply mean the following. If suppliers are treated badly they will not tend to offer their best work in return. What is supplied may well be exactly what is required by the customer in the short run. The long run possibilities of Alderfer's 'Type 3 growth needs' (the desire to be creative and achieve full potential) - which is what emergence is all about - are, however, foregone. If the customer were to give the supplier scope for growth by trusting them, and by rewarding quality and development skills rather than price cuts, the long term gain for both 'sides' of the system will be greater.

This last point is especially important in the machine tool industry. As was mentioned in chapter two, a polarisation has occurred in the industry. Fewer organisations are now able to supply the ever more complex equipment required than, say, ten years ago. Examples were found during the field work where, through antagonistic relations with its suppliers, one major aircraft builder has been removed from the list of desirable customers by a machinery supplier which is not only a world leader, but is also unique in some of its capabilities. The results of antagonistic behaviour in this particular customer will only be felt as its rivals achieve higher market-driven quality due to more efficient and effective machinery[3].

B - A Change in Behaviour

In general, however, many of the managers visited were indeed beginning to change the way they thought, and the way they expected their buyers to act. Those in organisations where behaviour was still slow to change were often nevertheless aware of the issues - though cultural were factors quoted as continuing hurdles to change. That this began some ten years ago[4] is evident from the letter shown in appendix A7.2. The content of this letter is important. It shows the acknowledgment within Ford of the potential that supplier inclusion can unleash. Comau has expert knowledge of the development of machining systems; knowledge superior to that of Ford, whose core competence is the design, assembly and marketing of vehicles, not necessarily the design of internal manufacturing processes. The development process would have continued on a simultaneous basis, whereby stages of the development would be discussed with the Ford buyers and those engineers who would later be affected by the purchase. In other words, the development process included design engineers from the supplier and customer, user-manufacturing engineers, and buyers who would track the commercial implications from a strategic, procurement perspective.

The letter also shows a great deal of trust emanating from Ford towards its supplier. Relating back to Alderfer's categories of needs, Ford in this case is

[3] For obvious reasons of confidentiality, the name of this organisation cannot be revealed.

[4] Letters were exchanged in 1986, reflecting negotiations of 1985. At the instigation of Lamb Technicon, involved on a similar basis in the programme, the Ford letter was also used by GM and Chrysler in the US to change their relationships with mahcine tool companies. The change appears to have been short lived, in some cases, as is described below.

certainly doing more than treating the supplier as a usurious entity. According to Alderfer's theory, this means that the supplier in turn would have been more willing to be creative and responsible. In practice this was also the outcome.

The Ford letter shown in A7.2 contrasts with that shown in appendix A7.3. Written from a well known machine tool builder, Ingersoll Milling Machines, to the author of the letter in A7.2, it describes their experiences at the hands of General Motors. GM have for some years been through a severe cost cutting exercise, and the part of this exercise relating to purchasing was led by the Senor Lopez mentioned in the letter. Lopez's tactics of highly antagonistic threats and dictats have been successful in reducing the procurement bill of the organisation in the short term. According to Lopez, $4 billion dollars were slashed from the company's annual materials bill alone[5].

In chapter five the difference between purchase cost and process cost was introduced. Being aware of and measuring process costs had been a great source of efficiency in several of the machine tool builders, as described in chapter six. Such efficiency sometimes meant paying prices slightly above the minimum in order to optimise process costs. Lopez's savings set off a feedback process. Firstly they illustrate the category one type of treatment on the Alderfer scale, which reduces the creativity of the supplier. Secondly, poor quality arising through the concentration on costs and lack of early and appropriate supplier inclusion and interaction causes effects in the system which are subject to delays, but which cause the high costs spoken of in the letter in A7.3.

At a recent presentation to UK suppliers, GM spoke of the need to increase efficiency, productivity and price performance (Barrie, C. 1995, p. 60). In addition, the delegates were warned that supplier switching would also occur where cost reductions were achievable. Such constant supplier switching causes ill-feeling within the supplier, reducing the scope for creative work. It also

[5] As will become clear below, the later process costs caused by feedback from these cost 'cuts' mean that this was a hollow claim.

increases process cost as the new supplier has to become acquainted with, firstly, its new partners and secondly the new partners' systems, standards and procedures. Kerwin et al (1993) describe the difficulties caused by Lopez's approach:

> "But already, the Lopez system is causing problems. At the company's Arlington (Tex.) plant, an ill-fitting ashtray from a new, sub-par supplier caused a six-week shut-down of Buick Roadmaster production. At another plant, GM managers had to go begging for help from a supplier that Lopez had rejected in favour of one that bid 5% less.
>
> "Trouble was, half the low bidder's parts flunked the quality tests. So within four days, the other supplier geared up to make parts that were flown to GM by charter plane. 'My guess is that their 5% savings turned into a 15% loss,' the second supplier says."
>
> (Kerwin et al, 1993, p.65)

Despite Lopez's departure from GM his 'warrior' influence still remains[6]. At the presentation mentioned above - subsequent to Lopez's departure - one supplier stated:

> "I have never won a contract with GM at a price at which I thought I could make the product."
>
> (Barrie, C. 1995, p.60)

Initial attempts by Lopez to introduce warrior tactics at Volkswagen appear to have been slowed, as the trade media's reports of such activity have substantially calmed in the course of 1995. Indeed, the new head of GM, Jack Smith, is now actively trying to "mend tattered relations with suppliers angered by the draconian practices of Ignacio Lopez, Smith's former purchasing czar" whose "penny-wise approach led to quality problems". (Both quotes, Kerwin et al, 1993, p.62)

The two examples given are extremes. Nevertheless, the trend in the automotive industry is definitely towards a new way of managing the supply base consistent with the concurrent engineering philosophy. Hence Bob Lutz, President of

[6] One of the methods employed by Lopez to motivate his buying staff was to rename them from buyer to warrior.

Chrysler gave the following statement to an audience at the Royal Academy of Engineering:

> "At Chrysler, we don't view our suppliers as generic, interchangeable 'vendors' whose only purpose in life is to do what we tell them to do and never have any ideas of their own. Instead, we view our suppliers as true extensions of our company - as an integral, creative link in the value-added chain, just as we ourselves are merely a link. We call it the 'extended enterprise concept'.
>
> "As part of our Philosophy, we've done something radical: We've totally scrapped the age-old system in the auto industry of auctioning off contracts to the lowest bidder. Instead, we set what we call a 'target cost' for a given part or component. And then we work closely with trusted, pre-selected 'supplier-partners' to arrive at that target. And we do not do that by cutting profit margins, but by encouraging new and innovative ideas, and by rooting out waste and inefficiency - much of it, by the way, in our own system.
>
> "And, the result is, our final costs are often much lower than they would have been had we had an old-style auctioning system."
>
> (Lutz, 1994, p.9)

This statement contains much evidence of recognition of Alderfer's category 3 needs. It also illustrates the feedback link between customer and supplier; working closely with suppliers can help to improve customer-internal process efficiency.

John Towers, Chief Executive of the Rover Group, gave a similar address, containing similar sentiment:

> "Some 60 per cent of the finished car is comprised of bought-in components and sub-assemblies. We have the common sense to acknowledge that there are areas of specialist knowledge where our suppliers are the fact-holders and providers of expertise.
>
> "Common sense as much as competitive imperatives indicate greater delegation of engineering and design authority to suppliers. More and more, suppliers are providing vehicle manufacturers with complete systems and sub-assemblies rather than specific components. This re-orientation of relationships is yielding major benefits in terms of cost, quality and reduced development times. We have removed the old adversarial

> customer/supplier culture and encouraged seamless processes involving exchanges of design information and, indeed, people."
>
> (Towers 1994, p.13)

Statements released by the three main Japanese transplant organisations operating in the UK, Nissan, Honda and Toyota reflect this attitude.

Those organisations changing from the short term, antagonistic approach of auctions and competitive bidding are all experiencing the advantages mentioned by Rover's champion; quality, cost and lead times. These advantages are being realised, in effect, by acknowledging the system of influence in which the organisation exists. The customer organisation is dependent upon the supplier organisation for quality in-bound supply and, most importantly, for information concerning design and development techniques in product *and* process.

At the same time, the supplier is dependent on the customer not only for business in financial terms, but also for motivation and recognition. When the boundaries are extended, there soon develops a similarity between HR management and the management of suppliers.

This chapter began by stating that the supplier could be as efficient as possible, but is still in the hands of the customer. What does the new behaviour mean in terms of the supplier's business? Initially, 'systemic' supply management, to be outlined below, presents a threat to those suppliers who have not been increasing efficiency over the last period, as supply bases are actively reduced. However, the trend for long-term, partnership sourcing is good news for the supplier who can be more certain of the future. Where parallel sourcing techniques are used[7], further improvements can be achieved if the customer actively encourages lateral coordination and benchmarking. Certain managers interviewed in the course of the field work were not in agreement with this, being of the opinion that supplier improvement was an issue for respective suppliers themselves. These individuals had not realised the feedback connection of the wider system whereby helping the

[7] As explained in Cusumano & Takeishi, 1991.

supplier actually helps them in the long run too. This is the concept of the win-win situation in the Prisoner's Dilemma.

The earlier sections of this chapter speculated from a theoretical point of view that the boundary around an organisation engaged in industrial supply is false and misleading. The above statements of policy from current organisations illustrate a change in behaviour confirming the validity of the Systems view. More importantly for industry, they highlight the potential for competitive effort that can be released through systemic behaviour.

Chapter six showed how new behaviour within suppliers aimed at efficiency improvements was based upon greater amounts of communication, interaction and information flow between the elements of the system, as and when required, so that the feedback processes produced could realise the emergent properties of the system. The new behaviour outlined above, and to be outlined in more detail below, will be seen to be based on exactly the same variables.

Before continuing with a detailed description of changes in behaviour towards systemic management, a few lines should be dedicated to individual behaviour and organisational learning. The current 'gurus' of organisational learning such as Senge or de Geus describe organisational learning as the alignment of personal mental models and shared values within the organisation. In a similar fashion to vectors in the physical sciences, this alignment of forces produces a powerful cumulative effect. The changes to be outlined in the management of the supply base represent a similar opportunity for emergent potential, *but only where all individuals in the system align.*

Nissan's commitment to systemic supply management is an example of the awareness of this:

> "The principle of 'Partnership' is the key to our supplier relations.

> "It is, however, not just a Purchasing principle - it is a whole Company philosophy. To work properly it needs full commitment from all parties involved in the buyer/seller relationship on both sides of the partnership. It is a principle that we pay particular attention to when selecting suppliers."
> (Nissan Motor Manufacturing (UK) Ltd. Information Pack 1, p.1)

A recent interview with a manager from a machine tool builder who was, at one time, engaged in CE procurement at Ford confirmed this. Whereas the Sigma engine programme had run better than anyone had thought possible, another similar programme under the Ford umbrella in the UK had not. The results of this second programme had been so discouraging as to call into question the true value of CE (a part of which is systemic management of supply). When questioned further, however, it turned out that it had not been CE which was at fault, but the management of the flows of information throughout the inter-organisational process teams, which is essentially a human system. Success in human activity systems is reliant on the behaviour of all involved. Individual activity can cause amplified effects subject to delays, which, as in so many systems, can cause its demise.

Another example of this originates from the Ingersoll Milling Machine Company. Having been audited by one of their major automotive customers (see section C.2 below) the customer failed to complete the evaluation. This had a great demotivational effect on Ingersoll. Apart from the fifteen thousand pounds spent on the audit and the time 'wasted', the company was left seriously doubting the efficacy of such new methods of supply management. When carried out well they do work, as seen below. When the individuals involved act badly the results are akin to those of the traditional approach.

It is imperative for the management of the organisation that not only the management is committed to quality and partnership, but that all engineers, buyers, finance and other staff involved in a project are similarly convinced.

C - The Change in Detail

At certain points in the preceding chapters the concepts of efficiency and concurrent engineering have been explained and discussed. Attention has also been paid to the increasingly urgent components of the competitive challenge which have placed new requirements on both suppliers to organisations and internal employees alike. In the area of HR - *people* managing *people* - new demands on workers have at once required existing staff to be examined as to their true input into the organisation and to undergo training programmes, and new recruits to be vetted more thoroughly than before. The way in which *organisations* are now beginning to manage other *organisations* is exactly the same in principle. This apparent paradox comes as no surprise to the Systems Scientist, since an organisation is as much a system as a person, and therefore will have great similarities (on a low resolution).

In this section of chapter seven the details of the changes alluded to in the previous section are discussed with particular reference to four automotive companies - Ford, Rover, Nissan and Mercedes Benz. The author's gratitude is extended to all those who participated in the field interviews or otherwise from these four organisations. Once again, references are given where possible, but where the argument proceeds with unreferenced material, information will have been obtained from personal interviews details of which, through reasons of confidentiality can, unfortunately, not be made public.

C.1 - The Need for Downsizing in the Supply Base

The term downsizing has traditionally been applied to the reduction of the work-force that occurred across many Western industries in the mid-1980s, as described in chapter six. Functional organisation and ineffective management had permitted staff counts to grow too large for the given volume of work, and the introduction of IT meant that ever fewer staff were really needed. In anticipation of industrial relations problems, however, ‘downsizing’ became ‘rightsizing’, or even ‘employee optimisation’ - the original term became a ‘dirty word’.

Despite such linguistic trickery, downsizing is exactly what happened to HR, and is exactly what is happening to the supply base. Just as companies realised they had too many employees to do a given volume of work, purchasing departments have begun to realise that they work with too many suppliers. Whereas Ford had a supplier count of some 4000 for its European manufacturing and assembly operations, it had reduced its count to well below 1000 in 1995, with further reduction planned.

Nissan, too, works with a ‘lean’ supply base. It imposed a limit of 200 suppliers for its manufacturing and assembly base in Sunderland, UK[8].

The reasons for the large expansion of the supply base throughout the development of Western industrial organisations when compared to Japanese companies are concerned with the approach to supply adopted. Due to the West’s preoccupation with competitive bidding, contact with in excess of three suppliers is needed for every job quoted for. One ramification of this policy, itself based to a great extent on mistrust, is often waste and therefore inefficiency. Purchasers within customer organisations waste time and effort in the contact, and, potentially more critical, they also often do the same to the supplier.

The absence of attention to supplier quality in the West that persisted amongst customer organisations compounded the issue. Competitive bidding often led to more than one supplier being chosen, since quality could not be assured. Where quality control within the customer organisation showed that serious problems existed with supplier A, supplier B could be concentrated on, or more could be

[8] Personal communication, Terry Allen, engineering manager, Nissan Motor Manufacturing (UK) Ltd.

sourced from B instead of A[9]. The Japanese approach was to select one supplier and to work at designing out the roots of problems before they occurred, so that the one single supplier could be retained.

As was mentioned above, the wider relational effects of auctioning business include ill-feeling amongst those turned down. This feeling is accentuated when the justification for awarding the contract to a particular supplier is suspect - cases of this sort were mentioned on several occasions during interviews.

Large supply bases were nevertheless felt ever more necessary as a continued threat to current suppliers in a bid to squeeze cost savings out of them. When suppliers were found who spoke of potentially cheaper supply, switching would occur in order to gain the cheaper unit purchase price. A critique of this was given in chapter five, as well as in the discussion of the 'Lopez approach' to business given above.

The Japanese approach to business is characterised by smaller supply bases. Competitive bidding is far less common, and is not relied upon for low prices. Parallel sourcing, or single sourcing are the more common approaches to the management of supply[10]. These two related approaches involve the long term, 'locking in' of suppliers to a particular vehicle in order to ensure consistency of supply and to be able, together, continuously to improve both product and process.

C.2 - Supplier Evaluation and Selection

The reduction of the supply base has not been an arbitrary procedure in the organisations visited. Highly sophisticated rating procedures, often called 'quality

[9] Although seeming to have much in common with parallel sourcing, the underlying mentality of the buyer, and therefore treatment of the supplier, is greatly different.
[10] Cusumano & Takeishi, 1991.

audits' have been devised - similar to those used in the FMEA process outlined in chapter six. It is important to note that the purpose of the audit is *not* to ascertain which suppliers are to be kept and which discarded. Quality audits are a way of knowing who suppliers are and what they do, or can do. When combined with the desire to work in long term partnership with suppliers, the base can be reduced. Auditors are at pains to make clear that performance in the quality audit is not necessarily the turning point for the organisation. The outcome of the process is a report which will be judged on its merits. Certain suppliers may well be discarded immediately. Others may be informed of the areas they need to concentrate on to secure business in the future, following a second audit.

C.2.1 - Supplier Audit Criteria

The rating systems used take an holistic view to supply - quality no longer being accepted as a given, and price no longer the preoccupation. Examples of the criteria measured are given below:

Organisation	Criteria
Ford[11]	commercial[12], process[13], design, policy[14]
Nissan	quality, cost, delivery, development[15], management[16]
Rover	project management, total quality[17], business performance[18]

[11] The criteria given here are the Ford 2000 'core' criteria. This means the strategic aspects of a supplier's activities that make it suitable or unsuitable for strategic selection to become a turnkey supplier. In the context of this research it is this kind of supplier management in which interest is shown. Other, less strategic, supply is governed by the criteria of quality, commercial, technical and delivery ratings.

[12] 'Commercial' factors relate to the 'health' of the supply streams into the organisation, and the way that the supplier manages its own supply base.

[13] This criterion looks at the appropriateness of the supplier's internal processes and process management, as well as the fit of such processes to Ford's own internal policies.

[14] 'Policy' measures the appropriateness of such areas as investment, training, growth etc.

[15] 'Development' pertains to employees and management potential as much to the technological and design development of product and process.

[16] This is less the management of the organisation, which comes under development than it is the scheduling and management of projects.

Although different names are given to the criteria from one firm to another, more or less the same issues were measured. Nevertheless, one supplier complained that confusion had been caused internally due to two separate audits being performed simultaneously. More lateral communication across customers would have prevented this; the confusion only causing waste[19].

The criteria listed above may not appear, prima facae, to be particularly holistic. However, in each category are between 3 and 10 sub-sections, each with some forty questions covering almost every aspect of the supplier's business. A page from one audit, remaining anonymous, is given in appendix A7.4.

C.2.2 - Performing the Quality Audit

The approaches to quality audits were similar throughout the organisations visited. The following section describes the steps employed by just one, however. Once again for reasons of confidentiality the organisation involved cannot be named.

A supplier is informed that it will be audited on a certain day. The customer team visiting comprises purchasing, engineering and expediting[20] staff, occasionally with staff from the quality assurance area. The team from the supplier organisation will vary, but generally involves management from engineering, finance, purchasing and sales. Where contract administration and quality areas are present these will also be involved.

[17] This includes human resources as well as quality assurance in products and processes

[18] Including finance, business and product strategy and planning, manufacturing operations and engineering.

[19] Complaints like this became more and more frequent through the early 1990s. This has led to an important meeting of policy between Ford, Chrysler and General Motors - the 'big three' of the United States. In an almost unprecedented move of public collaboration in supply base management these customer organisations have begun to merge their supply base management and audit criteria into a single document recognised by all three, as part of their joint QS9000 system.

[20] The so-called progress chasers. Field staff who visit suppliers to ensure that projects are progressing to schedule, or to find the source of delay.

The supplier will be sent a copy of the audit book, so that it can prepare for the audit. This has two purposes. Firstly, it saves time on the day of the audit. Secondly, it means that the supplier is at more ease with the audit. Customer organisations try hard to make the supplier aware that the audit is in the interest of both parties; springing unknown questions upon unprepared candidates will not spawn good relations.

Although audits can potentially involve over 500 questions, all will rarely be asked. Often the auditing team will be satisfied by a range of questions either picked at random, or tailored to what the particular supplier is involved in.

The questions themselves take the form of verbal questions that may involve the provision of evidence such as production schedules or financial figures. The trend towards this policy of 'transparency' of suppliers' records, or 'open book costing' is further described below.

C.2.3 - Audit Results

As mentioned above, the results of the audit are scores that are weighted according to the type of supply involved[21]. An important aspect of the audit is its potential to motivate. Customers may often give purposely low scores for performance that in fact was good - in order that the supplier has a target to beat at the next audit, whilst still being praised and securing business with the current 'low' rating. The page shown in A7.4 illustrates this. Three columns are shown. The first will contain the possible rating, the second the actual rating achieved. The supplier is

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[21] The Rover Group, for example uses four categories of supply. The first is where the product is 'proprietary, or jointly owned'. The second is for 'major functional and selected non-functional components and assemblies'. The third is for 'simpler components in normal or high volumes'. The fourth category is for 'less complex or special components in low volumes' (Rover publication - 'supplier business specification RG2000 - a supplier's guide to total customer satisfaction'). Those suppliers in the fourth category need only part 3 of BS5750 to work with the company. Those in the third need part 2 of BS5750 and certain parts of the RG2000 audit. Category one suppliers need full BS5750 accreditation and all parts of the audit.

shown these two scores and will be encouraged to accept the chance to discuss the outcome. The third column, 'score 2' is intended for the second audit which may occur in 6 months, the intention being that 'score 1' is beaten.

Certain supplier interviewees talked of the 'big stick' approach to supplier audit; it certainly could be used as a threat. However, most were left with a positive impression of the process. Often the supplier was left with a better picture of what its own organisation really is and does. Similarly the process can decrease the organisational distance between customer and supplier, firstly by both parties becoming acquainted with the processes and secondly by becoming better acquainted with the individuals involved.

Incentives to perform well in the audit and continually improve do not include the promise of business. A well rated supplier may not always be the first choice for a number of reasons[22]. Incentives are mainly reputation-based, combined with the knowledge that contracts now *may* be secured.

Customers publish lists of preferred suppliers. Although this is motivational, the status can be removed. The negative effects of this provide an even greater incentive to perform well. The awards also carry titles - the QS 9000 award from Ford, for example[23].

C.2.4 - Beyond the ISO Quality Standard

Motivating the supply base is certainly one of the most beneficial side effects of the supplier selection and evaluation process. With the challenges presented to suppliers by the global expansion plans of modern day automotive manufacturers, only the most motivated will stand a chance of survival. Responsibility for this

[22] For example, capacity may be an issue if other jobs are currently being undertaken.
[23] Formerly the Q1 award. QS 9000 is an award that is based upon the international standards of ISO 9000. As described in section C.2.1 above, this has been taken further and moulded by the 'big three' American automotive organisations who have together created a sophisticated quality assessment package.

motivation lies to a great extent with the automotive customer. The manner in which the quality audit is performed, and its whole philosophy is often perceived by the supplier as an indication of how it will be treated by the customer. From a motivational point of view, the audit is highly geared, as it can either greatly motivate or greatly demotivate the target company.

The basis for much of the audit evaluation criteria has been the BS5750 and ISO quality standards. It was described above, however, how the major automotive companies are improving and developing these for their own specific purposes. One of these purposes is continuous improvement. As Deane (1995) describes, the ISO criteria are based upon static conformance. In order to encourage real improvement (and therefore systemic emergence) from the supply system, there must be more emphasis on dynamics and continuous improvement, whilst at the same time increasing system responsibility and authority.

To use the example given by Deane (1995), Ford wants to phase down its function of auditor to certain second tier suppliers, or suppliers' joint venture partners[24]. This responsibility is now being devolved down into the supply system to the suppliers themselves. This increased authority increases the motivation of the supplier and puts the responsibility for a given process into the hands of those who will actually be performing it, and who have the most perfect knowledge of it.

The primary audit focus is now between the 'full system supplier' and Ford itself. Here the emphasis is on dynamic, proactive improvement. An example of this is a departure from looking at the parts per million (PPM) defects at one snap-shot in time, but rather to look at the PPM trend over a period. This improvement is not imposed upon suppliers, but is arrived at by a consensus of both supplier and customer design and engineering input. This process uses criteria which are based

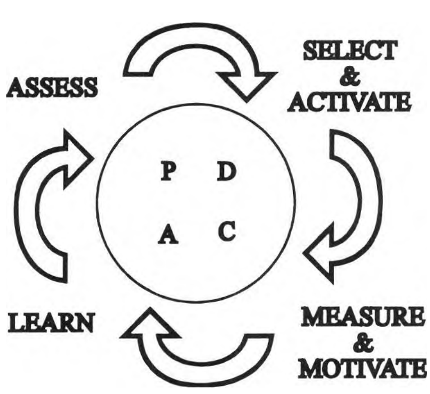
[24] This policy does not contradict the above description of a common set of audit criteria across the 'big three' car companies. All three use a common 'core' of criteria, and simply use supplements to adapt the audit to the company concerned.

upon ISO, but which have, themselves been continually improved to adapt to the requirements of the environment.

C.3 - Supplier Development

An important part of the 'new' management of the supply base is the introduction of kaizen, or the PDC/SA cycle. Continuous improvement in the quality of supply can be achieved from suppliers through encouragement and motivation, rather than threats. As was mentioned in section B.2.5 of chapter six, this is also the direction in which HR management has been moving to improve the quality of the output of an *employee*. That similarities exist between these two apparently dissimilar areas of business is depicted below in figure 7.2. This is a topic that will be revisited in later chapters, and will be seen to gain importance as the discussion of the conclusions of the current research progresses.

FIGURE 7.2
HR & SUPPLY MANAGEMENT



Mentioned above was the possibility of second quality audits occurring where necessary. Even out of contract, the most progressive audit teams will remain in contact with preferred suppliers in order to keep abreast of the supplier's organisational development. Experiences have been made where the 'preferred supplier' status had no longer been justified, but lack of contact had let this go unnoticed.

More importantly, the customer has now realised that it is in its own interest to help the supplier organisation develop. Therefore, where new processes are found in one area of supply, the customer will encourage other suppliers to learn by example too. The customer, in other words, can coordinate the 'kyoriokukai' mentioned in chapter 6. Unfortunately not all interviewees saw this as the responsibility of the customer. In general, however, most organisations had set up supplier development teams to assist their suppliers to become world class[25]. The supplier development area generally comprises staff from purchasing and engineering, and has responsibility for technical assistance and quality assurance. An example of the long term commitment to quality, and the inseparable part played by the supplier in this, is Rover's quality strategy, visible (on wall charts, desk jotters or white boards) from most points in their offices and factories. This is a five year plan, constantly rolling and up-dated that itself contains various areas of process improvement that pertain to particular processes, projects or functions.

There follows below a description of six ways in which customers are beginning to help their suppliers help them by improving their internal business. These six form the spectrum of the second half of the field work of the current research. As was the case in chapter six, some organisations display all these features, others only certain elements of them. From the Systems point of view, however, all of them are prerequisites to the encouragement of emergent properties from the system, and hence are necessary for the successful creation of competitive advantage. Also as in chapter six, it will be seen how the key to these issues is the mixture of interaction, information, self-organisation and the devolvement of authority to the elements truly responsible.

[25] Nissan Motor Manufacturing (UK) Ltd. have even gone one step further by helping suppliers develop their own supplier audit schemes. Again this shows awareness of the interconnectedness of the system, and is an important feedback process ignored by extant models of supply.

The six issues described are open-book costing, time of inclusion, formation of teams, customer volume, transmission of information, and project management responsibility.

C.3.1 - Open-Book Costing

Open-book costing (OBC) is currently a highly contentious issue in the area of supplier relations because it is open to abuse. In principle, OBC involves the supplier throwing open its financial figures to the customer so that together both parties can find areas of unnecessary cost, or where cost could be reduced through efficiency programmes. True OBC requires total transparency, i.e. the customer opening up its books to the supplier too. This rarely happens. Suppliers complained that figures shown to customers in good faith had then been mis-used. Either they had been used as a stick against other suppliers (the contract already having been awarded), or once contracts were awarded the customer would demand that the margins which had initially been agreed upon were reduced.

The potential of OBC is, however, undeniable. Since the customer may well have greater knowledge of the cost of certain areas of supply[26], or of certain processes, round table discussion of figures can have emergent results and need not be a sign of lack of trust. It is, however, another example of how individual abuse can cause the demise of a system reliant on communication and information exchange.

As customers begin to demand OBC, and indeed measure the supplier's willingness for open negotiations, it remains to be seen the extent to which it is used to *reciprocal* benefit.

[26] Examples being raw materials or labour costs in countries new to the supplier but well known to the customer.

C.3.2 - Time of Inclusion

In the description of CE given in preceding chapters, it was stated that one of its major novelties was the earlier than usual inclusion of all elements of the system who would have influence over the project - including suppliers. Early supplier inclusion (requiring prior supplier selection through the audit procedure described above) can help to ensure quality through reducing rework, since specifications are drawn jointly and no islands of knowledge exist. Quality can, in fact, be improved and costs reduced by exploiting the synergic effects of group dynamics where differing sets of expert knowledge come together.

The benefits of early inclusion are reciprocal, and can aid the development of the supplier by allowing it insight to the workings of the customer and making it less likely for the customer to become dissatisfied with inbound supply. Early supplier inclusion, allows the promotion of yet another feedback process, as shown in figure 7.3 below. This figure shows the interplay of the buyer-supplier interface. This commercial interface is complemented by a more technical one of, for example, the design/process engineer and supplier. The following section investigates the importance of the nature and activity of those involved in such teams.

FIGURE 7.3
EARLY SUPPLIER INVOLVEMENT

Ideas and information flow around the cycle, (with additional input from other systemic elements[27]), and where allowed to do so in the appropriate environment they have a reinforcing 'snowball effect' of benefit to both organisations.

[27] These additional inputs are not shown here in order to keep the message of the figure simple. Figure 7.4, however, does show these to full effect using the example of 'sub-studies'.

Opinions vary as to the correct moment for supplier inclusion. Some of the customer organisations visited involve the supplier right at the conceptual stage and use the supplier's opinions in the design of whole processes and products.

Other organisations, Nissan for example, begin to involve suppliers at a slightly later stage[28]. The rationale here being that target costs can be established for the final product which help the supplier in the establishment of its own projects. Furthermore, the customers recognise that much time is 'wasted' in the decision making process, and that too early inclusion of suppliers will pass some of this waste on to them. This does, however, run the risk of producing an over-the-walls situation having lost the benefits of the exploitation of supplier knowledge.

The flip-side of supplier inclusion is supplier exclusion. Despite the reduction of the volume of suppliers dealt with in the supply base, multiple suppliers are still retained. This continues to run the risk of ill-feeling being caused amongst suppliers who, having gained such awards as Q1/QS9000 or RG 2000, still do not secure contracts. Moreover it still sounds like the competitive bidding approach, where multiple suppliers were necessary. To overcome this, Nissan have a policy of informing suppliers who were not to receive contracts before those that would, and to justify their reasons[29].

C.3.3 - Formation of Teams

The improvement of the CE environment compared with the over-the-walls approach is the interaction of stake-holders in the process who would a) not usually have come together and b) who would not have had input into the development process. QFD is often quoted as a tool of CE. In effect, however, CE itself is a form of QFD. The production engineers provide processes to those

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[28] Personal communication, Bob Gray, purchasing manager, Nissan Motor Manufacturing (UK) Ltd.

[29] As seen in operation during a visit to the organisation in 1994.

who eventually manage the operatives who will use the machine tool supplied by the outside supplier via the purchasing activity. These engineer/managers are therefore the internal customers of the buyer (internal supplier) and the machine tool builder (external supplier). In chapter six the importance of feedback from customers was discussed, along with the importance of using this information not to correct mistakes, but to design mistakes out from the beginning.

CE teams are an improvement that can increase the efficiency of the customer and supplier organisations[30]. Without such group dynamics, as was stated above, the most internally efficient organisation can falter. Carlisle and Parker (1989) use the term 'mandate team' in their discussion of the creation of these units. A more common term used in industry to describe such crossfunctional and interorganisational teams is 'platform team'[31]. The main use of CE has, until now, been its potential in the development of projects. Its real potential is far greater, however. Concurrent to 'development' comes design and build, together with commissioning and installation of production equipment. Finally the machines are handed over to the production plant engineers and operatives who then, with cooperation from the suppliers must have become acquainted with the TPM[32] associated with the system.

Each of these steps requires input from all members of the platform team. The members will comprise individuals from the following areas:

purchasing
design engineering
production engineering
finance
supplier (of materials, components and equipment)

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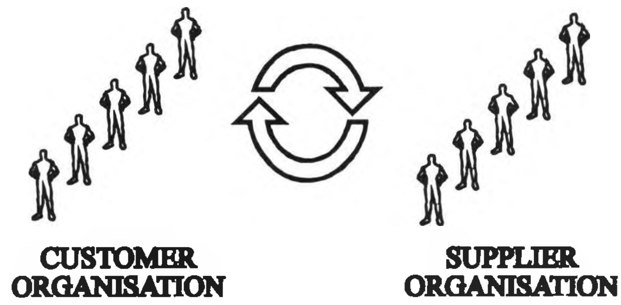
[30] These teams should not be confused with the supplier development teams discussed earlier. Supplier development teams are customer groups that visit the supplier to assist in the supplier's internal development of products and processes. CE teams are groups that work on current projects, consisting of both supplier and customer individuals. One supplier may well be involved in several CE teams whilst at the same time also have interaction with supplier development teams. Chapter eight will revisit this area.
[31] See, for example, Lutz, 1994. These high level teams break down to lower levels of, for example, component review teams.
[32] 'Total productive maintenance', see chapter six

Each interaction of individuals in the team has the potential to generate a similar feedback cycle to that shown in figure 7.3. The 'whole potential' of such mandate teams is shown below in figure 7.4

FIGURE 7.4
TOWARDS CONCURRENT ENGINEERING



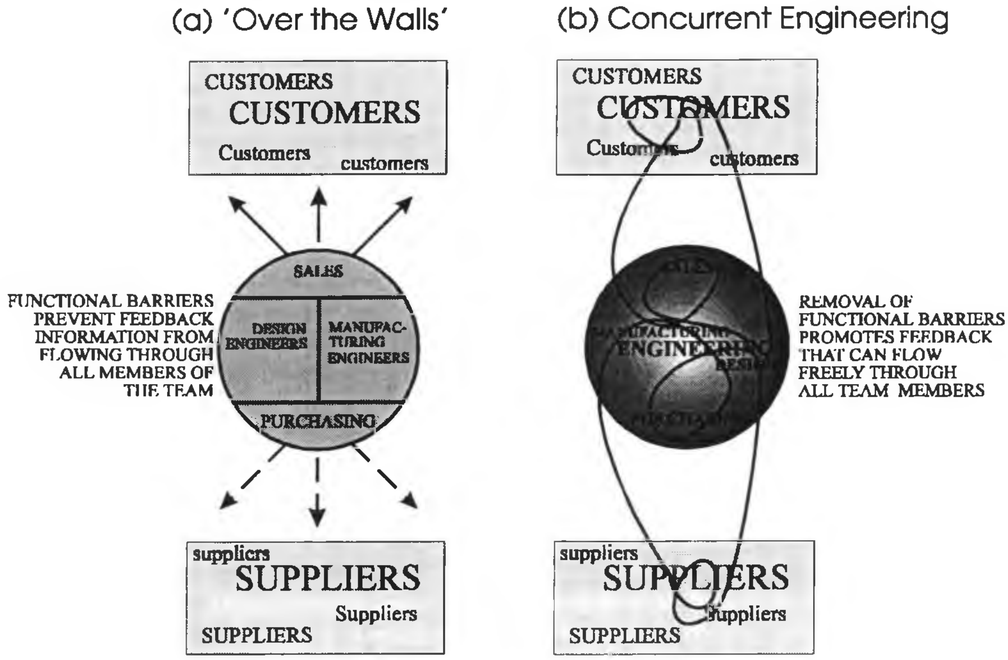
Although often direct, the input may well be implicit - especially from the marketing activities. The OTW approach would not have had such a high degree of interaction - suppliers being kept at arms length by the power of the buyer, the designer neither seeing the need to discuss issues relating to the shop floor, nor wanting to (Parkinson, 1984).

Key to the success of the CE teams is, once again, the free flow of information as and when required. Traditionally organised 'functional' departments have natural barriers to this flow of information. Such barriers prevent the synergies necessary for the promotion of systemic emergence which is the whole essence of concurrent engineering. This point is made graphically in figure 7.5 below[33]. The issue of self-organisation in platforms is paramount. Depending upon the stage the project has reached (develop, design, procure, build, install etc.), a different member of the teams will be the primary customer.

[33] Figure 7.5 is adapted from two similar figures, here merged together, to be found in Chelsom, 1996.

FIGURE 7.5

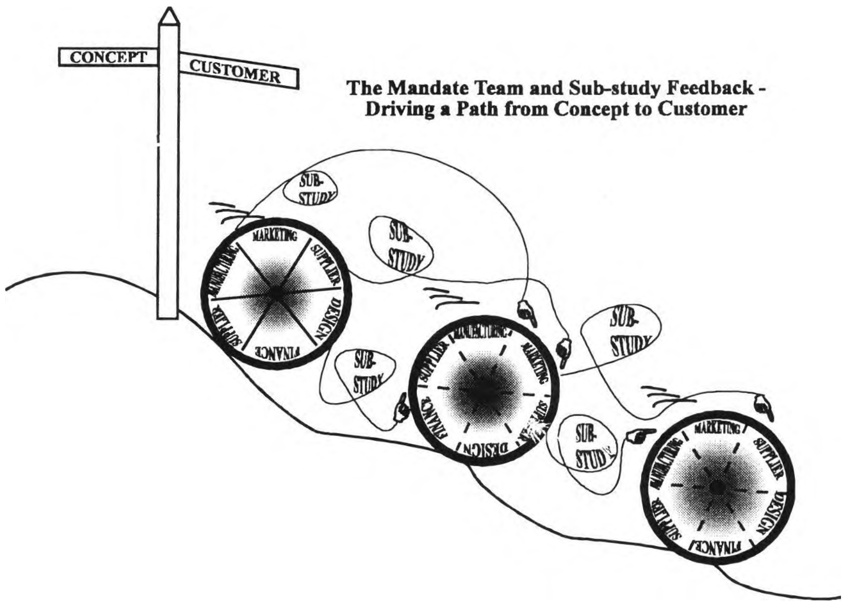
How Internal Functional Barriers Restrict the Flow of Information and Feedback from Supplier to Customer



At the early stages the supplier is, paradoxically, the main customer, whose requirement is accurate and timely information about functional specifications of the final product. At this stage the supplier should have the ability to drive much of the process - the reality was, however, often different. Although included far more than under the OTW approach, suppliers are still not given full trust and responsibility (see below). Many of the managers interviewed in the customer organisations put this down to lack of ability amongst the supplier. The suppliers argued that they were simply not allowed the initial freedom to prove their worth. Again, Alderfer's category of needs is of relevance here.

As the project progresses through its stages, different elements become the primary customer. Although the stages themselves can be scheduled with increasing accuracy, the change-over of the drivers of the process can only with great difficulty be prescribed. Chelsom (1996) illustrates this highly fluid process as a rolling wheel, as shown in figure 7.6 below.

FIGURE 7.6



In some instances admitted by the customer organisations during interviews, the customer organisation had taken ownership of a machine too early[34] and had subsequently shut out the supplier. This caused difficulties with installation and training, causing poor quality output. This poor quality was then blamed on the supplier, who in fact was quite innocent and would not have made the mistakes. Following the feedback cycle through, this bad experience would be remembered and the supplier would firstly be less likely to get contracts in the future and secondly be less willing to help the creative effort of the customer.

Through holistic behaviour, i.e. inclusion of those elements responsible for or influencing the system, these difficulties can be avoided.

A further advantage of the platform team was seen during visits and described in interviews. This is the set of feedback processes which is set into action from the platform team. The team itself benefits from internal feedback, but then sets off other flows when individuals return to their own departments and feed into others the opinions generated in the platform. In figure 7.6 above this is illustrated by the hands

[34] 'Ownership' here meaning more than simple possession and property rights. It implies 'assuming full knowledge of, and responsibility for'.

hands spinning off the wheels, and then returning with the results of sub-studies, helping to push the wheels further down the road.

Returning to the extant models of supply mentioned in chapter five, these detailed, synergic flows of information in the teams are not acknowledged, nor encouraged. The models of Turnbull and Valla (1986), embodied by their 'Interaction Model' do come close. Hakansson, too, presents a model showing the importance of organisational interaction (1982)[35]. These are very much macro studies of organisational behaviour. Although they have successfully attempted to break the chain linearity of Porter's work, they have not been able to address the simultaneous interaction of many different resolutions of the system that are the real source of systemic emergence.

C.3.3.1 - The Nature of the Purchasing Team

Platform teams were found useful due to the potential of synergic group dynamics amongst those who were to be stake-holders in the process at some point. The opinions of all elements are needed at the beginning to avoid bottlenecks or mistakes. Another change that the major motor companies are introducing is related to this, but rather than concerning individual, on-going project teams, this concerns the nature and knowledge of the buying personnel itself.

The ideal buyer has both technical knowledge of what is to be bought and commercial knowledge of the supply base, the organisation for which the buyer is buying, the distributor and final customer. Because the oft-described functional separation found in industry seems, in fact, to be part of wider Western culture, it is also found in education. Hence, engineers are traditionally not taught commercial concepts, and business management students are not given any

[35] These 'interaction approaches' concentrate on the successful marriage of the partners shown in figures 7.3, 7.4 and 7.5. Later chapter will discuss why it is that a model of the 'total' supply system must embody more than this.

technical experience. The case in Japan and the Pacific Rim nations is different (Chelsom & Kaounides, 1995). In the West the commercially literate buyer may attempt to cut technical corners in order to save money, whilst the buyer with the engineering bias may be more concerned with the specification than the wider commercial implications.

This failure introduces an important concept to be revisited in later chapters - that of the necessary inclusion of the education system in the workings of the system of industrial supply. At this stage, however, the discussion concentrates on the current situation.

The research found two differing approaches to the improvement of the traditional situation in industry. These are embodied by the policies of Nissan and Rover. Nissan accepts the need for a certain division of labour, and continues to promote commercial awareness amongst the buying staff and technical skills amongst the engineering staff. Buying decisions are, however, made jointly. Subsequent to the platform discussion deciding upon the fine points of design, groups or pairs from both procurement and engineering staff will decide together what to buy, where and from whom. An important part of this policy is that both functions are situated in close proximity to one another. The flat organisational structure at Nissan further aids the higher than usual degree of communication that this approach requires[36].

The Rover Group has also addressed the problem of instilling both sets of knowledge into its buying team. Although there is a similar degree of communication between the engineering and procurement areas in Rover[37], it has

---

[36]The term 'higher than usual' is used since in the OTW approach these groups would not have communicated at the operational level on a constant basis as a matter of course. Certain interviewees at Nissan were of the opinion that the *culture* of the organisation itself promoted more communication than other organisations they had previously been employed by, and that having existed much longer were more bound by what is here called the 'traditional' approach.

[37]Rover have learned much from their experiences with Honda. Teamwork was mentioned as one of the most important aspects of this learning. Associates speak freely of 'geba gai', a term from their erst-while partners meaning 'everyone in' - pertaining to the holistic approach adopted to problem solving.

been attempted there to free the engineering department from the administrative role that is much of the task of the procurement process [38]. Buyers are expected to have both commercial and technical knowledge. The 'Rover Learning School', a collaboration with Warwick University, is used to this end. Those buyers with a commercial background are taught technical aspects of the automotive process, and those with engineering knowledge are acquainted with 'management' skills.

It is not the intention of these two approaches to create buyers who can answer all supplier difficulties, nor who know everything about their area of responsibility. This would not only be too time consuming, but would also reduce the potential uncovered in group dynamics and would create an imbalance of power towards the buyer. Widening the mindset of the buyer assists both the customer and supplier organisations by giving the buyer a frame of reference from which to work. This means, for example, that when suppliers get into difficulty the buyer will have a better idea of who to switch on within the customer's engineering or technical assistance activities.

C.3.4 - Customer Volume

Customer volume relates to the number and type of customers dealt with by suppliers. The issue of supply base reduction has attracted much attention in recent years, but this other stone has been left relatively unturned.

In the Japanese model - that towards which many Western organisations look for inspiration - the strong kieretsu systems (like those of Toyota or Nissan) lock certain suppliers into a particular customer. This is not done on a formal basis, but the desire is strong and well aired, and owners of customer organisations have

[38]Having said this, it has been found within Ford that the cost of the administration of purchase orders can sometimes exceed the value of the bought-in item. Certain responsibility for the physical processing of purchase orders is being devolved down to the user, a) to overcome this inefficiency and b) to empower the engineer. Nevertheless, the responsibility for the administration and control of the aggregate procurement still lies with the purchasing manager.

stakes in suppliers too. Furthermore, the volume of business awarded to suppliers - on a long term basis - is such that simple capacity limits the number of customers a supplier can deal with.

The traditional model in the West is the antithesis of this. The constant risk of supplier switching means that suppliers need a large customer portfolio. One of the areas of questioning in the research was to ascertain the extent to which this policy would change.

Turnbull et al (1992) speculate on the difficulties that might be experienced by a customer organisation such as the Japanese automotive transplants if they tried to implement the Japanese model in Europe. They describe the large relative size and power of the European supplier in comparison to the Japanese one. This would present a barrier to the implementation of such a policy.

Those managers who had actively considered the issue of supplier customer volume were totally in agreement with this latter view, but did not think that it would be insurmountable. Nevertheless, no managers expressed the desire to persuade suppliers to lock into their business alone.

The reasons for this were varied. One reason mentioned was risk. Although supplier audits should go a long way to assessing the future viability of a supplier's strategy, the complexity of the environment means that no supplier can ever be sure of its survival chances. Locking into one supplier increases the risk of shortages caused by supplier demise.

Another reason was mentioned which for the purposes of this research was of greater interest. This was the learning opportunities offered within a customer portfolio. In other words at the same time as the customer is able to develop its suppliers (see above), the supplier is able to assist in the development of its customers.

An example of this was seen on two occasions. The development, procurement and assembly of the Rover K-Series engine was, to a great extent, dependent upon the input from certain supplier organisations. These suppliers had, in turn, gained their CE experience from working firstly with other customers, but also with other suppliers[39]. The complexity discussed in Turnbull and Valla's Interaction Model, is, therefore, not simply a source of difficulty as assumed in that model, but also one of learning - if properly managed.

Another example of the potential of supplier interaction that benefits customers was seen in one supplier that had had substantial dealings with Honda Engineering[40], and Honda itself. Having expanded its business, and also its customer portfolio, other customer organisations confirmed the benefits they were experiencing from this supplier's new-found expertise.

Allowing the supplier a portfolio of customers allows the supplier the chance to learn through a variety of channels. By preventing this through active shareholder influence or through absorbing a high proportion of capacity, the ability to learn from the market is precluded.

C.3.5 - Dissemination of Information

In chapter six improved methods of information sharing and transfer were mentioned as methods of improving efficiency; IT-based methods were seen to be of particular worth. The EDI/CDX tools of chapter six aided efficiency through speed, accuracy and by overcoming barriers of distance. This section is concerned with a somewhat similar concept - that of the dissemination of general information from the customer to the supplier in order to assist the supplier's activities.

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[39] See footnote on page 208 referring to the Ford/Comau letter and Lamb Technicon.

[40] Honda Engineering is an independent organisation engaged in automotive design and consultancy. Although now separate from the Honda automotive manufacturing organisation, strong ties are still retained.

Ford and Daimler Benz are the target organisations who provided material for this discussion, although most companies operate similar schemes to those outlined.

Daimler Benz's automotive section, Mercedes Benz (MB) has begun to reorganise the management of its supply base quite late compared with its competition. Although it still has a long way to go, the Managing Director of Mercedes Benz Purchasing Coordination (UK) Ltd. spoke of being able to learn from the mistakes of those other companies who had already addressed the issue. One area of learning was keeping suppliers up to date with MB internal affairs - improvements, changes or plans - as well as with developments within other suppliers. Not only does this assist in the learning opportunities of shared information described in the above section, but it is also a concrete sign of MB's commitment to its suppliers.

MB has developed a 'cooperation concept' called Tandem - pertaining to the fusion of supplier and MB effort to achieve competitive advantage. The commitment to partnership and reciprocal development are embodied in the following statement from the Tandem brochure:

> "Through identifying with our philosophy, firms with strong potential will become our long term partners.
>
> We want creative suppliers that are able to criticise projects objectively, not just the performers of pre-conceived ideas.
>
> Through openness on both sides, and though information and insight into our thoughts and actions, a long term bond of trust will be created between ourselves and our suppliers."

(Mercedes Benz "Tandem - Das Kooperationskonzept", 1994, author's translation)

The Tandem scheme as a whole is a part of MB's partnership sourcing programme, and is concerned with the sharing of information. Appendix A7.5 shows the 3 'pillars' of the scheme. The left hand pillar called 'Veranstaltungen' represents a series of events organised for suppliers. The middle pillar 'Organisation' represents MB internal organisational changes to assist suppliers.

The right hand pillar 'Information' represents printed matter sent to suppliers. Together the three pillars support the basic principles of the concept, entitled 'Tandem - creating the future together'.

Each pillar is made of three blocks. Each block is a resolution of the respective method of information transfer. Turning first to events, the lowest resolution is the Tandem Plenum. This is a general meeting for suppliers where the MB strategy is communicated. Forum is then a series of individual workshops, and Projekt is the organisation of events aimed at specific project difficulties or plans.

Internal organisation allows supplier improvement suggestions to be submitted through the Ideenbörse - some of these will be emergent results of internal improvements (see chapter six), some will be results of working with other customers (see C.3.4 above). Patenschaft means that every supplier has dedicated partners in MB to whom the supplier can turn for help - these partners are in purchasing, engineering and quality assurance[41]. Support is the facility offered to suppliers to ask for direct assistance from MB personnel.

A whole series of regular written communications was also planned by MB. Again from the lowest resolution (the highest block), journals were planned to discuss issues in supply. These would be supported by general letters and circulars. Tandem Konkret is a series of memoranda sent to individual, or groups of, suppliers.

Although new to England when the interview was performed, Tandem had been in existence in Germany for some time. The first Tandem Journal, which appeared at the end of 1993 (some 12 months after pilot projects) highlighted several areas of improvement similar to the CE benefits described above. The most impressive change from MB's point of view was the willingness amongst suppliers to join in

[41] This marks a departure from the traditional OTW approach where the buyer would be the initial point of contact , even in non-commercial matters. (This approach is outlined in Carlisle and Parker, 1989)

once the Tandem initiative had begun - confirmation, it would seem, of Alderfer's link between needs and behaviour.

Ford runs a similar scheme - as much for its suppliers as for its dealership network. It is not felt necessary to go into detail as to the construction of the scheme. Of interest to this project is the innovation of CDX and multimedia packages aimed at quick, easy and menu driven dissemination of information to suppliers and dealer customers. Wide ranging as MB's scheme is, the intention of Ford to invest heavily in the multimedia scheme is an even more impressive show of the commitment of the customer organisation to the development of its wider system.

C.3.6 - Project Management Responsibility

As was alluded to at the beginning of this chapter, one of the findings of this research is the similarity that can be drawn between empowerment policies in HR management and supplier management policies under CE. Accepting certain generic qualities to be present in all systems, this should not be a surprise to the Systems Scientist, but it is a characteristic of the industrial supply process that has been ignored by models of supply. Whilst models of HR draw heavily on psychology and the 'soft sciences', supply is still stuck in the rigidity of organisational theory.

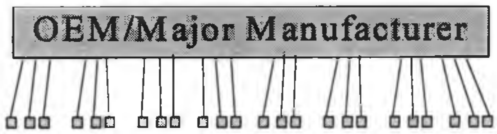
One of the keys to empowerment was the devolvement of authority and responsibility for projects, machine supervision, cell output etc. away from those with hierarchical superiority (ergo *power* according to many hierarchies) to those who actually 'own' the process, i.e. have influence, control and knowledge of its running. Hence, in HR, employees are now authorised (empowered) to stop production lines when faults are suspected. The benefits of empowerment were seen to be motivation, quality and learning.

The change that has been underway in the supply base is startlingly similar. As described above, reductions in the supply base have occurred, assisted by audit processes. Moreover, a change in the whole structure of industry has occurred. The two models below in figure 7.7 illustrate this change.

The first of the two models shows the traditional model found in the West; an uncoordinated, flat supply base. Negligible amounts of interaction occur laterally and the point of contact is with the buying organisation. The second shows the Japanese model, towards which the West is converging. A far smaller 'tier' is shown in direct contact with the buying organisation, and firms in this tier interact laterally in the 'kyoriokukai', as described above. From each supplier in the upper tier, similar tiering filters down into the less complex areas of the system.

FIGURE 7.7

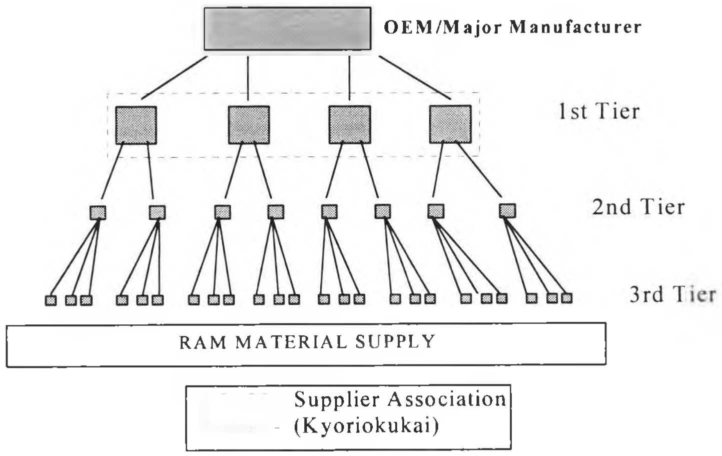
The Western Model



'Flat Supply Base'

Although suppliers still supply in a tiered relationship to one another above, communication and control is handled centrally by the purchasing operations of the major customer organisation. In the Japanese model below, tiering applies not only to physical supply, but also to the responsibility for programme management, procurement, design and training. This allows for a much reduced purchasing function within the customer organisation and provides motivation for the lower tiers of the supply base through increased resonsibility. It also means that those responsible for the management of specific areas are those with immediate knowledge rather than with the greatest bargaining power.

The Japanese Model



A system emerges, therefore, that is self-replicating at all levels. In chapter four, self-replication was one of Fitzgerald's generic properties observed in systems that seems highly applicable here.

Rather than being a tiering of mere physical product, as in Porter's supply chain, this 'Japanese model' is a step in the direction of systemic organisation. Here, responsibility for aspects of procurement, programme management and planning as well as training are devolved into those areas where specific knowledge is held rather than being left to those areas where the greatest amount of bargaining power is held.

In order to encourage the best, creative effort from suppliers, a certain amount of responsibility and authority for the management of projects has to be devolved away from the customer organisation to the supplier's personnel themselves. From what is known of the CE environment, this is sensible since the suppliers have certain knowledge sets not evident in the customer.

This responsibility includes more than design and development. It also includes procurement, scheduling and logistics, where applicable. Certain commentators in the media have suggested that this is simply a ploy by the automotive manufacturers to cut their overheads by imposing more tasks on the supplier. Where badly managed, this may be true. There are certainly short term gains to be made by the customer by forcing the supplier to take on more work at no extra charge in return for the retention of business. But these are short term benefits only.

Where well managed, proper recognition is afforded to those who have taken on more responsibility. Many suppliers actually levy a project management charge which the customers are willing to pay due to the reduction in their overheads and the improvements felt in quality, cost and lead times.

The tiering is important. Where the customer organisations making cars devolve responsibility to the top tier suppliers, so these suppliers are encouraged to devolve similar responsibility to their respective suppliers. In this way the whole tiering lattice becomes an active, indeed an interactive system of interdependent elements. As the interaction increases, so the activities of the upper tiers can become more sophisticated. What used to be the top tier of manufacturing suppliers is now increasingly becoming a 'systems' tier[42]. These organisations manufacture less and less - their main activity being the coordination and assembly of sub-systems and turnkey systems for their customers, who again are also making less and less. By being able to rely on the less sophisticated suppliers in the system for manufacturing, the more complex ones are able to concentrate on their core competencies of design, marketing, and assembly[43].

Devolving responsibility for project management means that those who 'do' are 'responsible for', and through this responsibility comes the potential for creativity and learning. An important lesson learnt by Rover was the issue of learning from mistakes. By devolving responsibility to the supplier there will always be the risk that things do not go according to plan. (They may also have gone wrong if internally supervised too!) If the motivational aspects of supplier empowerment are to function properly then the responsibility must go hand in hand with the confidence to take risks. Rover learnt the value of this by trying the Japanese approach of treating mistakes as opportunities[44].

Where the supplier is in fear of recrimination through mistakes in timing or quality, the result was seen to be sub-optimal when compared to the results where suppliers were truly given an environment of non-recrimination. In other words, the supplier is allowed the chance to self organise along its own lines - and where

[42] 'Systems' here being used in an engineering sense, meaning complete set of interconnected components, or subassembly.

[43] Where some five years ago up to 60% of the value of a car could be out-sourced to suppliers, this figure is now growing. One source speculated that the figure could grow as high as 80%

[44] Personal communication, John Hart, manager, technical assistance, Rover Group.

mistakes are made to be able to analyse them and learn to both Rover's and the supplier's benefit.

Too often the cycle employed was plan-do-check-punish rather than the PDCA of the learning organisation.

D - Components and Machines, People and Processes - A Commentary

Much of what was learnt in the field research was the ideal situation. It is beyond doubt that the customer does have an interest in the selection and development of quality suppliers, with whom long term partnerships are beneficial. The automotive supply sectors in the UK, and indeed across Europe are certainly benefiting from the behaviour outlined above - provided they are efficient enough to withstand the initial audits.

Nevertheless, two issues have to be raised at this point that were felt lacking in the approach adopted by the representatives interviewed in the automotive industry.

The first of these is the continued concentration on components above machinery suppliers. Most interviewees were able to outline in detail the new procedures, policies and publications they had devised for the component sector. Only a few were able to do the same for machinery suppliers. Although true that this was partly a reflection of the amount of time spent with component suppliers and the amount spent with machinery suppliers, it still fans the fire of the complaints from machinery suppliers of lack of interest in their development. After all, despite the trend of producers needing fewer machines, and procuring machines that last longer, machines are still equally important as the components they process, assemble, move or connect.

The second point to make at this point has been mentioned several times above, but is important enough to warrant space again here. It is the trap for the unwary laid by the reliance on procedures and plans. CE teams, empowered employees and preferred suppliers can all fail to live up to expectations if given insufficient, false, or misleading information. Sources within one supplier told of the most startling false information that caused weeks of work on a particular section of a project within the supplier to have been wasted - the section had been cancelled with no word to the supplier. The sum result is that the project as a whole will overrun either cost or time targets - a fact that will be blamed on the supplier, setting off the negative feedback spiral mentioned above.

Systemic management relies not upon IT, nor upon procedures or budgets. It relies upon people. In the following chapters the issue of people will grow in importance. Until now the system boundaries have only been extended to the customer and suppliers. An argument will soon be made for the extension to the design and development areas of the human capital supply system - education.

E - Summary

In this chapter it was stated that the efficiency benefits of internal programmes such as those outlined in chapter six were of little use if the interface between the customer and supplier was not properly aligned to the efficient transfer of information and physical product. Having discussed the issue of the system boundaries from the Systems perspective, and asserting that the customer is inherent in the supplier's system, the research then investigated the nature of the industrial 'real world' interface.

It was found that the policies adopted in the buyer-supplier interface were converging towards those of HR management. The importance of the supplier was increasing, following sophisticated selection and development procedures, made necessary by new requirements being placed on the supplier.

Along with the audits themselves, six policies were identified that had been initiated to help the supplier develop its competitive potential - in other words to encourage emergent properties from its activities. These six were all ways in which the flow of information between elements could be facilitated, or ways in which the salient elements could come together at the right time, or both.

In this sense, the improvements to the interface have much in common with the improvements made internally. All are ways by which the system can make more use of the phenomena of feedback and emergence. This is the subject of the next chapter. Chapter eight returns to the Systems world, and attempts to model the underlying concepts of chapters six and seven in Systems terms - in terms of interaction and feedback. The results of chapter eight, primarily a discussion chapter, will then form the basis of chapter nine. This final chapter is devoted entirely to the modeling of industrial supply from the perspective of the system.

CHAPTER EIGHT - BACK TO THE DRAWING BOARD...

If at first you don't succeed,
Try, try again.

Try and Try Again
W.E. Hickson

Introduction

Chapters eight and nine form the final part of this dissertation of the current research project. Chapter four introduced the characteristics of systems as accepted by Systems Science. 'Supply', the subject-matter of this thesis, was argued to be a complex, dynamic, human activity system, and therefore would exhibit the same fundamental generic characteristics as all other human activity systems.

Chapter five then described the development of the most widely used models of supply 'chains' (not systems). These models failed to acknowledge the importance and potential of systemic generics. It was therefore hypothesised that these models were not consistent with the promotion of best practice within industry. The mental models they spawned could well explain the poor competitive performance of parts of Western industry - the machine tool industry being an example.

The field research of chapters six and seven tested this assertion by direct company visits and interviews. It was found that behaviour was changing. The threat to Western industry posed initially by the Japanese, and increasingly by South Korea, Taiwan, Hong Kong and Singapore has forced the West to re-examine and 're-engineer' the very fundamentals of the way business is performed.

The type of behaviour that 'world-class' industry now scorns and tries to turn its back upon is that embodied by the functional separation of the traditional models of supply. The type of behaviour that industry leaders are desperately trying to adopt is argued here to be 'systemic', i.e. a set of behavioural patterns that reflect an awareness of the generics of systems, and the desire to exploit them to the advantage of the system. It is not argued that such explicit knowledge of systems in detail, as described in chapter four is acknowledged in industry. This, however, is of lesser importance, and is more a matter of parlance.

Chapter four stated that all systems are complex, and that this complexity itself is detailed and dynamic. Having delved into the 'real world', as the SSM methodology terms it, chapters eight and nine return to the 'systems world'. In this, the eighth chapter, the true complexity of the environment of the supply system is explored and illustrated. From this complexity, the purpose of the system is also explored. A more comprehensive and explicit purpose is arrived at than that of the Purchasing Lead Body cited in chapter five.

Awareness of this increased complexity brings with it the need to re-think business processes. Chains and forces of competition are not representative of the type of behaviour increasingly evident in industry today. From a systems perspective, not dissimilar to the system dynamics approach mentioned in chapter four, chapter eight shows the difficulties experienced when introducing feedback and self organisation into linear models. Having done this, a systems tool, the Viable System Model (VSM) is put forward as an improvement on traditional structures of the firm, the most important aspects of which are its ability to acknowledge what the traditional models cannot. It is a model that has been arrived at in the Systems literature through the work of Stafford Beer, and has been observed to exist in biological and political systems alike. In this chapter the author has not attempted to adapt industrial behaviour to fit the VSM. Simple analysis of the way in which organisations are re-forming - with the virtual integration of suppliers and customers into the process lends itself to the model with very little manipulation.

Having begun to remodel the way in which organisations involved in supply are perceived, the next and final chapter in this thesis presents a model of the whole, or 'total' supply system which, it is argued, includes the whole set of elements that exert influence over the competitive potential of machine tool companies, their suppliers and their customers.

A - Towards the Root Definition for the Industrial Supply System

As stated above, the first section of this chapter is devoted to the completion of the root definition of the system. Having arrived at this definition it can more easily be seen why and how the problem situation arose, defined here as the deterioration of an industry, along with the misconception of what it *really* is, and what steps can be taken to rectify this situation.

A.1 - The 'Rich Picture' of Industrial Machinery Supply

In chapter four the guiding research methodology was laid out. This methodology, SSM for short, was described as a set of seven stages which were not necessarily to be performed consecutively, but concurrently or otherwise[1]. The true richness of industrial supply could not be fully appreciated from literature reviews alone, but necessitated a substantial period of 'real world' research (the initial stages of SSM). The systems stages three and four were in fact performed before the first two stages were fully completed, which is part of the aim of this chapter. Stage five has already been addressed, that of the comparison of real and systems worlds. The remaining stages of 'desirable changes' and 'action to implement these changes' have, in a sense been going on continually in industry, but still have to be addressed fully in this dissertation.

In order fully to understand the system of interest, an understanding of its purpose is vital. Once this purpose is known, the requirements of the systemic elements can be better attended to. Checkland's method of arriving at this purpose (the 'root definition') is by using a rich picture. This tool lays out all of the environmental elements found to be important. From the literature review of both trade and academic sources, and from the series of field interviews, the resulting rich picture

[1] These stages were described in chapter four, section D.2.

for the machine tool industry (UK perspective) is shown in appendix A8.1. No ranking of the importance of the elements is given, and they exist on various levels of the systemic hierarchy. Some of these elements are systemic (where the nature of control and influence is two-way) others are more environmental (where influence is generally one-way).

The complexity of the picture is beneficial. Such an image says nothing new about the machine tool industry. The decision makers in the industry will already know that these elements are influential. The advantage of the rich picture is to lay them out together. From this the message can be conveyed that no areas may be ignored for any length of time. All are important, as all can potentially cause the failure of the system itself.

A.2 - The Catwoe Analysis

In chapter four the root definition of the machine tool, arrived at from a CATWOE analysis was stated to be as follows:

> *A system which exists to supply machinery encompassing all organisations or groupings that are involved in physical and non-physical input into the process and the consumption or appropriation of its output. It must recognise the importance and value of all of those directly or indirectly employed or engaged in all of these stages; these being active in the process of satisfying their customers. Ignorance of this could cause any part of the system ultimately to destroy or severely damage the system's performance. The satisfaction of the customers of each element or actor takes place within substantial dynamic environmental constraints*

The actual analysis, arrived at from the preceding chapters' discussion along with the definition is given again in appendix A8.2.

This definition of why the system exists at all goes further than the definition given by the Purchasing Lead Body or other references mentioned in preceding chapters. The improvements offered by the definition in A8.2 are as follows:

• inclusion of a wider set of organisations than simply those of the buying and selling organisations

The output from all organisations will affect the input into the buying firm - either through quality, cost or lead time. Hence they should be included in decision making considerations, and are to be included in considerations of the problem situation. Even those models that have been acknowledged as moving towards systemic management in this research (Cesarotti, Turnbull & Valla, Haakanson, Lamming) do not consider the totality of the situation.

• inclusion of 'groupings' in the consideration

This means that such units as the platform or component review team, and the commercial-technical mix of the buying team, gain importance, as do teams within suppliers or customers alone. The interface is as important as the separate units of the firm, and the interface comprises of dynamic groups just as much as the separate units do. The interface is not simply a 'support function'.

• acknowledgment of the parallel importance of both physical and non-physical inputs into the process

Before physical inputs can flow, non-physical inputs are a prerequisite if quality is the objective. Where such non-physical inputs as information and experience are not promoted the ensuing physical inputs cannot be guaranteed to be delivered in the right quantity, at the right cost and specification or at the right time. Furthermore, the system forgoes the ability to exploit the emergent results of interaction. It is arguably this failure to recognise the importance of process and organisational learning that cost the West much of its competitive head-start.

- an explicit concentration on the worker

  Not only the organisations or the platform teams are important in the supply of quality. All employees associated with the process, its organisations and teams, play a role in ensuring that market-driven quality is the output of the supply process. Within and around the organisational and process systems there are systems of people - both social and formal. These must be well managed in order that the information flow mentioned above can occur effectively and efficiently. Previous models have not addressed the issue of HR, in supplier, own and customer units, as an integral part of supply.

- all parts of the system are related

  Any part of the system has the potential to destroy the system. One of the most startling aspects of Systems Science has been the possibilities that arise from feedback. When of the positive, reinforcing type, feedback can cause the greatest results from the smallest stimuli. It is upon this, and the fact that the lines of cause and effect are hard to trace, that the areas of Chaos and Complexity Theory are based. Such effects occur in human activity systems, and are evident in the commercial world too. Ignorance of any of the areas shown in the rich picture (A8.1) could, arguably have effects large enough to cause the demise of the firm.

- dynamism

  Nothing stands still for long in the machine tool industry except the machines themselves after installation. The economic and political environment is constantly changing, as are the individuals and policies found within customer and supplier organisations. Hard, fixed planning can no longer be relied upon to take care of the company's future. The firm must be able to constantly adapt and remain flexible to the requirements of the environment. Chain models cannot appreciate this flexibility - the very name itself creates images of fixed, strong links. Quality and learning come from dynamic, ever changing links over varying time periods, but within long term frameworks, more a 'mess' than a chain.

These six points, borne out by the research described in chapters six and seven, are key to the message of this thesis. It is these six which must now be included in any new model of the structure of the firm, or more importantly of the supply system itself.

B - From the Chain to the VSM

After the first part of the field research, an attempt was made to conceive models in the normal linear 'chain' fashion that could contain the softer emergent properties found to be of importance in the efficiency programmes investigated. The resulting concepts are described below using the metaphor of electrical circuitry. As will be seen, these ideas were perceived to have failed due to the persistent inability of such a metaphor to embody a system.

Despite this failure, the attempts were of use as they began to introduce the idea of an 'unknown' property into the model that did not have to be called a black-box, but was *consciously* unknown. Previous models have left areas unaddressed as 'black boxes', only to find that these black boxes are, in fact, the sources of emergence. The 'unknown' in this case is the synergy of human minds. It is recognised from the outset, however, that this is the source of emergence, and rather than ignore it, the effort is made to include it in what can be known and modeled.

B.1 - Supply and the Metaphor of the Electrical Circuit

From early stages of the research, and from a personal perspective, the importance of recycling in the industrial field was acknowledged as an important aspect of supply. That the activity of supplying something should be linked to its subsequent degradation and reuse might seem paradoxical, prima face. However, the whole discipline of economics is based around the concept that the Earth's resources are scarce. The absence so far of sources of economic goods from other areas means that society should realise its responsibility to future generations and re-appropriate as much as possible of those resources that we no longer have uses for, rather than pass off this burden onto those not responsible for their consumption. Not only should we do this to spare them the cost, but also to ensure that the scarce resources of the planet are exhausted as far into the future as humanly possible, if at all.

Such societal perspective has rarely been reflected by industrial behaviour until recently when 'green power' has extended to consumer purchasing power. Whether this is the correct reason for industry finally to see the green light or not is immaterial. The fact is that organisations in industry are increasingly recycling from all stages in their production processes, as well as from their administrative and service areas. (Perhaps these three latter distinctions can now finally be laid to rest. Production, administration and services are all supply. They all supply a requirement to a user. As such it can be said that all functions and teams in an organisation are engaged in the activity of supply - all are active in the supply system. Therefore, for the purposes of the present argument, recycling is becoming a necessary activity at all points in the supply system.)

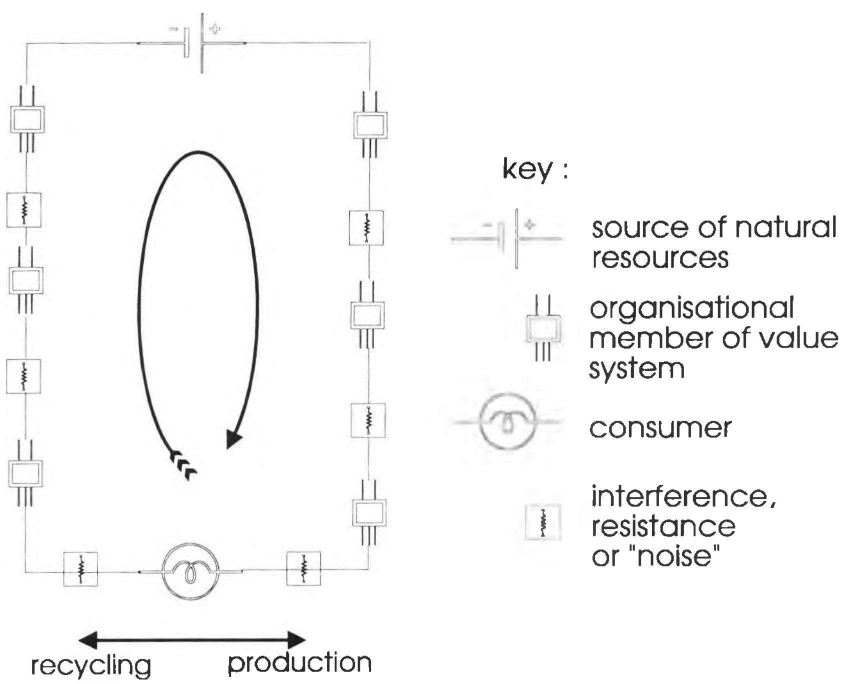
B.1.1 - The Hard Circuit

Recycling is not consistent with the chain model in its linear form. No chains found in the literature extend to become loops. It was this that became an early intention of the research - to extend the chain model to encompass recycling. The concept became a 'supply circuit', from which the allegory of electrical circuitry soon followed.

Figure 8.1 below illustrates the concept diagrammatically.

FIGURE 8.1

"Hard Systems" analogy of the supply system as an electrical circuit



Resources, whether natural or artificial all come, originally from the Earth, represented by the cell in the diagram[2]. At this stage the chain idea of separate business units was still adhered to; these are shown as organisational member 'components'. The flow, instead of being electricity, is of value. The consumer - the component representing the *ultimate* purpose of the circuit, is shown as an

[2] To be precise, the Earth's natural resources are only of use when mixed with energy which may come from outside the Earth.

element or filament from which the emission of heat and light is comparable to customer satisfaction.

The existence of resistance in the circuit - shown between the components, but also existing within them, is used to represent inefficiency in the circuit. Resistance in circuitry causes a 'loss' of energy to, in this case, the filament. The energy is not lost, but diverted away from the 'consumer component'. It was the removal of such areas of organisational resistance that the programmes in chapters six and seven were aimed at. Waste in the supply system is also energy in the form of human and/or mechanical effort which is not lost, but is simply diverted from or tapped out of the quality stream.

The second part of the circuit - which completes it - is recycling. Having appropriated resources in the process of value addition[3], the reverse must occur in order for future value addition to be able to occur. In the long run, and ideally, the circuit becomes a continual loop. This is, of course, somewhat utopian. The Earth's resources will be slowly used up, but it is surely as much a responsibility of industry as it is of individuals to slow down the process.

B.1.2 - Softening the Model

The field chapters of part two stressed the importance of interaction, feedback and information flow that was often seen to occur in opposition to the 'primary flow of value', i.e. that of the flow of physical product. The addition of the recycling section to the circuit was seen as an improvement, but not a completion of the model, since these non-physical flows were not shown.

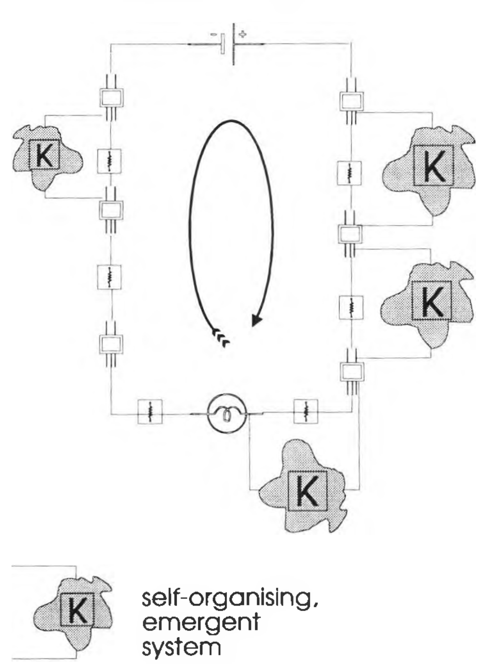
[3] The term value addition is used in preference to the more usual one of value creation. It is argued that most industrial activity cannot 'make' value, it simply adds to it by assembling units already possessing value potential.

The use of electrical circuitry as an analogy to the processes involved in supply is an example of hard systems modeling, which, as described in chapter four, is a useful, yet inflexible approach to the modeling of systems. Due to this inflexibility, the hard approach of the chain, or the circuit is not appropriate to supply.

Nevertheless, the stage reached in the research at this point still indicated possible utility in the circuitry metaphor. The idea was conceived that a new, soft component be added around certain organisational components in the circuit. These mini-circuits represented loops which ran back from one organisation to the previous one(s). The component itself represented the self-organising, synergic interaction seen in chapters six and seven which encourages emergent output from a system. The component was called the K-factor. The letter K relates in this case not to the common abbreviation from economics of the 'multiplier' but to the term 'kaizen'. Through these loops the possibility of continuous learning and improvement would be possible. An example of the resulting 'circuit' is shown below in figure 8.2:

FIGURE 8.2

Departure from hard systems - introduction of selg-organisation and emergence in supply and information flows.



The existence and potential that arises from such feedback loops has formed the cornerstone of the Ford 'EQUIP' programme[4]. EQUIP teaches engineers the importance of communication, control and feedback. Not only does it attempt to promote this behaviour, but it also tries to teach the participants exactly why feedback is important and how it works.

From having begun with the simple chain model, the more developed chain model, figure 8.2 offers substantial improvements. Not only is the recycling imperative shown, along with the existence of unwanted inefficiencies at the organisational interface, but the possibility of feedback loops is also illustrated. Nevertheless, as the research progressed, reservations about the utility of such a simple, primarily linear and sequential model remained.

B.1.3 - Departure from the Linear Model

The discussion in chapters four and five has already alluded to the fact that the chain model, or any other linear-type structure, would be sub-optimal in the pursuit of a useful representation of the supply process. Although the concept in figure 8.2 has some improvements, it also has, in common with all other chain models, the following short-comings:

- lateral interaction and benchmarking

  These were seen to be potential areas of inter-organisational learning. The regional supply networks and informal kyoriokukai have assisted firms in their drive for efficiency and the sharing of experience and knowledge.

[4] The mnemonic here stands for the 'engineering quality improvement programme'. EQUIP includes all of the process improvement programmes seen in the machine tool builders as described in chapter six - both on the production and design sides of the business, and the HR related side. The soft systems concept of the input -transformation-output process, surrounded by a feedback loop was presented by Ed Henshall, internal quality consultant, Ford Motor Company, at the First World Congress on Total Quality Management in 1995, (Kanji, 1995).

Within the physical sciences, experiments have shown that the alignment of the materials within a conductor can have emergent results. An example being a force applied to a ferrous material, producing magnetism, or the generative effects that occur when the atoms of conductive wires are aligned (Walmsley, 1910). These two examples are comparable with internal organisational change or re-engineering - the first with a step change, the second with incremental change. As has been described above, the alignment of mental models and shared values within an organisation can produce a learning and output 'vector'.

Although the emergent possibility of internal processes can be modeled using the electrical metaphor, the learning that occurs between *unconnected* firms cannot. A simple, linear-type model cannot do justice to the interconnectedness of the wider system.

- the *encouragement* of emergence

  In the HR section of chapter six and the supplier development section of chapter seven, space was devoted to the issue of the encouragement of emergence. Although elements in the system are able to interact on a self organising basis, they must be shown as free to do so. Years of hierarchical power have instilled an element of fear into the worker, along with an ignorance amongst management of the worker's ability to improve the products and processes worked upon. This was thought to be the work of distant designers and managers.

Providing the non-recriminatory framework in which responsibility and accountability can become the norm is an important aspect of the supply system, since it directly affects the output from the organisational elements. Once again, the chain cannot depict this, since the nature of interaction is ignored.

- the nature of the individual

Although the introduction of the K-factor into the circuit showed the importance of feedback and interaction, the actual nature of this interaction and of the individuals involved in it cannot be addressed. In chapter seven, the nature of the individuals - their educational background and values - was seen to have had important influence on the outcome not only of the platform design and development teams, but also on the continued procurement decisions and supplier development programmes.

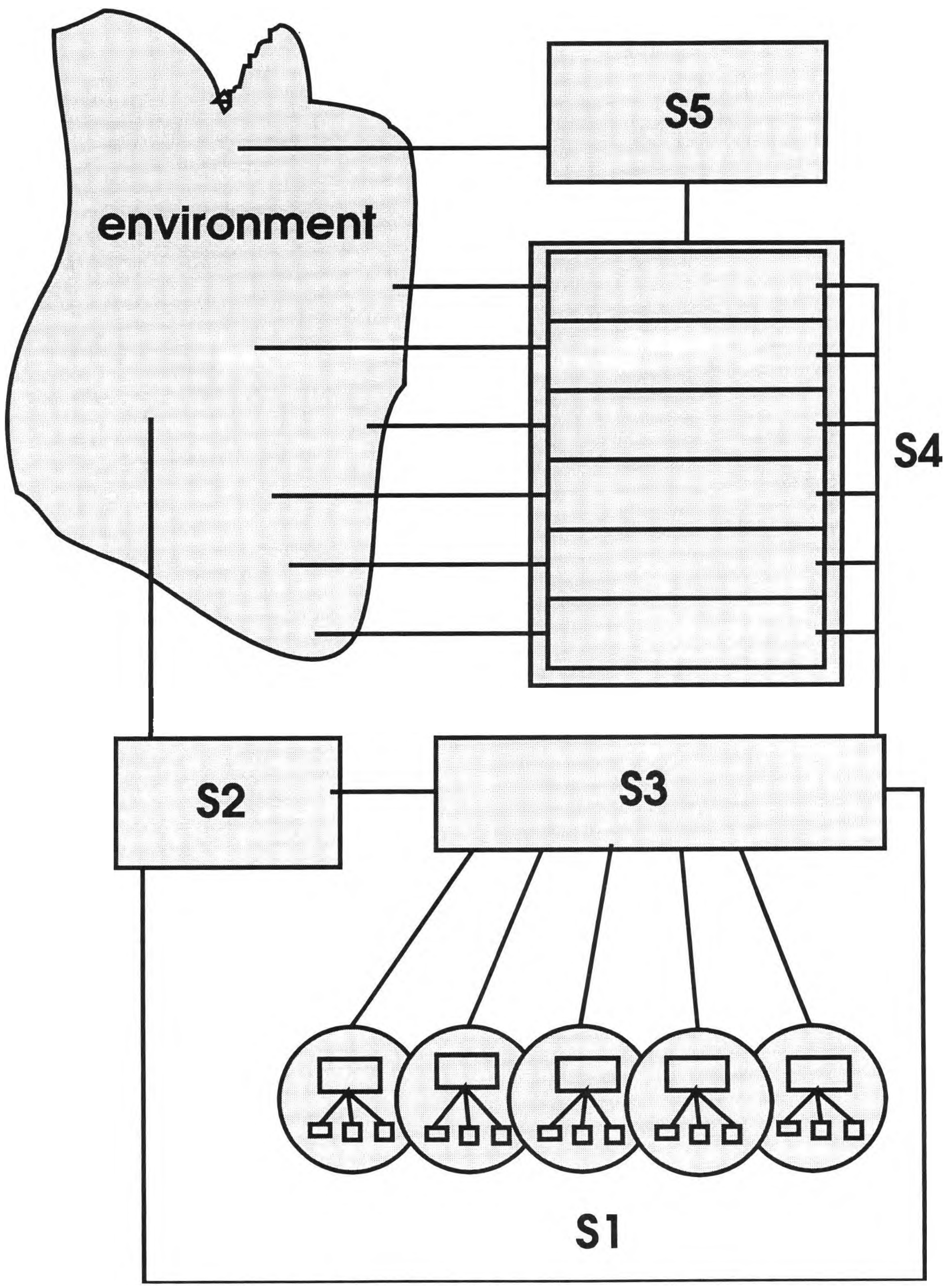
Ensuring that the individuals involved are appropriate not only requires interaction between the employing departments (the customer) and the recruiting departments (the supplier), but also the recruiting department (now customer) and the education system (the supplier of human capital into all industrial and societal systems).

No models of the industrial supply system have, in the experience of the author, as yet included the interaction of the organisation with the education system. The concept is introduced, however, in Clewer, (1995 [b]) and Chelsom and Clewer, (1995). Certain elements of industry are slowly changing to include education more and more, but these are unfortunately the exceptions, rather than the norm[5].

[5] It must also be said, however, that academia itself must also do more actively to seek the requirements its customers (employers) are now expressing. Just as QFD has been employed to create market-driven quality in products, so it can be used to produce graduates that suit the requirements of industry and society as a whole. This is the responsibility of the education system, which at present does not seem to be met, and which is affecting the ability of the supply system to meet the competitive challenge. Having extended the boundaries of the WSOI to include customer and suppliers, there is an argument for extending them further to include the education system when there is the need for either recruitment or further training.

FIGURE 8.3

The Structure of Beer's Viable System Model Showing Subsystems 1 - 5, the Environment and Lines of Communication and Control



B.2 - The VSM as an Alternative to Organisational Modeling

Having identified these shortcomings from both the perspectives of Systems Theory and empirical evidence, the search for a Systems tool was begun that could include those systemic characteristics that can encourage market-driven quality. It was found that the work described in chapter seven on the nature of the individuals involved in supplier development provided the key to the solution.

The VSM was originated by Stafford Beer and is also described in Flood and Carson (1993), and Espejo and Harnden (1989). It is not intended that an in depth discussion of the model be given here, since this has been done at length in much of the Systems literature, including those mentioned above. It suffices to say that Beer attempted to create a model that would be applicable to all systems. It would be able to depict those areas where emergence is encouraged, where hierarchy is evident and where interaction takes place both systemically and environmentally. The very name alludes to the use of the model - it seeks to show the structure that a system needs to adopt or possess in order to be viable over a period. Viable here meaning robust enough to withstand entropy and also to be able to exploit the dynamics of complexity. The model, shown in figure 8.3 in the page above, has been observed to be applicable in political, industrial and human physiological systems.

Having made the assertions about the short-comings of the extant models of supply as outlined above, a new model was needed. The chain and the traditional model of the hierarchical organisational chart were sub-optimal. Attendance at a seminar on the VSM[6] uncovered an immediate similarity between this Systems model and the way in which the target organisations had begun to restructure their procurement operations. Further study of the model and its mechanics have shown it to be appropriate as just such a new model for organisational re-structure.

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[6] With thanks to Dr. Sionade Robinson, Department of Systems Science, City University, London.

The VSM consists of 5 functional elements (each possibly systems in their own right) on each resolution of the hierarchy in question. The elements are almost totally interactive, and exist in association with an environment. Within S1[7] are to be found the operations of the system; those elements which implement actions in order to achieve the systemic purpose. Each sub-system in S1 has the potential for autonomy in its own right. At a higher resolution the elements within S1 become individual viable systems themselves, whilst at a lower resolution the viable system thought of at one period becomes part of the S1 of another, greater VSM.

The systems 2-5 are management systems guiding and encouraging S1 to generate the greatest amount of emergence possible. S2, for example works towards assuring harmony and consistency amongst the S1 elements. S3 provides the interface with the higher, decision-making elements in the system. It does more than the coordinating role of S2 - it ensures that the coordinated effort of S2/S1 is consistent with the policy of S4/S5. S4 provides another interface - between the essentially operative systems below it, and the environment around it. Where there are interactive and interdependent operative areas, S4 is the coordination of these. Using the metaphor human physiology, S4 is the part of the brain that matches the sensory perception, motor impulses and personal desires to effect physical movement towards an object, avoiding obstacles in the path, and taking the shortest most effective route. Lack of coordination in this action would make arrival at the object not only somewhat hazardous, but also something of a matter of chance!

S5 is the element in the system that would have made the decision to move towards the object in the example above. If S4 is 'intelligence', then S5 is the mind. It is the decision making function of the system, rather than an executive one.

In appendix A8.3 a,b&c, the structures of the procurement interface of Ford, Nissan and Rover are shown in terms of the VSM. Traditionally, these structures

[7] The abbreviation 'S1, S2...' means 'system 1, system 2...'

would still be given in the form of an organisational tree chart, where the emphasis is on reporting lines and authority - i.e. the importance grows as one moves up. In the viable system model, including those shown in A8.4, the emphasis is on interaction, feedback and control. This is shown by the overlapping of elements as well as by the lines connecting the elements which represent lines of communication and information exchange.

S1, as stated, is the implementing element; it is where things actually happen. From the organisational perspective in the supply process, S1 represents the interaction of the buying teams with the supplier[8]. Ford, Nissan and Rover all have slightly different approaches to this interface as described in the preceding chapter. All effect a strong element of integration across suppliers. This affords learning benefits to both the buying organisation and the supply base.

S2, the coordinator and developmental system, is also approached from three different angles by the three companies, but each performs essentially the same task. Ford's Supplier Technical Assistance (STA) addresses the technical development of its suppliers, leaving the commercial aspects to the purchasing activity[9].In Rover, technical support is offered by the development team, and commercial guidance from the purchasing area. Assistance is given in both areas by experts from the Warwick Business School, Warwick University[10]. Nissan's supplier development team takes care of both technical *and* commercial aspects

[8] With reference to the above description of S1, it is the supplier that is here the autonomous unit, and which on a higher resolution could exhibit its own viable structure. This is the concept of recursion - that systems exist on various levels of a hierarchy, and that on each level of this hierarchy there are structures to be found which are replicated on both subordinate and superordinate levels.

[9] Hence the mandate for STA under the Ford 2000 reorganisation is "to increase the manufacturing process capability of suppliers to achieve Ford's quality requirements and price targets." The purchasers' role is "to provide dedicated and co-located support to the vehicle centres and product centres (i.e. to source them) with responsibility for part procurement and quality."

[10] The Rover Group case was the best example found of industrial collaboration with academia. Rover used Warwick in policy making and implementation, and exploited the possibilities of the proximity of the school to found the Rover Learning School. Further education is also offered to Rover employees on other courses. Several Rover employees have now been employed by the University to perform research and to teach prospective engineers and managers using their direct experience of change and lean manufacturing.

A role similar to that of the S3 elements was seen to exist in the three organisations. Within Ford, the Core Purchasing team fulfilled this role, along with the higher levels of the more day-to-day volume purchasing teams. Through interaction with the other areas of the company, Core Purchasing fine tunes procurement policies for the coming periods, and coordinates the activities of the operative elements to ensure that existing targets and strategies are met. The internal specification of the role of Core Purchasing is "to manage the composition of the supply base and establish rates of improvement with suppliers" through interaction with the buying *and* engineering functions. This mixture of commercial procurement and engineering input was also evident at Rover and Nissan.

All of this behaviour marks a departure from the uni-directional linearity of the chain model, and the antagonism of the related 5-forces model of competition. The latter would have completely precluded the scope for continuous learning that is afforded by the partnership approach.

As an operation, procurement is, of course, only one essential function found within a manufacturing organisation. The whole process of supplying consumers with quality products also involves other functions. It is this set of functions that comprises S4, as shown in appendices A8.3&4. S4 itself is an important element as far as intra-organisational emergence and information is concerned. Each function represented in S4 has 'below' its own S1-3, building up a three dimensional structure[11]. The various 'levels' come together to meet at S4, and it is here where much experience of the various different suppliers and customers of the respective functions is exchanged, and where cross-functional interaction occurring in the elements S1-3 is encouraged. As explained in preceding sections and chapters, it is such interaction that increases efficiency, improves products and processes, and helps to achieve the purpose of the system as laid down in the root definition - i.e. the all round satisfaction of the system's elements, and the final consumer (where this is not already a systemic element).

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[11] Once again this is recursion. The VSM is able to deal with interactions on all three 'X, Y and Z' axes, because there is a recurring pattern across the dimensions of viable systems.

S4 also provides an invaluable interface with the environment. In reality this would also be done by those in S1-3 too, and indeed some of these individuals are capable of being members of all four systems. It is important that the VSM structure is not read in the same way as the organisational chart - each system does not represent boundaries around individuals, but simply around types of behaviour. Within the environment are to be found those firms with which benchmarking is performed, as well as financial institutions and all other parts of the 'rich picture' seen in A8.1.

Finally, S5 equates to the board level of the organisation. Whilst S4 provides intelligent information and synergic communication and coordination across organisational dimensions, it also communicates strategy and policy downwards from the 'brain' of the operation. S5, too, has significant interaction with the environment - using it as a framework within which to set future strategy and policy, and drawing from it information on which to base strategy and policy.

In such a model there is no top-down control, rather there is influence. There is no functional separation other than that necessary to perform the tasks at hand - interaction between functions is necessary for the system itself to be viable.

B.2.1 - Criticisms of the VSM

No effort has been made to adapt the systems seen in industry to fit the VSM. They have adapted themselves. No awareness of the VSM was found amongst those engaged in the systems seen in industry - the organisations had restructured along those lines thought best for what has become a much more holistic approach to the management of the business of supply. This somewhat organic process could be seen as a validation of the VSM due to the success that the new structures are generating compared with old ones. Such validation is not, however, the intention of this section. It is left to others to provide that.

What is important is that an accepted model has been found that does accurately represent what is occurring in industry. If validation were the intention of this discussion, rather than description, then certainly the nature of the structures that the three target organisations have adopted is validated by the VSM itself.

Nevertheless, the VSM, as a tool originating from the study of cybernetics, does attract strong criticism from certain areas of the Systems movement. Flood and Carson (1993), Checkland, and Espejo and Harnden give examples of this. The main criticism seems two-fold.

Firstly, the VSM *appears* to be a model from the harder end of the Systems spectrum, and is, as such, somewhat inflexible. Offering it as a model around which organisations should structure themselves could well ignore the idiosyncrasies of the firm. The inflexibility also stifles the organisation's ability and readiness to change.

The second criticism is also linked with the soft-hard dichotomy. It is argued that the VSM pays too little attention to the individual. Too much attention is paid to the links between the systemic elements, rather than the individual elements themselves, which, in a human activity system, are so very important.

From the experience gained by the author during the field research of the current project these criticisms do not apply to all organisations. All three organisations mentioned in detail are engaged in the same business of assembling motor vehicles in the UK. However, all three are also very different. The fact that one has its roots in Japan, one is owned by a nation with a strong culture, but has important locations in many others, one has had to lose the shackles of public ownership - all these variables make for highly concentrated, as well as distinct, organisational cultures. Despite these differences, all have arrived at a structure similar to the VSM, and all have achieved substantial benefits.

Since Systems Science accepts generic similarities across systems, the ability of the three to adopt similar structures and for them to work should not be surprising. The VSM is not a detailed model - its does not prescribe the nature of the individual departmental organisation, nor the personalities involved, nor the particular processes it uses. The VSM has its roots in the structure of the human body (Beer, 1979). Humans display the structure of the VSM, and it certainly cannot be said that there is not variety in the human species. As far as change is concerned, retaining a concentration on communication, interaction and information exchange should avoid stagnation. Surely an increased awareness of the dynamics of the environment prevents stagnation?

The second criticism of the human factor is also called into question in this research. The restructuring that has occurred over the last five years (and still continues) has been initiated to take the human input into account, and indeed to assist it. Since it is this input from which emergence arises, and improvements originate, it would not have made sense to re-engineer the organisation around a system that continued to shut out its most valuable asset.

Flood and Carson do, however, list one criticism, from an epistemological perspective, that is considered justified:

> "The cybernetic model is held to give an impoverished, or subset, picture of organisations."
>
> (1993, p.87)

The five-system structure, as outlined above, only shows detail of the procurement activity - including all other functional dimensions would not be possible in the two dimensions of paper. Nevertheless, awareness of the recursive nature of viable systems should keep the user alert to the important existence of other dimensions.

More important to this research is the fact that only immediate suppliers are shown - those that have direct contact with the buyer in the vehicle assembler. In the 'old way' of supply base management this would have been appropriate, since systems procurement was less common. With increased tiering in the system of supplier organisations, fewer suppliers deal with the major buyer directly, and many are therefore excluded from the boundary of this model, but are definitely included within the boundary of the system.

Another exclusion is what other models have solely modeled - that of the flow of physical product. The return of this physical product for recycling is furthermore omitted. This research also calls for the education system to be included in any new model of supply, and this is not the case in the VSM.

These are not criticisms that invalidate the VSM. Rather they simply put a limit to the immediate utility of it as a model. It does offer a subset picture, but it is not felt that this is impoverished - since this is all it claims to do: it shows structure, not flow. In chapter nine - the final chapter of this thesis, the structure that has been observed in industry will be adapted to create a fuller picture than that offered by the VSM. The culmination of the research, presented in chapter nine, is a model of supply that is argued to show the total system. This model will show the important flows, feedback and interaction that encourage emergence as well as elements of the recursion, control and hierarchy that are the basis of the VSM.

Summary

The second part of this research explored the real world of machinery supply to the automotive and aerospace industries. It showed how the organisations involved in supply are increasing the efficiency of their internal processes, as well as their inter-organisational interface management.

This analysis of industrial behaviour illustrated various things. Firstly it highlighted the interconnectedness of apparently unrelated variables in the business process, and how small effects in one can effect large results in others. It also showed how similarities existed in the manner in which seemingly unrelated groups are managed - since these are all groups of human workers, this should not surprise the Systems thinker. Also of importance was the realisation that supplier performance can be stimulated by customer behaviour, and that customer behaviour conducive to supplier development is also, in turn, beneficial to the customer. In detail, the individual chapters presented ways in which the machine tool sector was increasing its efficiency, and the way in which present day automotive manufacturers in the UK are addressing the need to change the way their machinery suppliers are managed. These two areas alone are new to the study of the management of machine tool manufacture.

Overall, the second part of this research highlighted the real complexity of the machine tool market, and how it is being dealt with and harnessed - perhaps the *leitmotif* of this research. A rich picture of the machine tool market was formed, from which a 'root definition' of the supply process was obtained. Arriving at the purpose of the system in this way was seen to generate a wider ranging definition than had been accepted previously.

This greater understanding of the purpose of the supply system is argued to be proof of the inadequacy of extant models of supply and business. Such models as those of Porter do not and cannot depict the complexity of the market, nor encourage what is necessary for continuous improvement and learning through PDCA-like processes.

A tool from Systems Science - the Viable Systems Model - was then used to show how the restructuring of the supply system in industry was consistent with the principles of Systems Thinking. Nevertheless, the VSM as a model is still not sufficient to represent the whole process of the industrial supply system because of its concentration on structure. This is the subject of the next, and last chapter - modeling the system.

CHAPTER NINE - MODELING THE SUPPLY SYSTEM

Men honour what lies within the sphere of their own knowledge,
but do not realize how dependent they are on what lies beyond it.

Chinese proverb attributed to
Chuang-tse, ancient Taoist philosopher, in
Benjamin Hoff,
"The Te of Piglet"

Introduction

Chapter nine is the final chapter of the description of the current research. It is, however, followed by the conclusions and recommendations that have arisen from the research. In preceding chapters a problem situation was outlined by statistical and anecdotal evidence. The extant literature pertaining to this situation was also reviewed, along with existing models of the situation as used and taught in industry and education.

Reasons were then given as to why the extant literature and models were considered sub-optimal. A new perspective, that of Systems Science, was introduced, from which an analysis tool was chosen which appeared suitable to an exploration of the problem situation. This tool was Checkland's Soft Systems Methodology (SSM). SSM entails a comparison of the '*ist*' and '*soll*' of the situation, and works towards an holistic model of the *system* of interest from which the situation arises.

In detail, the current research set out to explore an industry in decline which had, in some areas, died out altogether. This was the UK machine tool industry. The field research attempted to uncover the reasons for the survival of certain organisations and to investigate the nature of their business processes.

By using the SSM process in chapters two and four, the machine tool industry was shown to be a complex human activity system comprising of many interacting, interrelated elements, the scope of which was far greater than has traditionally been considered important. Intraorganisational issues were confirmed to have significant bearing on the machine tool builders' success, but *inter*organisational factors were found to be equally important in the drive to achieve efficient and effective business processes and practices. Such interorganisational perspective has not been acknowledged before in the machine tool literature, and has not been included in models of the process. The organisational 'gap' has previously been accepted as a 'black box' rather than a source of emergent advantage. Failure in the industry was, in this research, often traced to organisational and cultural distances that reduced the ability of the organisations to realise the potential that arises from such interaction.

It was seen, in chapters three and five, that whilst industrial behaviour implied ignorance of the benefits of interaction and information exchange, existing models that claimed to represent competitive behaviour also neglected to depict these non-physical flows. Without these non-physical flows, or where they remain poorly managed, the market quality of the physical flows - what existing models depict quite well - cannot be guaranteed. Once again, the importance of a marriage of physical and non-physical aspects of supply has not previously been attempted. Consequently, the argument was put forward that competitive advantage is not simply a factor of physical 'value creation', or addition, but also a factor of the quality of individuals involved in the process, and their ability to communicate and interact with other elements in the system. Competitive advantage was seen to be a dynamic concept; attainment of advantage is no guarantee of its retention. The processes and elements in the business environment are what, together, form the system. The human elements of these processes have begun to acknowledge such dynamism and the resultant need constantly to improve and learn. This continuous improvement is captured in the kaizen philosophy as well as the PDCA cycle, increasingly referred to in those parts of Western industry where the importance of feedback has been realised.

Chapters two, three, six and seven were secondary and primary research into the true nature of the system of industrial supply. Having become thus acquainted with the industry and its stakeholders, a CATWOE analysis was performed, as was discussed in chapters four and eight. From this analysis a definition of the purpose of the system was obtained. This definition included a wider range of perspectives than had previously been taken into account, and offers a possible answer to the question of the industry's decline in relation to the Japanese model, and that of other South-East Asian nations.

A - Requirements of a new model

Having performed the first five stages of the SSM process in earlier chapters, chapter eight discussed two attempts to model the resulting 'system'. The first of these addressed the flows (dynamics) in the system, the second the recursive structure of it. Both attempts contained improvements on what existed, and were examples of what Systems tools can achieve. However, a new model is required that can capture the essence of the dynamics of the system, and its structure, in their entirety in a way that the ingredients of emergent effort - as found in the CATWOE definition - can by represented. These are the requirements of the new model to be arrived at in this chapter. In the process of building the model, it will be seen that various aspects of the existing models, such as the interaction and chain models as well as those touched on in chapter eight, will be used. This is recognition that much of the foundation of extant models is of use. Often their danger lies in their sub-optimality, rather than their basis.

To recap, the model depicting the system within which machine tools are supplied to industrial concerns (the industrial supply system) must be able to depict the following characteristics of the process:

- the flow of physical product within and between firms
- the flow of information within and between firms
- the flow of products *and* information between the firm and the consumer
- the feedback-loop nature of these flows
- the recursive, hierarchical nature of the system and its tiers
- integration of firms, groups or individuals on different levels of this recursion
- integration of firms, groups or individuals *within* the same level

- integration of complementary firms within the system where they originate (i.e. rather than only within the user organisation - hence the creation of systems tiers)

- the inclusion of the education system, and of vocational education and training to show the importance of human capital input

- recognition of the importance of recycling in the system to complete the cycle, and also to increase efficiency

- recognition of the existence of a 'technology push' emerging from the science base, complementing the flow of market pull

B - Building the Model

A model that manages to fullfil these requirements does more than offer the ability to track costs, facilitate administration, and allow for a disaggregated competitive positioning, as is the case with Porter's model. It must also be able to embody the purpose of the system as arrived at in the CATWOE analysis of chapter eight. Through depiction of the above variables the model must be able to illustrate how competitive advantage is encouraged, achieved and retained. Through the ability of the firm to achieve quality in its products and processes by driving for emergence from the system, consumer and customer requirements can be met, if not bettered. Through acknowledgment of feedback and learning, costs can be reduced with no adversarial tactics or usurious behaviour. It is this sort of model that will be the result of this chapter.

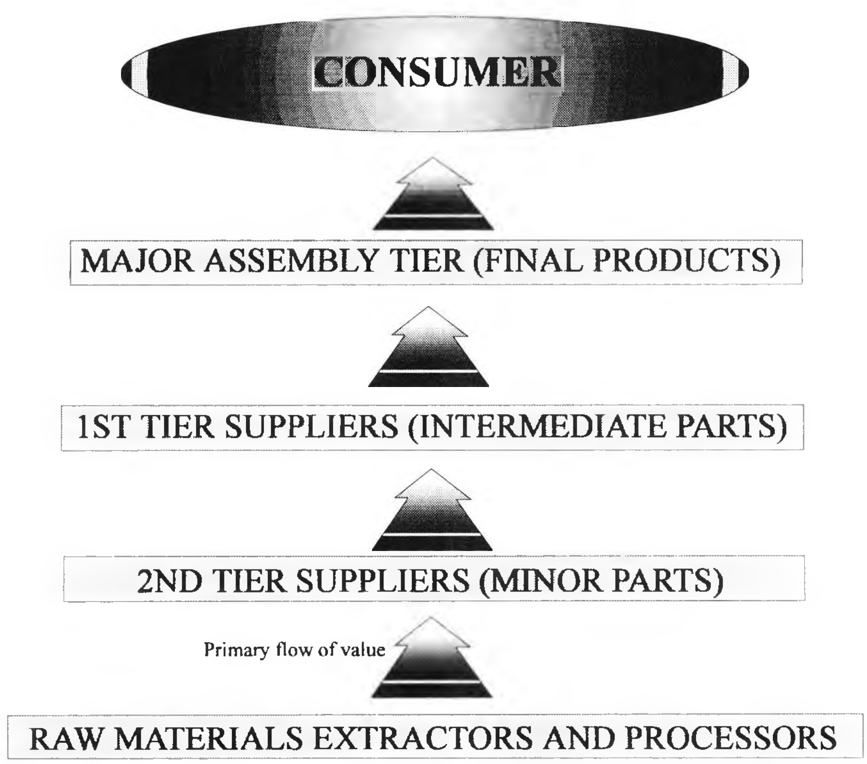
Four stages are discussed in the creation of the model. From the starting blocks of a traditional chain model, elements of interaction, feedback and hierarchy are introduced. The system is then extended away from the pure organisational focus of current models to create an holistic picture of the true supply system.

B.1 - Stage One

Figure 9.1 below shows the chain relationship of firms in the supply of goods to consumers. The flow of physical products is termed here the 'primary flow of value', since value is added to the product in this general direction. The potential for this value addition - created by information and feedback - is ignored, however, and needs to be brought in in subsequent stages.

FIGURE 9.1

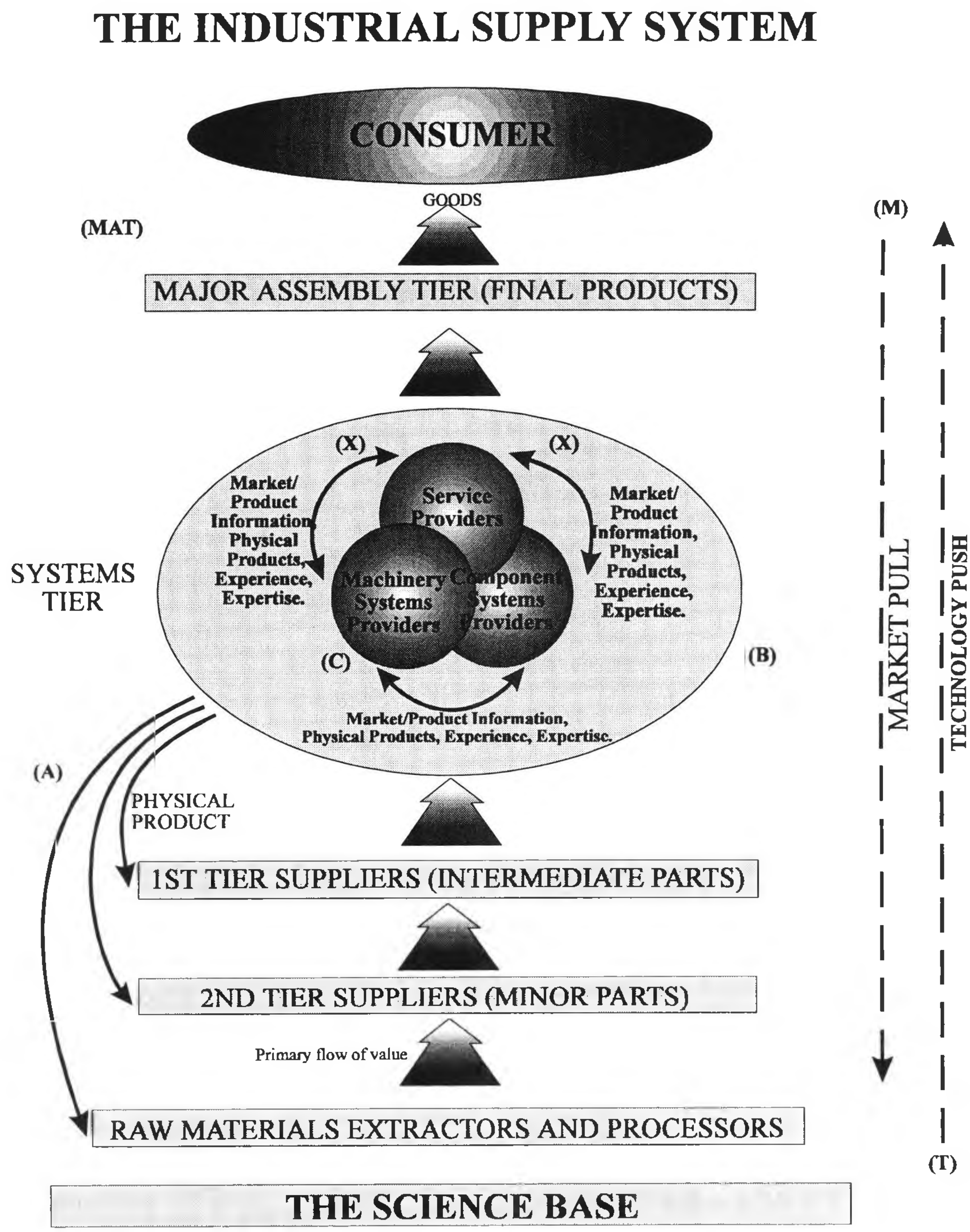
THE INDUSTRIAL SUPPLY SYSTEM



B.2 - Stage Two

The model shown in figure 9.2 below addresses some of the initial criticisms of the chain model.

FIGURE 9.2



The importance of the market and market information (M) is show in opposition to the flow of primary value. Complementary to this is flow (T), the influence of the so-called technology push rising from the science base. There is also a flow of physical product from certain suppliers to others in opposition to the primary flow of value(shown as A). This flow represents, for example, the provision of facilities used in work processes supplied by customer organisations attempting to assist their suppliers. It also represents logistical units such as crates and pallets supplied by customer organisations to the same end. It also includes the flow of information from the customer organisation to the supplier that the supplier requires to fulfil orders.

In the example of Nissan in the UK, for example, this flow is especially important to the lean manufacturing system. Where production of components is organised on a just in time basis, both the supplier and the customer are dependent upon requirement information that flows 'backwards' in the system.

The major improvement of this 'second stage' is the creation of a 'systems tier'(shown at B). This tier, situated 'above' the first tier of suppliers acts as a coordinating, procurement and project management tier, as well as being involved in assembly and limited amounts of machining and production. It is a part of this tier that corresponds to the machine tool industry (C), as visited in the research. Also in this tier are, for example, software houses that provide CNC programmes, design houses to whom the major assemblers contract out aspects of their design, and, of course, component suppliers. To this tier also belong those organisations not directly related to the tier's line of business, but whose related processes are of interst for benchmarking activities.

The old model would have accepted that these three elements of machines, components and services meet only at the 'OEM' tier (the major assembler tier, or 'MAT'). World class systems see a far earlier integration of these firms however, and indeed one where the classifications of 'service provider' or 'component supplier' themselves become fuzzy (hence the 3-fold overlap in the centre of the systems tier). Many machine tool builders, for example, now offer substantial services themselves, examples being design or maintenance, as well as advice in the CE environment.

The importance of this integration is more than coordination in order to provide what the MAT needs to satisfy consumers' requirements. It is also important that the various different organisations in this tier are seen to have freely flowing exchanges of information and knowledge of products, processes and the market. These flows (X) form the feedback loops which generate emergent properties in the system, and were one of the vital omissions from the chain model.

B.3 - Stage Three

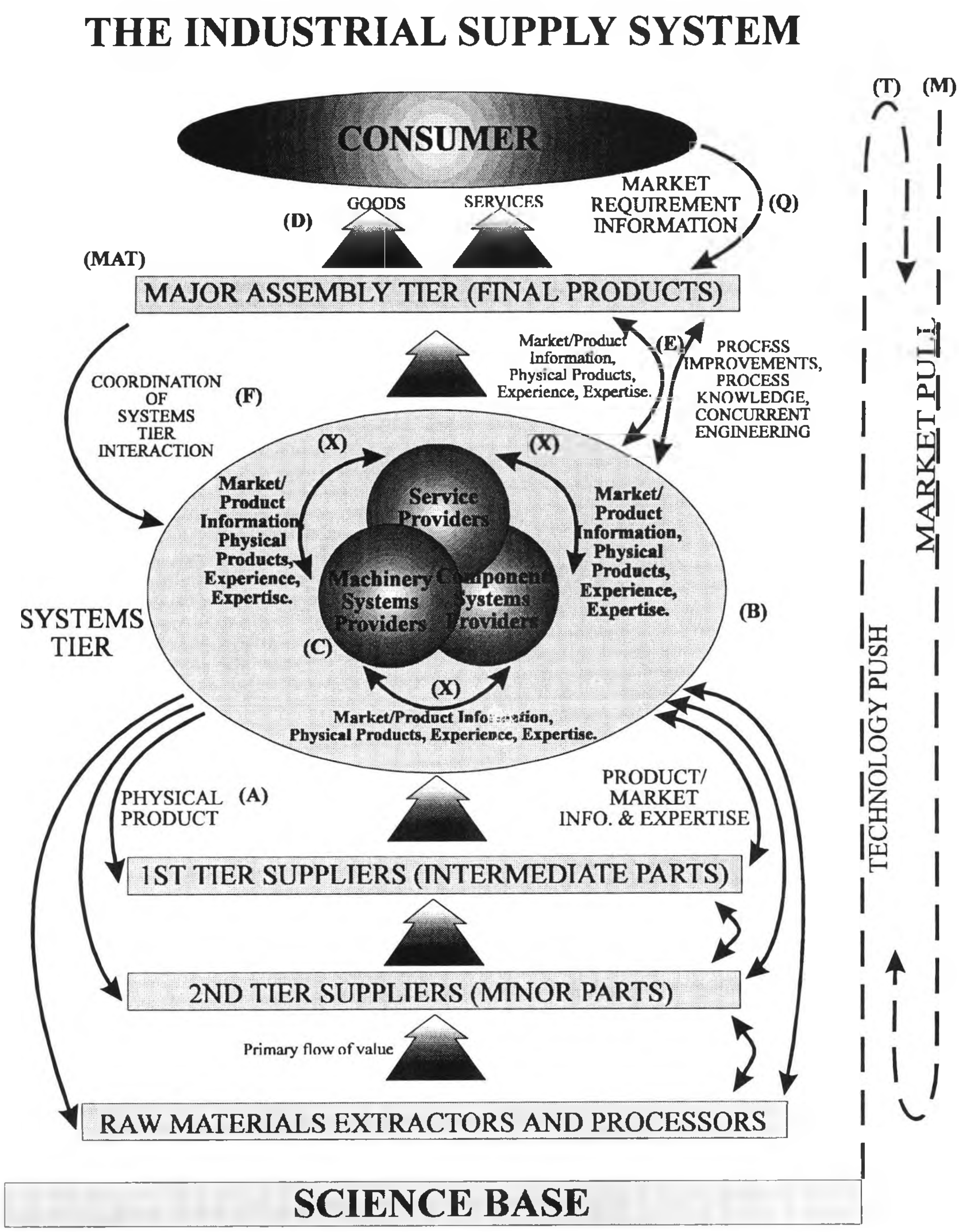
The next stage of the model is shown in figure 9.3. Here the full complexity of the situation becomes more apparent. Figure 9.3 is shown below. At (D), for example the full portfolio offered to consumers and customers is expanded to include the services the MAT and systems tier provide. These include financial services or repair and maintenance. At (Q), the initial feedback that is gleaned for use in QFD is depicted[1]. This is integrated with the flows of information at (E). These are the synergic results of the pooling of minds in the design and development processes of concurrent engineering, along with the subsequent integration of the supplier and customer during the installation and usage phases.

The recursive nature of the system is shown by (F). Just as the MAT, as the customer of the machine tool industry, passes knowledge back to its systems tier and direct suppliers, of which the machine tool builder is one, so do these direct suppliers pass information back to their suppliers. As a result, market information is passed back through the system, from where it is actioned upon and fed, once

[1] Market information input, as shown in the model by (Q), is combined with other intraorganisational feedback to generate the output from QFD. These other feedback flows come from manufacturing areas, service areas and engineering areas.

and 'bounces' back towards the consumer. This creates a feedback loop that is broken and delayed by the various tiers, but one which nevertheless sees information released from the consumer level returning to it once again in the form of final product.

FIGURE 9.3



This final product does not consist solely of value added physical product, but also contains an intangible element of non-physical information addition. (Q), (E) and (F) represent other 'sub-ordinate' feedback loops that are created as 'spin-offs', and which increase the potential for the efficiency and effectiveness of (M), (c.f. figure 7.6). The technology push is similarly bent - innovative products and processes from the science base are only successful once market-tested[2].

The MAT coordinates the activities of those tiers below it - those elements upon which it depends for quality inbound logistics. In turn, the systems tier is becoming increasingly active in the coordination of those tiers below it. By looking at the model the need for this is easily recognisable: if the MAT depends upon its subordinate levels for inbound quality, then the various subordinate levels must also be dependent upon each other.

In the text of chapter seven the need for the devolution of responsibility in the system was discussed. The flow at (F) is not simply information exchange in order to facilitate better products. It represents what would traditionally have been regarded as the surrender of competitive advantage by opening the door to the abuse of 'bargaining power'. In other words this exchange could not have happened in the Porter model because of the need to reduce this risk. The interaction model concentrates more on the complexity that arises through the number of interactions, rather than the nature of both the interactions themselves and the individuals concerned.

The degree to which suppliers in the supply system are responding to this need for trust-based information exchange is at present low, but if the current example and results of the real world systems tier is representative of the future of the whole system, the volume of coordination and integration will increase - it must.

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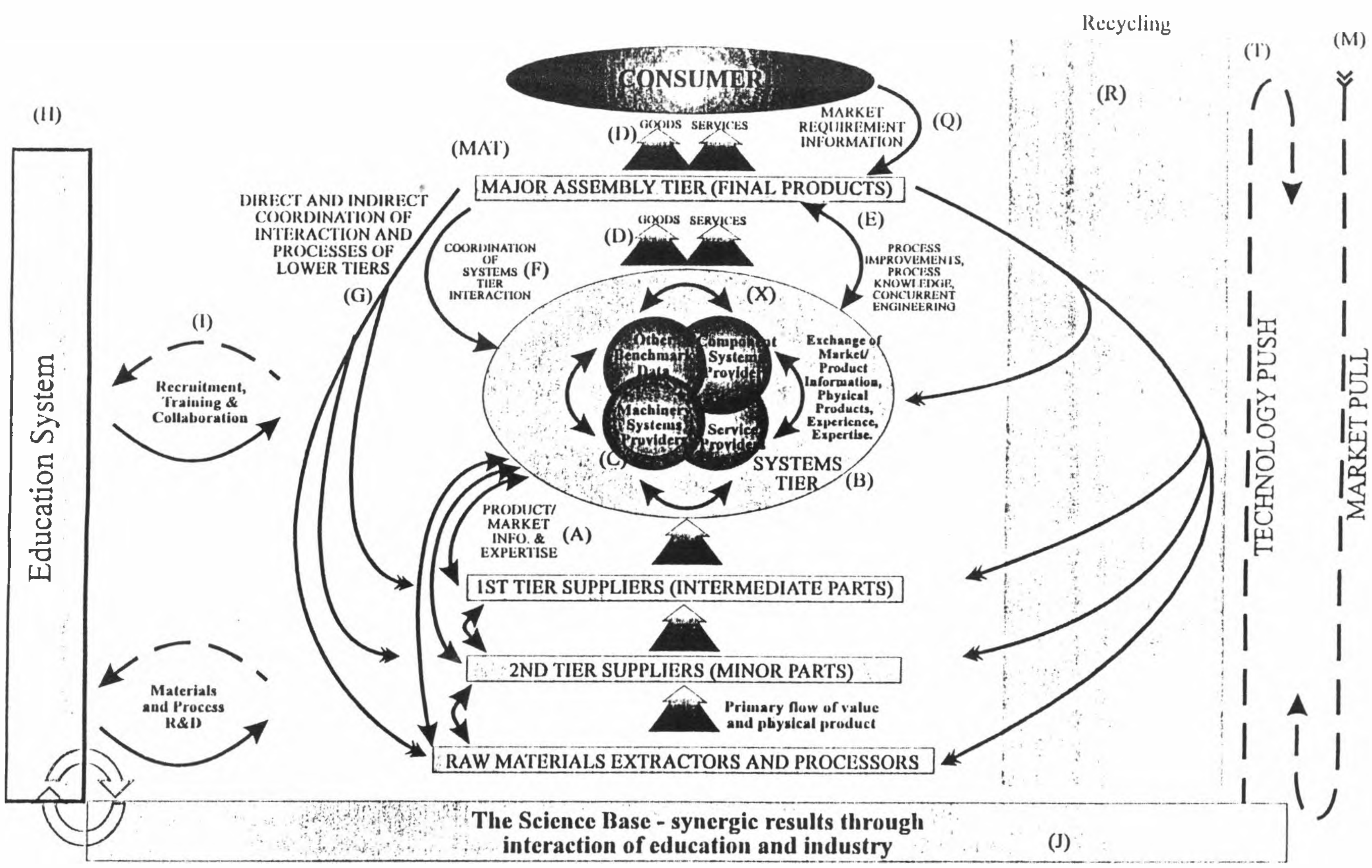
[2] The Sinclair C5 is a prime example of what can happen when appropriate market information and feedback is not obtained to guide the push from technology.

Figure 9.4 - The Supply System



B.4 - Stage Four

Figure 9.4, shown on the pull-out page above, completes the creation of the supply system from the perspective of the current research.

The flow shown as (G) helps the purpose of (M) - achieving market-driven quality. As was investigated in chapter seven, the MAT plays a role in the coordination of the activities of the lower tiers. This involvement includes commercial advice as to project management and procurement, as well as technical advice and business survival. Quality audits and supplier development are included in this flow. Stage three above introduced this concept to the model in flow (F) - now it is extended to show the influence that the major players in a market have not only over their direct suppliers, but over their suppliers' suppliers too. This is the second half of the feedback loop which, along with the provision of physical output or of services, shows how what customers do to their suppliers they do to themselves.

As well as the feedback flows shown in the above three stages, there exist others *within* the elements of the organisation itself which are of importance, and which have not been introduced in previous models concurrently with external flows. Hence, there is now a loop shown in the machinery systems providers circle (C), which represents such feedback loops as those discussed in chapter six - the FMEA process, internal teams and group dynamics or the reinforcing feedback that was found to begin when the issues of tidiness and cleanliness were addressed.

The above three stages were only concerned with the transformation of physical capital in the system. The research conducted in this project showed, however, that the human input into the process is of greater importance than the mere physical inputs themselves. This applied to existing, new and potential employees. Hence the education system is shown as the provider of human capital into the system (H). This element provides two inputs concerning people. The first is actual human input in the form of school-leavers, graduates and people returning to academia for further education. Secondly, the education system provides information in the form of training programmes for those in work. This may happen directly (as in the case, for example, of Warwick University and Rover[3]), or indirectly in the form of consultancy, research, published literature and training packages. It is from this last aspect in particular that academic models, such as the one constructed here and those of Porter, have importance (and therefore why they *must* be accurate).

The input of training and recruitment is shown as (I), and is evident at all levels of the hierarchy. It is significant that these flows are loops, and also that the loop back to academia is broken. The interaction of industry with academia is still too loose and must be pursued with more conviction if the efforts of the education system are to conform to the customer's demands - i.e. those of industry itself.

(I) is not the only area of interaction with the education system that is of importance to the supply system. (J) shows emergent properties arising from the 'science base' (Chelsom and Kaounides, 1995). Research at academic institutions is responsible for the discovery of many new materials and processes. The education of engineers and managers can be coupled with this discovery, not only to reduce duplication of effort across education and industry, but also to produce output from the education system with appropriate, up to date knowledge of advanced materials and processes.

Ignorance of the feedback that can exist between the providers of physical and human capital precludes the emergence of quality workers and slows the advance of new materials science in the West.

The full loop is completed by those activities involved in recycling, shown in the shaded area (R). The arrows represent the disposal of materials as well as the re-appropriation of certain materials that need not be discarded, but can be re-used.

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[3] c.f. chapter seven.

Figure 9.4 represents the supply system in its entirety. The requirements of the model, as laid out above in section A, have been met. It depicts both information and feedback as well as the flow of physical product. It addresses structure as well as flows. It marries human input to physical input and shows both the appropriation and recycling of nature's resources. When compared with figure 9.1, or with Porter's models in chapters two and five it seems hard to believe that the two are of the same process of transformations and interactions. The model in 9.4 is quite obviously a far more complex model with many more elements than the chain. The question that must now be addressed is whether this complexity is required.

C - Innovation in the Model

Having described above the stages of the creation of the supply system model from the perspective of the current research, it seems expedient to outline quite clearly how this model differs from, and indeed improves upon, those models that have preceded it in the area of industrial supply.

Stage one will be recognised as reflecting the Porter model of supply. Stages two to four will contain elements of the interaction approach from IMP, the International Marketing and Purchasing group. These inclusions acknowledge the importance of previous research in the area. Porter's work does show how the physical flow of goods progresses from firm to firm, though not how this is developed and improved. The interaction approach addresses the issue of the complexity of the process (not system) that arises from the array of players in the market, and how this can be beneficial or disadvantageous. The nature of these interactions is not addressed however, nor the individuals involved. In neither approach is the wholeness of the system addressed.

The system presented in figure 9.4 above includes the following innovations that have come to the fore as a direct result of the current research project:

- marriage of multi-directional flows to multi-dimensional structure

- inclusion of non-physical flows, often in opposition to the flow of physical value addition

- integration of market pull from consumers to technology push from the science base - inclusion of both these factors is rare in models of supply, a marriage of both has not previously been atempted.

- integration of vertical and lateral sections of the system, including tiers below what has traditionally been called the 'first tier'

- acknowledgement of the change of status of the major customer organisations from 'original equipment manufacturer' to 'major assembler'

- subsequent change of status of the 'first tier' to a 'systems tier'

- the supply from the systems tier of substantial services (project management, design) as well as physical product

- importance of both intraorgansiational and interorganisational integration and feedback

- inclusion of an 'unconnected' bank of benchmarking experience[4]

- inclusion of supply and continual improvement of human capital from the education system, and of the supply of (partly)used materials away from the production system back to nature or back to previous tiers through recycling

- the hierarchical, recursive nature of the system, and the devolution of responsibility down to self-organising elements in the system

[4] The word 'unconnected' here is used to mean that benefits can come from benchmarking in organisations that are not directly involved in the same business. In fact, this is the usual form of benchmarking, since it is unlikely that an organisation will find best in class in activity X in its own industry. Although common practice, such benchmarking activity is not included in models of supply, nor are the links between benchmarking exercises and improvement in other improvement programmes.

D - Complexity and the 'Ostrich Effect'

When first presented to an audience at the European Conference on Management of Technology, Aston University, Birmingham (1995), during the completion of this thesis, the supply system model shown in figure 9.4 was accompanied by the following commentary in the conference proceedings which is of similar relevance here:

> "The reader seeing such a system for the first time should not fall into the trap of the 'ostrich effect'. When confused, or frightened, by something it cannot understand the ostrich - arguably the mightiest of birds - drops its guard and buries its head in the sand, thus foregoing any opportunity to respond to the challenge it faces."
>
> (Clewer, 1995 [b])

The supply system model shown is a highly complex model. As has been discussed, however, the reality of the system in practice *is equally complex* - if not more so. A model should provide a comprehensible and comprehensive representation of a system, and therefore be able to assist in decision making and training. Can such complexity be said to fulfill this requirement? The answer here is that it must. The alternative is the 'quick fix' warned against by Senge (1990). The chain is easy and simple but has little to do with the reality of industry. Moreover, it fails to depict, and therefore teach, the very essentials of the competitive advantage it claims to be able to achieve.

Both education systems and industry alike need to recognise the existence of this complexity. The education system needs to be geared towards the teaching and demonstration of such complex environments as the supply of industrial and capital goods - with active support from industrial partners. Were this the case, models such as the one presented in figure 9.4 would no longer seem complex, nor confusing, but rather the norm. As 'life on the edge', as Fitzgerald termed today's business life, becomes ever more precarious, and the pace of industrial change accelerates relentlessly, it has become impossible to ignore complexity. It is no longer possible to create models that are comprehensible by kindergarten pupils and hope that they can accurately and usefully depict real world situations.

By studying the meaning and implications of the models shown in this chapter, it is argued that many in industry will discover areas of organisational distance, or barriers to communication in their organisations that rather than being natural, or 'generic', are in fact artificial, culturally determined and are the source of competitive disadvantage. This is the utility to be found in complexity.

Summary

In this, the last discursive chapter of the research dissertation, the detail of the preceding chapters was consolidated into a model of the industrial supply system.

Beginning with a simple model characteristic of Porter's work, and many of those that have followed, additional elements were added until the complexity of the relevant human activity system of interest was truly attained This model is multi-directional and multi-dimensional. No previous models have, at once, provided both complex dynamic and complex structural aspects of a system. The system of interest is no longer the organisation, but the transorganisational processes involved in the attainment of market-driven quality. The model showed the feedback flows of the process improvement programmes of chapter six - concerning processes, product and workers - as well as the essence of the improvements made to the buyer-supplier relationship outlined in chapter seven.

By expanding one of the tiers (the systems tier) it was intended to show that the system is capable of self-replication, or recursion. With an expanded systems tier, the MAT was the customer. By collapsing this, 'lower' tiers could be expanded, whereby the systems tier becomes customer and the 'first tier' would become a system of overlapping elements in itself. This structural element was, in chapters four and eight, discussed as a requirement of viable systems. Interpretation of prior models would only with difficulty have embodied this concept.

The system itself was also expanded to include all systemic elements involved in the input and output from the system. Therefore education and recycling became of interest. A link was made explicit between the output of the primary flow of value and the output of the education system. This link is new. Both are inextricably interrelated and interdependent. Quality in both is a prerequisite of customer satisfaction.

The model of the supply system as a whole takes a far more holistic look at supply than those models that have preceded it. It marries physical and non-physical inputs as well as workers and management, education and industry. The result is an ordered complexity from the apparent 'mess' of the rich picture in chapter eight. Such complexity should not be avoided, nor shied from. It must be understood and exploited if the gap that still exists in many industrial comparators between the West and Japanese and Pacific Rim countries is to be closed, and hopefully reversed.

CHAPTER TEN - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

It is, at this juncture, thought to be of use to re-state the aim if the research. The project was initiated to study the nature of the industrial supply system, using the machine tool industry as an example, and using Systems Methodology as a frame of reference and as a basis for analysis. Three years have been spent in the performance and reporting of the research. Research output has included conferences, publications and teaching seminars, as well as the production of this research dissertation.

With chapter nine the discussion and outline of the current research project came to a close. This final, tenth chapter summarises and concludes the dissertation. It presents nothing new as far as the research is concerned. Rather, it summarises the preceding chapters into a concise logic and draws together the conclusions to be made from the research about the machine tool industry and the nature of the industrial supply system within which, it is argued, this industry exists. Furthermore, this chapter contains explicit mention of how the current research has, or will have, contributed to the bank of knowledge that already exists in the field of industrial behaviour and Systems Science. Recommendations for further research are also given below in section C of this chapter.

A - The Chapters

The nine preceding chapters of this research project have presented a case study of industrial change. The industries involved were the UK machine tool industry - that part of the UK manufacturing sector that provides machines, in this case, for processing metals, and the main customers of this industry, the automotive and aerospace industries. The machine tools are used to mill, drill, bend, form and join - amongst many other functions. Some are tailor made, others comprise part of a standard line of machines produced by the organisation.

The machine tool industry was chosen due to the combination of personalities involved in the foundation of the project. The industrial partner and initial funding organisation, Lamb Technicon, is one of the Britain's leading UK-based machine tool builders. Their help in the project was invaluable, and is greatly appreciated.

A.1 - Chapter One - Introduction

The structure and nature of business of the funding organisation were given in the first chapter of the current research (section A). The aims of the research were also described here (section A.3). The industry has experienced a period of severe decline over the last two decades (not just in the UK), but the emphasis of the research was not simply to uncover the reasons for this decline. The objective was, rather, to uncover what those surviving businesses were doing that was different to others that had failed. It was hoped that such an approach would provide a more positive and useful outcome than extant research that had often concentrated on the pitfalls of individual organisations. Having explored the nature of the machine tool business and the improvement programmes its players were initiating, it was decided to check the validity of the extant models of industrial supply as to their relevance to the second half of the 1990s.

A.2 - Chapter Two - The Machine Tool and Its Market

Chapter two gave more detail about the machine tool, its functions, market and customers. From industrial market statistics (given in the respective appendices) the industry was seen to be in decline. A slight improvement in the market conditions was, however, evident, and this optimistic outlook has continued to the present day. Such optimism only reflects the fact that the industry is no longer declining - the volume of UK production is still far from the peaks of the early to mid 1980s.

A.3 - Chapter Three - Literature Review

Chapter three investigated the literature that exists in the field of machine tool research. Both academic and non-academic sources were described (sections A and B respectively). Many diverse areas were seen to have been studied, but most of them had been analysed in isolation from one another, and few connections had been drawn between business variables that, in reality, are inextricable. The current research project has attempted to crack this isolationist, or reductionist, approach. It is this that forms one of the major contributions of this project to industrial research.

Those literary sources that had attempted to explore an array of business variables and their effect on the organisation began to show the machine tool business in its true light, as a highly complex and erratic entity. Certain authors (especially Gaylord, 1990 and 1991) also alluded to one point which has been emphasised repeatedly in the current research in chapters six, seven, and nine, namely the vulnerability of the machine tool organisation to human behaviour, and hence to human attitudes and values[1]. In Systems parlance this vulnerability stems from the fact that the machine tool organisation is a human activity system; a 'soft system' where the majority of tasks are performed and decisions made by humans. The complexity of the human as a system, its susceptibility to external and environmental influences, means that human activity systems are inherently

[1] This is the case since behaviour is a visible function of values and attitude. Within an organisation a 'corporate culture' may even exist. This is the effect on current behaviour exerted by previous management styles and employee attitudes. Such corporate cultures can be so strong that they override individual behavioural patterns. It is precisely this strength and power over human behaviour that Senge attempts to harness for the good of the organisation through his book 'The Fifth Discipline' (1990). Where corporate cultures are thus harnessed, a learning organisation is said to exist. In learning organisations, the negative aspects of past management styles and employee attitude and behaviour are identified, learned from and, hopefully, avoided in the future.

unstable, complex and erratic. Complexity and the human activity system are further expanded upon in chapter four (section C.1.3.1).

In all, it was seen that the various elements of the extant literature covered a broad spectrum of topics relating to the machine tool industry. It was argued that too many of these elements concentrated on too narrow a range of topics. They are, therefore, unable to appreciate fully the 'rich picture' of the industrial environment and moreover its staggering complexity[2].

A.4 - Chapter Four - Systems Methodology

In chapter four the concept of the System was introduced. Various descriptions of 'a system' were given (section C.1.1 and C.1.2), ranging from a mere set of 'things' of no special connection to the fully integrated, interacting, interrelating and interdependent set of elements idea of Systems. It is this latter description in which the Systems Movement is interested. Of equal importance to the type, nature and volume of elements seen to interact on and in a System, the chapter described how the very interactions themselves create 'feedback' effects which can either negatively or positively affect the System (section C.1.3.2). This last point alludes to a further characteristic of the System - that it has a purpose. Feedback can either aid the purpose, or mission, of the System, or hinder its achievement.

Just as the perspectives, attitudes and behaviour of human activity systems are ever-changing, so is the systemic purpose - the aggregate requirement of all the systemic elements. This change creates system complexity (section C.1.3.1). A system is said to be complex in its detail (the number of interactions and elements) and its dynamism (the changing nature of the interactions themselves).

[2] This rich picture is discussed in more detail in chapters four and eight; in the latter it is also depicted.

Systems Science is the study of the nature of Systems and their behaviour. Chapter four introduced the many aspects of this effort, mentioning both the 'hard' and 'soft' schools, as well as the roots of the discipline in cybernetic engineering. Some of the analysis models, or tools, were also described in section C.2 - these are what the so-called Systems Thinker may use in the analysis of complex situations.

Chapter four introduced the detailed review of the System as a concept with a discussion of 'problems', and 'problem situations' (or complex situations) in section B.1. It was argued that a problem only exists as a function of individual perspective. Seldom are problems universal or generic. This introduces the second important contribution that the current research makes to the literature, and is related to the statement made above about the vulnerability of human activity systems. Not only is the 'human factor' the source of vulnerability, it is also the root of 'problems'. Only in the eyes of the human elements are certain situations problematic. For example, the decline of the UK machine tool industry is quite evidently a problem for those in the industry itself. For some time it was not viewed as such by its customers, however, and those not active in manufacturing industry would hardly have raised an eyebrow.

Not only are many people disinterested in the decline of the machine tool industry in the UK, but even more are oblivious to it. In later chapters it was demonstrated that the interdependence of the supplier and the customer means that in fact the 'problem' is not simply one that exists in the machine tool industry alone, but is a *situation* that also has an influence on the performance of, for example, the automotive industry. Indeed, through the intricacies of feedback and the interconnectedness of systems, the decline of the industry will impact on many areas of life not immediately, directly connected to manufacturing at all.

A belief in the existence of problems as 'things that can be solved' rather than situations from which much can be learned is typical of traditional Western thought. Chapter four traces back this thought to its philosophical and epistemic roots (section A and B). Many facets of science and scientific analysis have, as their goal, the discovery of the answers to all problems - a single, unifying theory. The belief in 'I am, I can control' as an underlying rationale blinds the scientist to the influence that the environment constantly places on all systems, and indeed the dynamism of the System itself. It is this kind of thought that supported the scientific theories of work that became known as Taylorism, after F.W. Taylor, arguably the best known of the 'scientific managers'.

An element of a System, for example, Man, can indeed have *influence* on a situation, but cannot ultimately control it. In the case of a 'controlled' laboratory experiment this influence is close to total, but not quite. In the 'softer' sciences such as psychology or psychiatry this influence is quite evidently less, and is even smaller in business and industrial situations.

Certain areas of science still pursue the search for a unifying theory; the divergence of knowledge around a common, contracting theme. Many others, however, are changing their focus toward the pursuit of understanding the complexities of the environment. Systems Science is an example of this. Once such complexity has been recognised and understood, learning and analysis can become directed towards the expansion of knowledge, rather than its divergence.

Nevertheless, the belief in the ability to control a problem did persist and was accepted as the way in which business organisations were to be moulded. Section C.1.4.1 of chapter four described how, as the tasks involved in commercial activity became more and more involved, the so-called scientific management movement divided up individual elements to the lowest common denominator. It described how tasks were intentionally made mundane and repetitive with no need for communication or interaction between workers (magnified by the Unions). The aim of this was to achieve greater concentration on the individual task at hand, which certainly was the result. Consequently, the effects on the total system, or organisation, were overlooked.

It was outlined how such scientific managers as F.W. Taylor attempted to turn the soft system of the factory into a hard controllable experiment and then tried to translate results back to the factory floor. In so doing the characteristic complexity of soft systems and the emergent possibilities of this complexity were dangerously ignored.

Chapter four moved on to a discussion of the quality 'movement' of such figures as Shewhart, Deming and Crosby in section D.3.1. Although the quality philosophy has become focused on management and business activity, Shewhart's original approach to qualitative improvements through quantitative analysis was combined with more traditionally oriental thinking by Deming to become a whole approach to life - that being the continuous improvement of the self within the environment, and therefore of the environment itself.

In the discussion of kaizen (continuous improvement) and the PDC/SA cycle, chapter four illustrated the pitfalls of management 'control' as a one-off action. Far greater results are achievable through iterative action, on all hierarchical levels of the system aimed at gradually attaining quality, or fitness for purpose - the purpose of the system.

It is the success of such a cyclical, incremental approach to improvement rather than unique, dictated step changes in policy that is one of the main reasons for choosing the methodology adopted in the current research - Checkland's Soft System Methodology (SSM) as outlined throughout section D. SSM also adopts a cyclical approach to the analysis of complex situations, and is recognised as being well adapted to human activity situations, particularly through its use of the CATWOE tool outlined in chapter eight.

Rather than having four steps in the cycle, SSM has seven which are outlined in chapter four, section D.2. These need not necessarily be carried out in strict order, but a certain logic is followed. In keeping with PDC/SA there is the attempt to find out what the real system and its environment look like - not simply in terms of 'a problem', but in generic terms of its nature, size, actors, locations etc. Having achieved this, the aim is to work out exactly what the purpose of the system is. This element is not explicit in PDC/SA, but is an important factor in systemic analysis. Since SSM has not been applied to the machine tool industry before, the resulting explanation of purpose is a further contribution to the field of research into machine tool industry analysis. The purpose of the system found through a CATWOE analysis in the current research is given in section D.2.2.

Why, exactly does the machine tool firm exist? This raison d'être, or 'root definition' is far more than the supply of a machine to a customer. Rather, it also involves the acknowledgement and satisfaction of needs and requirements of employees, customers and suppliers. This is a far greater, more complex and dynamic mission than 'building a machine to form metal'. It involves training, development and most importantly communication both within and across elements of the same system - and the realisation that the system itself is not a closed entity. This was re-visited and expanded upon in later chapters.

SSM then sets the task of finding the suitable pattern of a system that would fit this purpose - a quality system. Various tools exist to this end. The 'C/S' part of the cycle is the comparison of such a perfect system in the Systems world to that of the extant system. The final stage of the cycle is to attempt to close the gap. Solutions are not offered by SSM, however. It is a tool that, through its drive to achieve greater understanding of the system, makes areas of improvement evident to those within the system empowered to make the change. As is discussed in later chapters, it is just this that was often the first area needing attention; those who perform the task need the authority to improve the process by which it is performed and into which it feeds. No longer can control remain the area of the manager alone.

Earlier, chapter four devoted time to one particular author, Laurie Fitzgerald, and her discussion of the 'Chaos Frontier' (section C.1.4). This work was found to be of particular relevance and use as a way of tying up the preceding arguments and concepts in one discussion. Chaos and 'complexity science' are closely linked with the topics of the current research. Fitzgerald recognises the tendency of all systems to falter in their drive towards a purpose unless the energy injected into them increases. This tendency is called entropy. The common tendency of 'management' to manage a status quo is, according to this concept, doomed to failure. Status quo can only be the best outcome of such a policy, at a time when, in a competitive market the competition is moving onward. More likely is the dissipation of the system. Success requires advance, progress and change.

Fitzgerald, and indeed many others who have studied the field of Chaos, believe that once it has been accepted that change is the only constant, the best place to position the system, or the organisation, is right at the very brink of the complexity, at the heart of change. This she calls the 'Chaos Frontier'. By not shielding the system from change, possible improvements can be embraced rather than shied from, and mistakes can be learned from. This requires constant, empowered analysis to monitor the change, thus preventing such mistakes from going too far. What those who try to close the system off from the environment and create the 'machine organisation' have failed to recognise is that change and entropy will still occur due to the complexity of human nature. The suppression of communication, trust and empowerment simply means that mistakes go unattended. At best this is learning opportunity foregone, at worst it can cause the system to fail.

A.5 - Chapter Five - Chains, Forces and Systems

Chapter five is concerned with models of supply. Since supply is the prima face business of the machine tool manufacturer, it is these models which are of interest to this research. Models themselves are of interest to the analyst because they influence the way in which participants in the business process think about the process and the tasks involved in it. These mental models, or thought patterns, in turn, affect outward behaviour.

Inasmuch, chapter five is a detailed review of the extant literature on the topic of supply. Arguably the best known model in the area is that of Porter's 'chain'. Section A.1 concentrates upon the development of this model. Other models are then described in section A.2 which have been based upon this model, and present refinements or improvements upon it.

The chain approach was , by example and metaphor, shown in section A.1 and throughout A.3 to contain inherent flaws that were in keeping with the traditional 'reductionist' approach as described in chapter four. Elements of what are in fact the same system are 'disaggregated' so as to make them easier to control. This artificial segregation blinds the analyst, manager or decision maker to the possibilities that can exist in the interaction of firms, their employees or employee groupings. It was argued in the course of the current research that improvements to the supply process embodied in the quality philosophy and the environment of simultaneous (concurrent) engineering cannot be embodied by such a linear, uni-directional model as that of the chain. This is even more so when the chain model is combined with Porter's other model, that of the '5-forces'. Here, not only is Porter's advice to disaggregate the elements of the System, but, further, to reduce what gives the System its quality.

Chapter five illustrated how the chain model has become adopted by academia, and is widely taught in academic institutions. It also showed instances of its equally wide acceptance in industry, where it is similarly held as an accurate model of industrial behaviour. Questioning the use of Porter's model in a complex and dynamic environment such as the industrial world of the 1990s, where efficiency in core competence is key, is another of the important and novel aspects of the current research. The learning opportunities and efficiency benefits that are foregone through continued ignorance of the power of feedback, communication and interaction present a serious threat to the competitiveness of Western industry.

In chapter five, other approaches to modelling the supply process were discussed. Most of these do, however, still base themselves on the chain approach. Two models do not; they represent significant departures from the chain. These are the interaction approach, and the approach presented by the Supply Chain Management Group of Glasgow University. These two approaches have in common the fusion of customer and supplier, and focus on the need for inter-organisational communication before the physical supply process begins. This is in line with the concurrent engineering environment. Whilst encouraging such interaction on a 'tier 1 - tier 2' basis, these models do little to encourage suppliers on the same 'tier' to learn from each other or assist each other's efficiency. Since this is exactly the direction in which the more progressive of today's industrial concerns are moving, these models can be said to have only gone part of the way to break the links of the chain model.

A.6 - Chapter Six - Internal Process Improvements

In chapter six, modern industrial behaviour was investigated. The focus is now away from the tasks, jobs, and functions of the scientific managers. Of interest to the organisation attempting to create its own competitive advantage from the System, is the process. Processes run through and within Systems, and it is the inputs and outputs of the process, and its suitability to the consumer or customer that will determine its success.

Some time was spent describing benchmarking (section A). Still a comparatively new activity to many organisations, the successes that can be had through benchmarking are confirmation that learning and quality are indeed a journey and not a destination. Even best in class companies must continue to look for those who become better.

The outcome of benchmarking is often the discovery of inefficiency and ineffectiveness, in other words - waste. Chapter six described five sets of improvement programmes that were found during the field work of the current research, few of which had been initiated without benchmarking effort, and all of which were aimed at the elimination of waste. The first of these sets (as laid out in section B.2) is the removal of waste from the design effort (B.2.1) - i.e. how can design of product *and process* be made fit for purpose from the outset? The removal of waste from inventory and the production process was also studied (section B.2.2). Of importance here in the research is not only the repeated importance of the human elements in the process and inter-organisational interaction, but also the value of recycling (B.2.2.1). Although a belated realisation in the West, the importance of recycling is now clear. In fact, recycling is simply a form of 'physical' feedback - yet another example of a Systems concept in practice that is not promoted by extant models of supply, but which is essential for competitive effort.

The second set of programmes is concerned with removal of waste through financial analysis (section B.3). The third looks at efficiency in information exchange and communication (section B.4) - topics covered including internal concurrent engineering, quality action plans, and geographic diversification and communication.

The fourth section, B.5, shows how waste can be 'managed out' by human resource policies. A vital section, topics covered here include empowerment and the analysis and improvement of the relationship between the manager and the worker, the worker and the worker, and inded the standard of the worker per se. The power of cyclical feedback processes has by now been well established in this research, not only in these programmes but also in the discussion of the PDC/SA cycle, and of SSM. In this section of chapter six, yet another such cycle was discussed in its use in the machine tool industry and automotive industries - that of a 'select/train, empower, monitor, learn' cycle in HR management (section B.5.4). It is not by coincidence that the manner in which progressive firms are managing their employees for quality has much in common with the way they are - or should be - managing their suppliers. Since a supplier and an employee are both 'a system', the generics of systemic management - how emergence is promoted - apply. Such similarities in Systems have been long assumed by Systems Science.

To date, however, no attempt has been made to find commonality between HR and supply base management, and certainly not in the field of machine tool and automotive manufacture and assembly.

Again, here, the inextricable link between the success of the HR area and the success of the aforementioned programmes was identified. None of these programmes is independent, and none is 'hard' by nature, and all rely on quality in the human input.

The final set of programmes investigates improvements in the way the business process is measured and, in turn, benchmarked (B.6). Organisation plays an important role, as does, once again, the actual personalities (or champions) involved. Where benchmarking is left to individuals without the ability to fully comprehend the process, or without the authority to investigate the process, it cannot work to full effect.

The discussion in section C summarised the various sets of programmes. This in itself presents something new in terms of machine tool related research, since it looks at the improvement programmes in terms of the feedback and interaction that is created and utilised. It also looks at what the machine tool industry is doing right, instead of concentrating on its failures. The programmes are not discussed in isolation, but in a manner by which their interdependence is evident. Once again, however, each of these programmes is totally dependent upon the human elements in the system. If there is no commitment to continuous improvement by employees, from the bottom right to the top of the organisation (a distance becoming ever shorter in hierarchical terms) 'muda' initiatives aimed at waste reduction cannot fully be exploited. Continuous improvement is said to be an 'ultimate feedback system' (section C.2). Similarly, if there is not the appropriate level of empowerment from the top to the bottom allowing responsibility and authority - and the freedom to make the inevitable mistakes - the same outcome is likely.

This point must be reiterated. The success of process improvement programmes depends not upon the software, hardware or facilities available, but upon the calibre, the quality, of *all* the personnel involved.

A.7 - Chapter Seven - Interface Management

Chapter seven introduced yet another new aspect to the research into the comparative advantage of the machine tool industry - that of the management of the interface between the buying organisation and the machine tool supplier. It is based upon field work and interviews in the automotive and aerospace industries - mainly in locations in the UK.

Explicit mention is given to something previously only alluded to; the machine tool maker/supplier and the industrial customer are, in fact, a part of the *same system* (section A). Several explanations are given in support of this statement - both from the Systems perspective and from anecdotal evidence from industry. Hence, what the supplier does directly affects the customer's efficiency. What the customer does to the supplier's efficiency it therefore does to its own. In the same way that chapter six examined the intra-organisational management of waste, chapter seven looks at the management of the elimination of waste *between* organisations. In fact, the argument is presented that during the development and installation phases of the supply of complex machinery like machine tools, there can be no boundary between customer and supplier, and 'virtual integration' occurs[3].

Two 'approaches' to the management of the buyer-supplier interface were described. It must yet again be stated here that this split is artificial and exists only for the purposes of discussion. It would be wrong to describe the actions of one

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[3] Increasingly, this is also the case in the usage phase of the machine. With extended warranties and moves towards devolving the responsibility for total productive maintenance to the full system (turnkey) supplier, ownership of process responsibility remains, to a great extent, with the supplier.

organisation as typically 'traditional', or as the 'old way', since the transition to the 'new way' would be hard to monitor from a macro perspective. Indeed, within those organisations who are accepted as displaying 'progressive' behaviour, evidence does come to light of 'traditional' buying practices.

Anecdotal evidence is given of the pitfalls of traditional reductionist management, and of the benefits of systemic management - that that being the timely inclusion of the relevant supplier on a high-trust basis. It was seen how the majority of organisations is moving towards this systemic approach - albeit at varying speeds (section B).

At the same time, another change in behaviour is the reduction of the supply base to reduce the waste of high administration and switching costs and the costs of validating product and process designs and prototypes from new suppliers (section C.1). The move towards long term supplier relationships reduces further the need for large supply bases. From the suppliers' point of view it also is an illustration of commitment from the customer. This is an important contribution to the success of the customer-supplier relationship when thought of in terms of Alderfer's category of needs as outlined in the early parts of this seventh chapter.

Such changes required the initiation of new customer behaviour in the form of supplier audits, selection and development. As mentioned above, the similarity to empowerment in HR management is evident. Major customer organisations have realised the benefits to be accrued not only from reducing the size of the supply base (requiring thorough pre-selection, as outlined in section C.2) but also the subsequent development of those suppliers still used (section C.3). By helping its suppliers, the organisation helps itself. In section C.3.3 personalities are seen to play a part, once again, in the success of supplier development and inter-organisational interaction such as the concurrent design and supply of product and process.

A.8 - Chapter Eight - Back to the Drawing Board...

In chapter eight the discussion revisited the SSM process in section A. Having investigated the system of interest, and established that this includes both the customer and supplier, a truly rich picture of the system was developed in section A.1. From this, the root definition was once again stated. The improvements that this definition of the *system* offers above other implicit definitions of the supply chain from extant models are made clear in section A.2.

The remainder of the chapter, section B, was devoted to the creation of a model which, it is argued, gives an accurate representation of the physical structure of supply. This is what the supply 'chain' attempts to achieve, but fails to do in the context of today's environment. This new model also depicts the non-physical structure of flows and exchange shown to be of importance to the systemic purpose from the root definition. These are non-linear and multi-directional, they are also dynamic and soft by nature. They are the necessary ingredients of systemic emergence, and therefore competitive success.

To this end, the chapter discussed the attempts made during the research to introduce softness and feedback to the system using real evidence from primary research. The necessity of an 'unknown' component in the initial models points to the risks attached to complex situations. This unknown factor is described as a multiplier of the emergence created through feedback and continuous improvement. Acknowledgement of the existence of this factor allows its exploitation, ignorance of it (or the attempt to suppress it) can cause the downwards multiplier effect that creates stagnation and decline.

Despite the improvements offered by the initial circuitry models over the linear chain model (section B.1), they are still regarded as being simplistic when compared to the requirements of the supply *system*. Feedback has been addressed, but a vital aspect of the generics of systems has not been included. That aspect is hierarchy. All systems exist between subordinate and superordinate hierarchies. It is from superordinate systems that motivation and direction is encouraged, and from where empowerment and authority is bestowed. It is upon subordinate systems that the system is, to a great extent, dependent for efficiency and effectiveness. This fact has long been alluded to, but never made explicit by industry in its use of 'tier' terminology in the supply base, which tends to have a top-down perspective only.

The toolbox of Systems Science provides a model well suited to the representation of hierarchy, feedback and interaction in the form of the VSM. Chapter eight introduces this model (section B.2) and shows how, with very little adaptation, the supply system fits well into the structure of the model whilst allowing the representation of those components and elements that encourage emergence from the system.

By extending the use of the VSM, it was shown how not only supply, but all functions of the organisation fit in the model. This creates a multi-dimensional system. Lateral interaction within the system is shown, as is that between systems, as well as 'vertical' interaction with subordinate and superordinate levels.

Criticism of the model is addressed in section B.2.1. Those points of criticism that have previously been made are discussed, and either refuted or used in the latter stages of modeling in chapter nine to improve the model.

A.9 - Chapter Nine - Modeling the Supply System

Chapter eight ends with certain criticisms of the VSM that must be addressed if a useful model of the supply system is to be achieved. Such a model is the subject of the ninth, and final, chapter of the discussion of this research. Section A of the chapter laid out explicitly the requirements of a new model of the supply system, some of which were addressed by the attempts in chapter eight, but never all at once, in one model[4].

For ease, the process of creating a new model was divided up into four logical stages (section B.1 to B.4 inclusive). The culmination of these is what this research argues to be a true and accurate representation of the supply system. Physical elements of the system are shown to interact in a hierarchy, in a non-linear fashion. There is also lateral interaction across individual resolutions of the hierarchy. Non-physical interaction and feedback is included, too, in an equally multi-directional, non-linear fashion.

The pull of the market is married with the push of technology from the science base. The elements of the system have a responsibility to promote and exploit both of these to achieve quality.

A major innovation shown in the supply system as depicted in chapter ten is the inclusion of the education system. The education system and academia (as a subset of this system) is a supply system in the same manner as is the supply of machinery, goods and service to industry. The discussion of the VSM introduced a multi-dimensional aspect to the model, whereby all functions of the organisation adopt a similar structure allowing feedback and interaction at all levels with the external environment and other internal functions. Similarly, the system of supply of human resources to industry should be regarded in the same manner as the system of supply of physical resources to industry[5]. Industry is one of the major customers of the education system, alongside other divisions of society. If industry is to achieve quality in the output of its processes, then it must include the quality

[4] This is not to say that such attempts were of no value. Only through the use of the existing models was it possible to prove, firstly, the weakness of the extant models of supply, and, secondly, the need for a new model not purely dependent upon existing models from Systems Science. This is consistent with SSM. In the phases of the methodology within the 'Systems World', Systems tools are used not as rigid frameworks, but as guides to real world solutions. Hence, those who criticise the rigidity of the VSM, for example, may not be realising its full utility. Instead of copying it as a structure, it should be built upon to suit the situation.

[5] Again this illustrates the generics of systems. It was earlier described how similarities were seen to exist between the requirements of the management of employees and of suppliers. These similarities are also evident between the greater systems of physical and human resource supply.

of the input of its human resources in its plans. It was stated above that the efficiency of a system is dependent upon subordinate systems that have input into the system of interest. This is no less so for the relationship of education to industry. Yet no models of industrial supply have, to date included the education system.

Only through societal *and* industrial collaboration in education policy can quality in education, and the output thereof, be achieved. Since these are the two customers of the education system, this has to be the case[6]. Yet many of those involved in education still secretly frown upon industrial input, and industry remains slow, in the West, to adopt its role of guide to its supplier of human resource.

Chapter ten ended with a brief reminder of the power and danger of complexity (section D). The supply system presented as the culmination of this research is a complex model - almost too complex to fit within the confines of a two dimensional model as required by such a thesis. It is recognised that this may be perceived as a weakness of the model. Can the model be of value if it is only with some degree of difficulty understood? Surely the value of a model rests with its accuracy and relevance, its fitness for purpose, rather than its complexity. Were this not the case we would still believe in a flat Earth.

A complex environment requires models that accurately reflect it. Once this has been achieved, then it may well be further broken into more simple models, so long as the total picture of the system is not lost[7].

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[6] The discussion in chapter six on quality function deployment describes how quality is a function of, amongst other things, the timely realisation of customer requirements.

[7] This is an issue currently being addressed by the Ford Motor Company in it Engineering Quality Improvement Programme. The whole programme - taught to all Ford 'engineers' at different levels - only broaches detailed topics once the full process involved has been comprehended. This means the combination of human, physical and information inputs into the process.

B - Summary of Research Conclusions

Section A above presented a summary of the chapters as they appear in the body of this research. Here, section B will further condense the research and summarise the findings of the research into 'bullet-point' form. It is these points that constitute the contribution that this thesis makes to both academic and industrial knowledge.

- The machine tool industry, despite its relatively low profile, is a strategically important sector of industrial activity as a whole, and yet it has been in serious decline in the UK for some ten to fifteen years.

- The extant literature, although not large by academic standards, has covered a wide range of topics in its research into the machine tool industry. The decline has been charted, and reasons for it have been 'found'.

- These reasons are often narrow in focus, and are therefore argued to be too simplistic in a complex environment made of human interaction.

- Models of the supply process, involving more than just the machine tool industry, are similarly simplistic. They fail to recognise and promote that which encourages success from a *system*.

- The automotive and aerospace industries, along with their suppliers - of which the machine tool industry is one group - are parts, or resolutions, of a 'soft' human activity system.

- In common with all such systems, this supply system is volatile and dynamic. Its output depends upon its ability to allow interaction and feedback on a physical and non-physical level. This feedback occurs on multiple dimensions and in multiple directions.

- The effectiveness and efficiency of the feedback, and the resulting emergent properties of it, (ergo its quality and competitiveness) are dependent upon the people that form the structure of the system.

- Rather than concentrate on what has gone wrong in the industry, this research examines what is changing and being done to improve performance.

- Recent improvements in the competitiveness of the machine tool industry have centred around the process of supply, as well as the individual functions that combine to make this process. People are a part of this process as well as physical hardware.

- The success of one area of improvement depends upon the success of others. All are interdependent.

- Likewise, improvements in the success and competitiveness of the customer organisation depends upon the success of its suppliers Therefore it is in the interest of the customer to promote quality in its suppliers' processes.

- Such development is continuous in nature. Due to the complexity of the environment, perfection in process or learning can never be achieved.

- Similarities exist between the methods used to promote the continuous improvement of employees and of suppliers. This is consistent with the concept of the generics of systems.

- The responsibility for the supply of full service systems, or turnkey systems is increasingly being devolved onto single suppliers. For the machine tool supplier this means that lateral collaboration with component suppliers and service suppliers is necessary. The full service supplier becomes a purchasing centre.

- As this occurs, the role of the customer procurement centre changes - although having ultimate responsibility, the role has to become one of a procurement co-ordinator rather than simply a buyer.

- Due to the increasing complexity of the environment, and the changing requirements on the organisation that occur as a result, the demands placed upon human resources are becoming ever greater.

- As ever, meeting such requirements requires the inclusion of customer requirements which in this case requires industrial collaboration.

- The changing environment outlined in the preceding points places new requirements upon human resources. The resultant necessity of collaboration with the education system to provide employees of high calibre, and to continue their training once in the world of work, calls for the education establishments to be included in the model of the supply system.

- The resulting model of an industrial supply system must embody all of these findings, therefore able to encourage competitive effort through true recognition of the nature of a system. This is presented in chapter nine. It is a complex model that depicts an even more complex system.

The machine tool industry and its customers exist in a complex environment where the activities of none are easily separated from the success of the others. The decline of the element of this system whose purpose was the supply of machine tools therefore impacted upon its customer elements. The actions of these customer elements themselves played an equally important role. The diverse and considerable improvements to the success of the system, found during the course of the research, were seen to depend upon the small set of common themes of feedback, interaction, quality, human activity, hierarchy and complexity. It is argued that these are what shape the nature of industrial supply. It is this that the current research set out to determine.

The research used the machine tool industry as its basis for study. It has been shown, however, that the source or location of the common themes that shape the nature of industrial supply - its success, failure and structure - are not only to be found in the machine tool industry.

The future success of the machine tool industry, and of its customer and suppliers, will depend upon the ability of those human elements within the system to recognise these assertions, and further to exploit them. Current behaviour is encouraging. Traditional Western reductionism appears to be giving way to a more systemic set of behavioural and managerial patterns, as much in the customer sector as in the machine tool sector. Only time will tell how successfully the system continues to adapt to the dynamism of the markets and exploit their complexity.

C - Recommendations For Further Research

The intention of the current research was to provide a relevant, useful and comprehensive study of the nature of the industrial supply system, using the machine tool as a basis for research. It is hoped that this has been the result. It is, however, recognised that constraints are placed upon such a project. Such constraints include the resources of time and funding. The need to present clear and concise arguments further restricts the breadth of research to be undertaken. As a result, questions and issues were uncovered and raised throughout the course of the research which could not be pursued. This section aims to bring these points together and make suggestions for further research.

C.1 - Recommendations for Further Research Relating to the Current Project on Machine Tool Supply

The public output from this research - both formal and informal - has been received with enthusiasm. It would seem that the concepts of Systems and feedback are becoming more widely recognised, especially in application to the business community. In view of this, it is hoped that work continues in the field. Having made what is argued here to be an important first step in industrial dynamics by presenting not a chain model, but a feedback system, the door to future research has been flung wide open. The few points below are areas for further work that would, in the opinion of the author, not only complement the current study, but also prove of value to industry. It is not an exhaustive list, but is intended as a basis for further discussion.

From a purely 'business administration' perspective, it is hoped that work continues in the analysis of the machine tool industry. It is not likely that the industry will ever have such a strong UK or US manufacturing base as was seen in the 1970's and early 1980's - nor need it have. Nevertheless, the improvements outlined in this thesis that the machine tool industry is carrying through, with the assistance of its customers, mean that it will certainly remain a strong competitive force for the foreseeable future. Future research should continue to track the progress and success of improvement programmes. It should also look to chart the introduction of the innovations in process measurement and improvement that will undoubtedly appear in the near future.

From the perspective of soft systems analysis, sociology or behavioural science, the impact of individual and group behaviour upon the success of the supply process is a further field for study. Analysis of individual development programme successes compared with the nature of the development mandate team, their background and time of inclusion, would further assist both customer and supplier in the effort to design the development process needed to develop quality products.

It may even prove the case that corporate size or culture will also play a part, especially if background and education are, indeed, found to be as influential as they seemed through the course of this project.

Due to the complexity of industrial supply and its dependence on human input and interaction, there are also opportunities for research into the efficiency of the decision making processes, methodologies or tools used - if any formal approach is used at all. The same applies to project management activities. Tools for decision making and strategy creation are available that have been created from both within the area of Systems Science, and outside of it. Although a variety of these does exist, their use in industry, where speed is often the key, is rare. Nevertheless, almost all programmes and projects encountered in the course of the project entailed a certain degree of fixed, scheduled meetings. These, too, were run on an ad hoc basis. Through selection of appropriate decision making methodologies, future work should ascertain the efficiencies to be found by paying formal attention to the decision making process.

C.2 - Recommendations for Further Research Outside the Area of the Machine Tool Industry

The above recommendations for further research effort are based directly upon the disciplines of Management and Systems Sciences applied to machine tool supply. Below are suggestions for research that are not immediately connected with the current study, but, as in section C.1 of this chapter, are intended as in-roads into further discussion rather than to provide an exhaustive list of possibilities for spin-off research.

- *The Role of Financial Institutions in Industrial Supply*
  Funding was always an issue in the development of supplier relations, and indeed in the development of machinery itself. As the complexity

of the environment increases, and as competition in the financial sector increases, it is likely that the Western financial and industrial sectors will become as intertwined as they are in Japan and the Pacific Rim. As and when this process happens, what will be the effect upon the industrial system, and what role will the financial sector play? Will it become a supplier of funds, and therefore become a true element of the system?

- *The Role of the Government in Industrial and Education Collaboration*
  This topic was avoided as far as possible due to its political nature, thus making it unsuitable for a project such as this which has tried to be without bias. On several occasions, throughout the research, however, the role of the education system has had to come into question, and it has been found that government policy is not always consistent with the requirements of the markets. What can be expected of the ruling government? If it is to remain the manager of the education system, how can it remain in touch with industrial policy and strategy? If it is to devolve responsibility to society through the opt-out and privatisation scheme, how can it ensure that its role as a co-ordinator of these establishments maintains close industrial collaboration, rather than leaning too closely to one of its customers - society. If government is the funding establishment of education, how can it avoid the short-termism characterised in industry by maximising year end profits rather than long term shareholder returns? In terms of government this short termism would mean the cutting of education expenditure to keep taxation low rather than adopting a long term view of maximising the long term value to society of high quality educational output.

- *What is the future of concurrent engineering?*
  As the project draws to a close, the successes of CE are many and varied in industry. Nevertheless, competition is becoming tighter, and the challenge is now truly global. Can long term, trust based,

collaborative relationships really be maintained in a globally complex environment, where political instability and cultural distance are as important as quality? Will the need to satisfy protectionist criteria jeopardise CE? Can suppliers be expected to develop designs to a world class competitive standard and at the same time invest in the capacity to supply globally? If not, can they be expected to allow their technology to be passed on to sub-standard suppliers in emerging markets as a matter of course? The alternative for the customer organisation is too costly. Can new forms of global, multi-cultural alliance be developed and managed?

- *Entrepreneurship and Execution*
  Britain has a history of invention and entrepreneurial spirit. What is it then, that is now lacking that means that the UK is no longer a 'nation of shop keepers' and owners, but a nation of the employed? Why can we execute policy and strategy, but not own the organisation? Is there a link here between this and the first two points above?

D - Concluding Remarks

This final chapter of the current research provided a summary and conclusion to the project as a whole. It is hoped that the overview given in the first half served the purpose of tying the project together in a concise, logical manner, such that the summary of the research findings subsequently listed may be of future use.

Conducting this research has proved to be an enlightening experience for the author. Still active in the area of manufacturing procurement, it is hoped that the experience gained from the research can further promote the Systems perspective and contribute to the success of industrial systems.

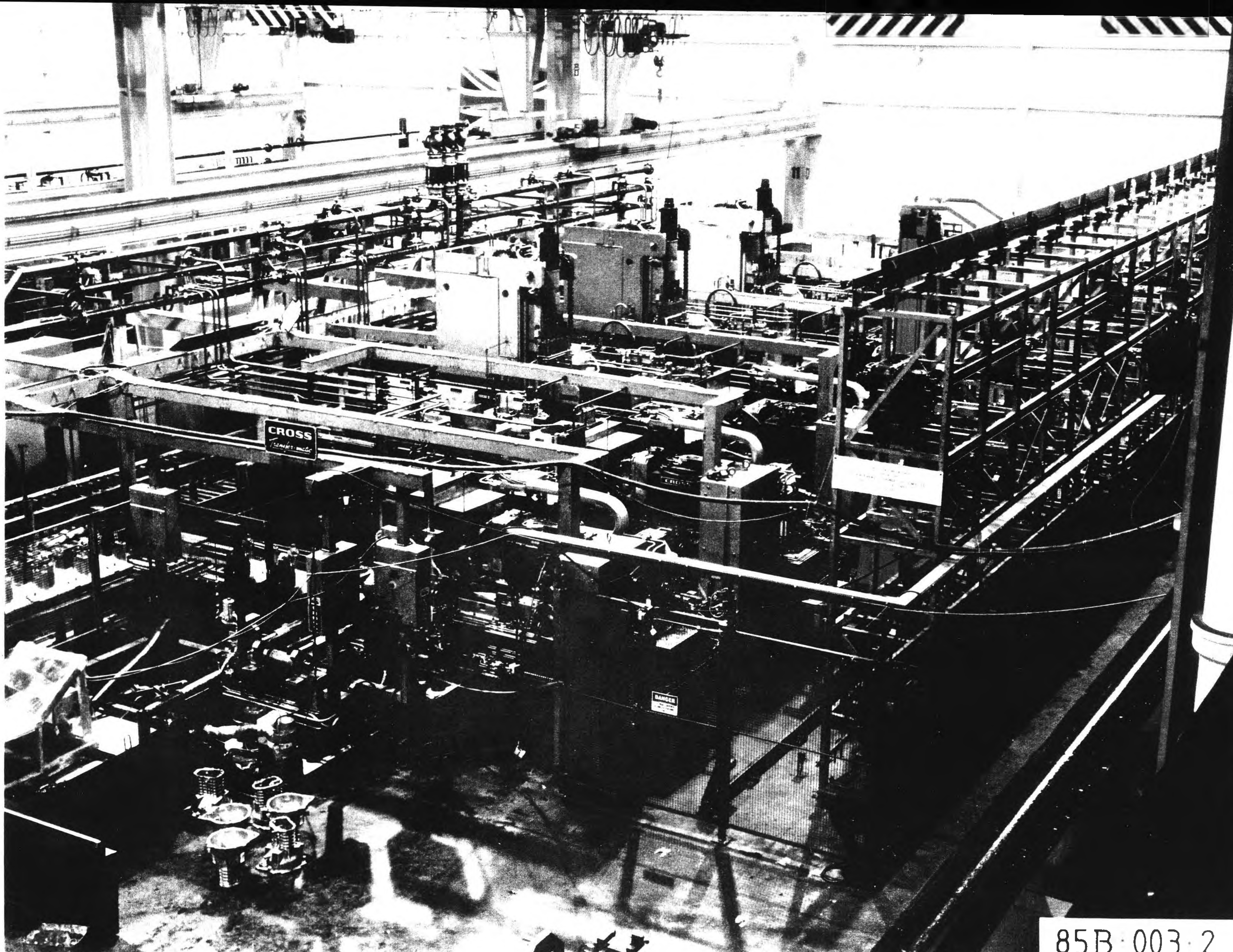
More importantly, it is hoped that this thesis can be of further use to both the academic and industrial worlds. The thesis itself will only have served its purpose if through its findings it contributes not simply to a bank of extant literature, but to teaching, knowledge and behaviour.

APPENDICES

APPENDIX A2.1 - PHOTOGRAPHIC EXAMPLES OF MACHINE TOOL TECHNOLOGY

Machines shown are examples of transfer line technology - groups of connected machine tools carrying out specific tasks to produce a complex part. The part being machined is 'transfered' from one machine (a station) to the next by non-robotic mechanical devices rather than by hand.

The pictures illustrate the complexity and size of typical machine tool lines.



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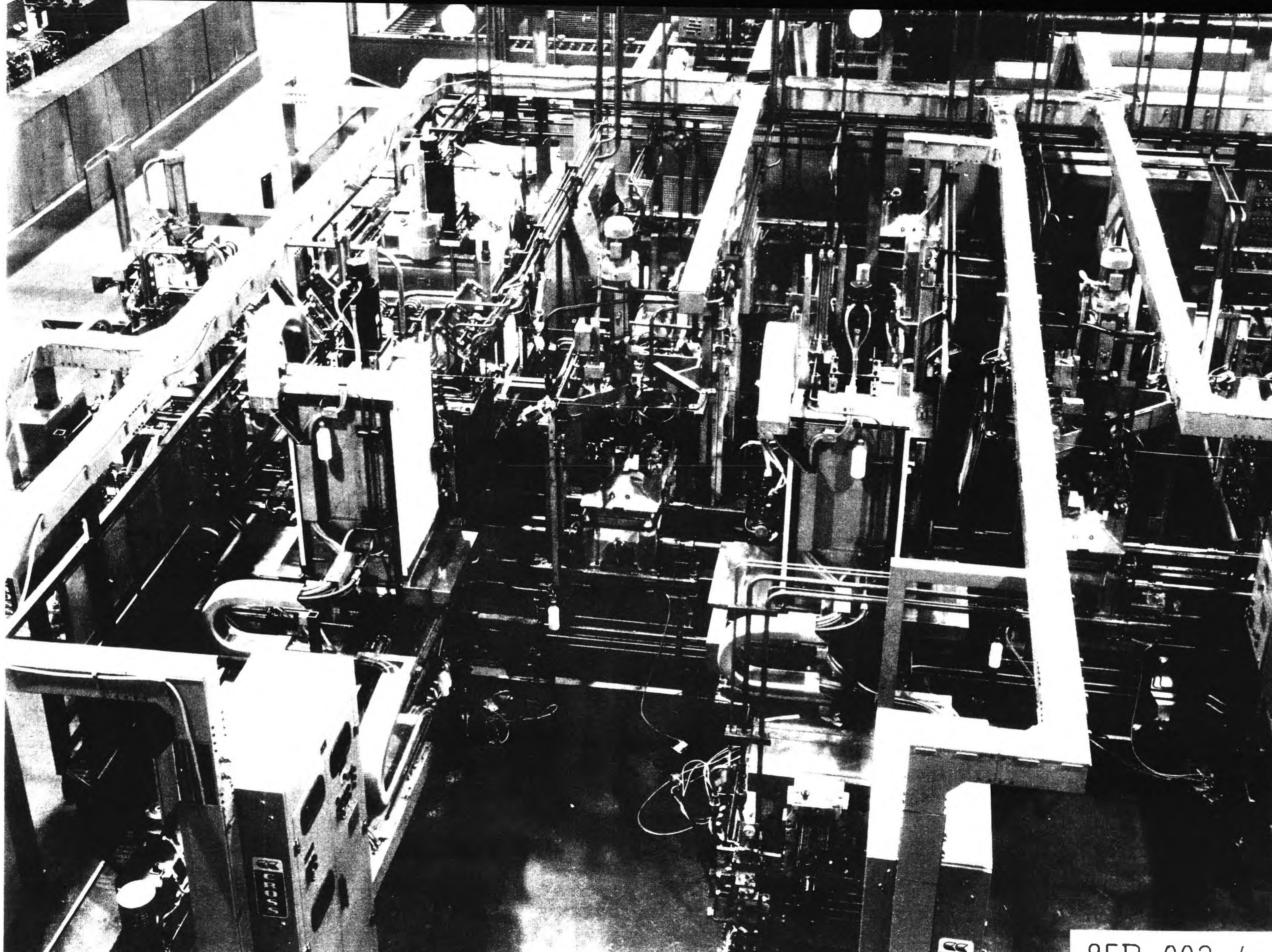

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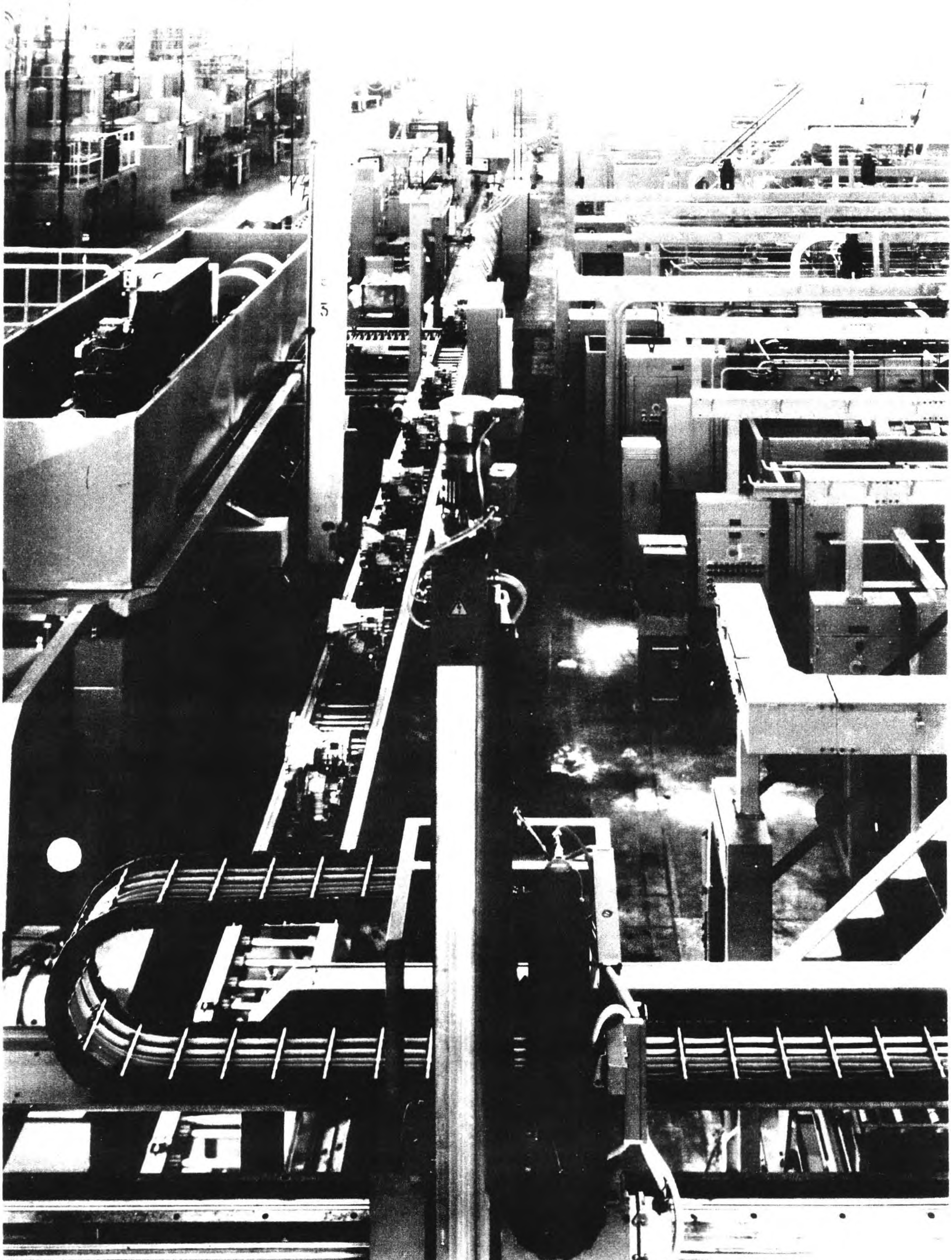
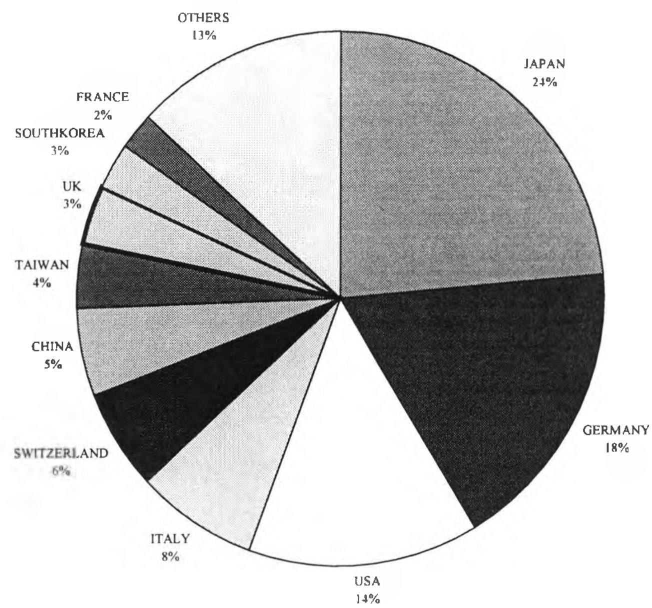
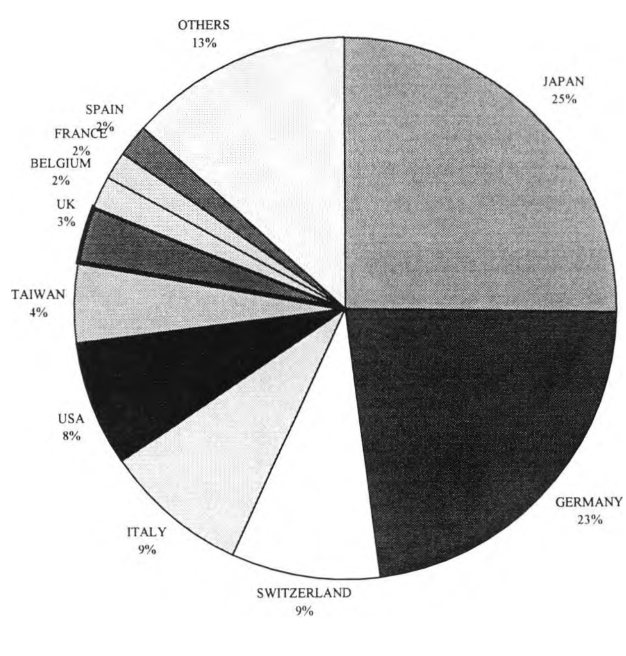


APPENDIX A2.2 - WORLD RANKING OF MACHINE TOOL PRODUCTION AND EXPORTS (1994)

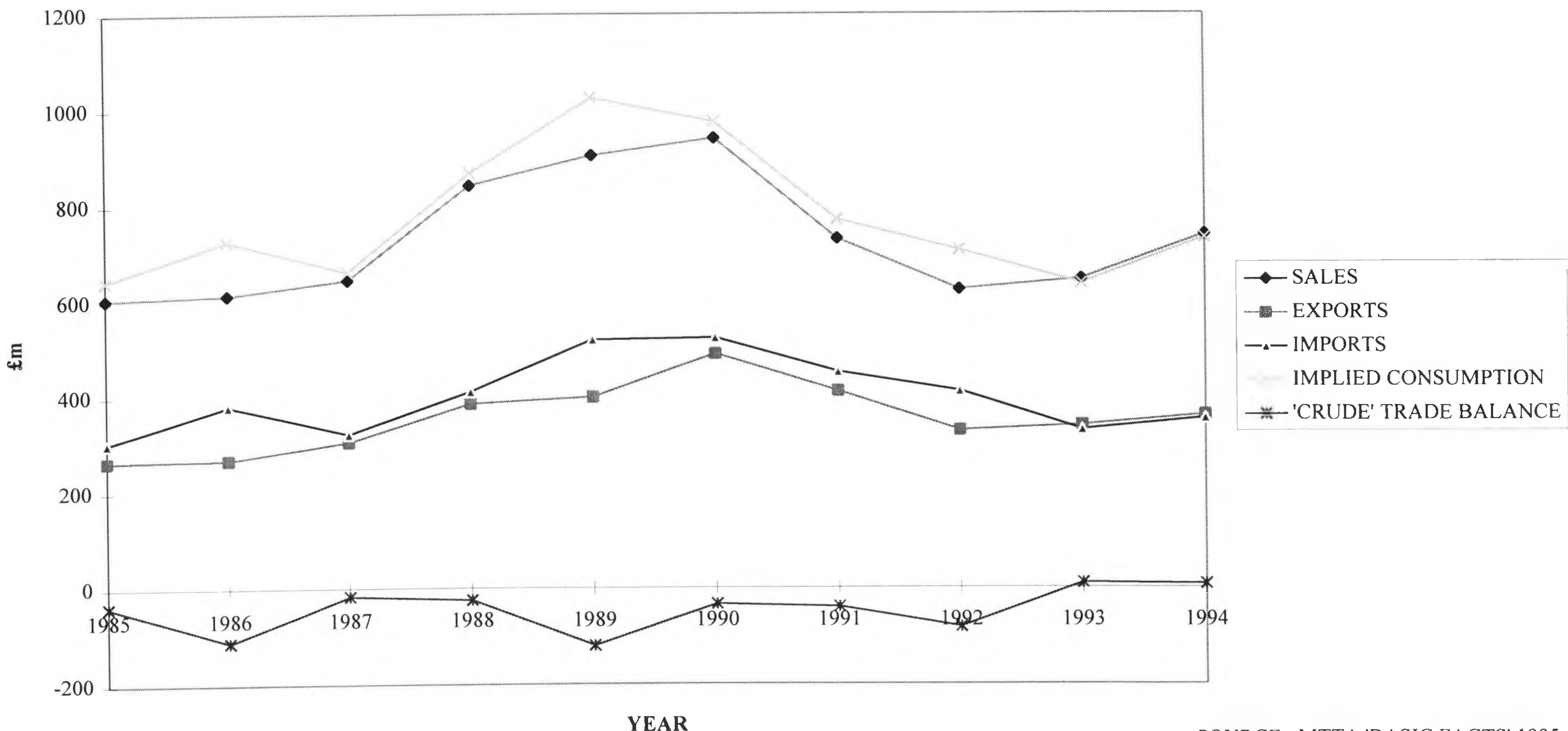
PRODUCTION ($29.0 bn)



EXPORTS ($16.6 bn)



APPENDIX A2.3
TRADE TRENDS IN THE UK MACHINE TOOL MARKET 1985-1994 (1995 PRICES)

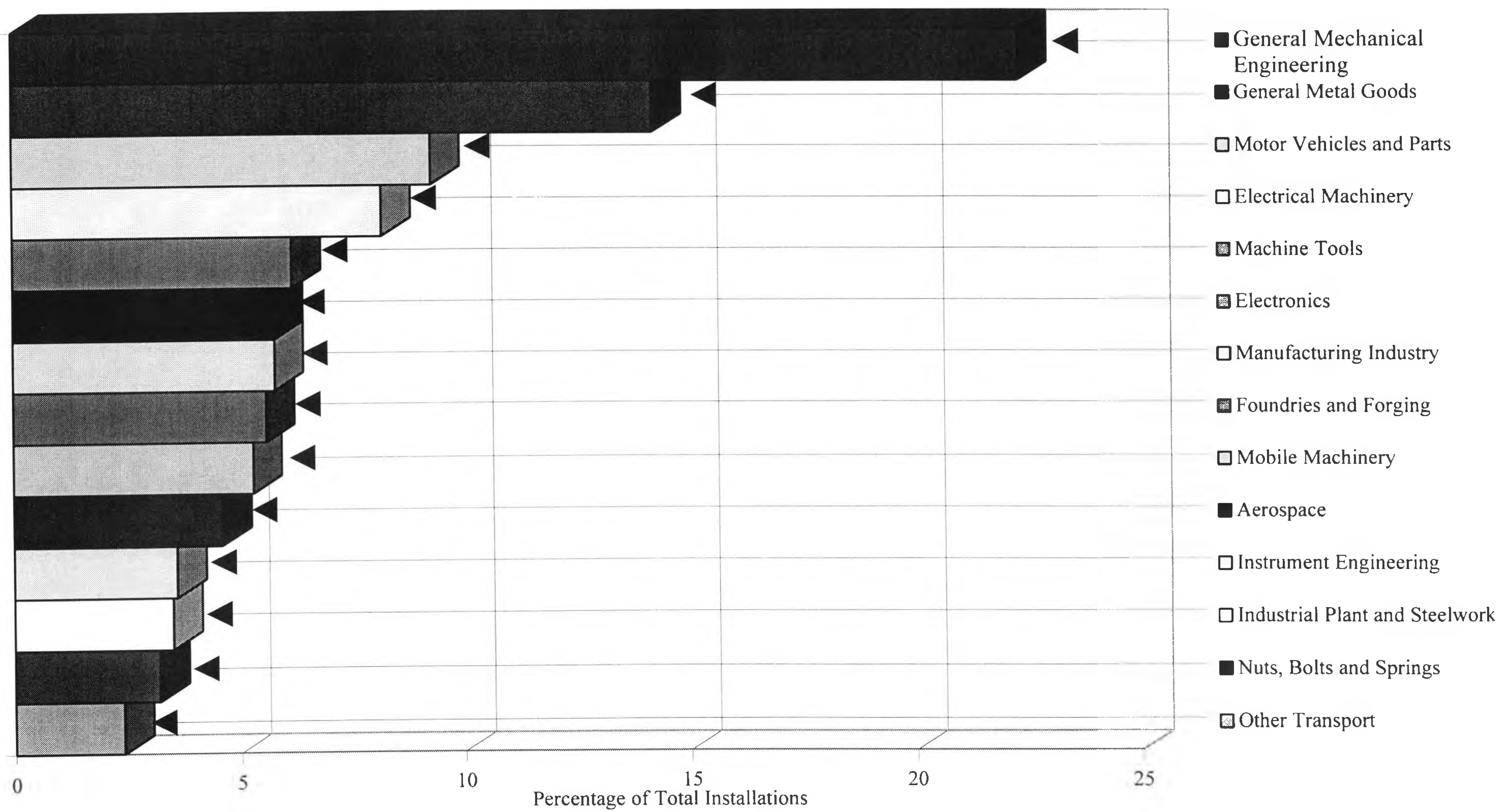


SOURCE : MTTA 'BASIC FACTS' 1995

Appendix A2.4

Sectoral Distribution of Machine Tools Installed in UK Industry (1988)

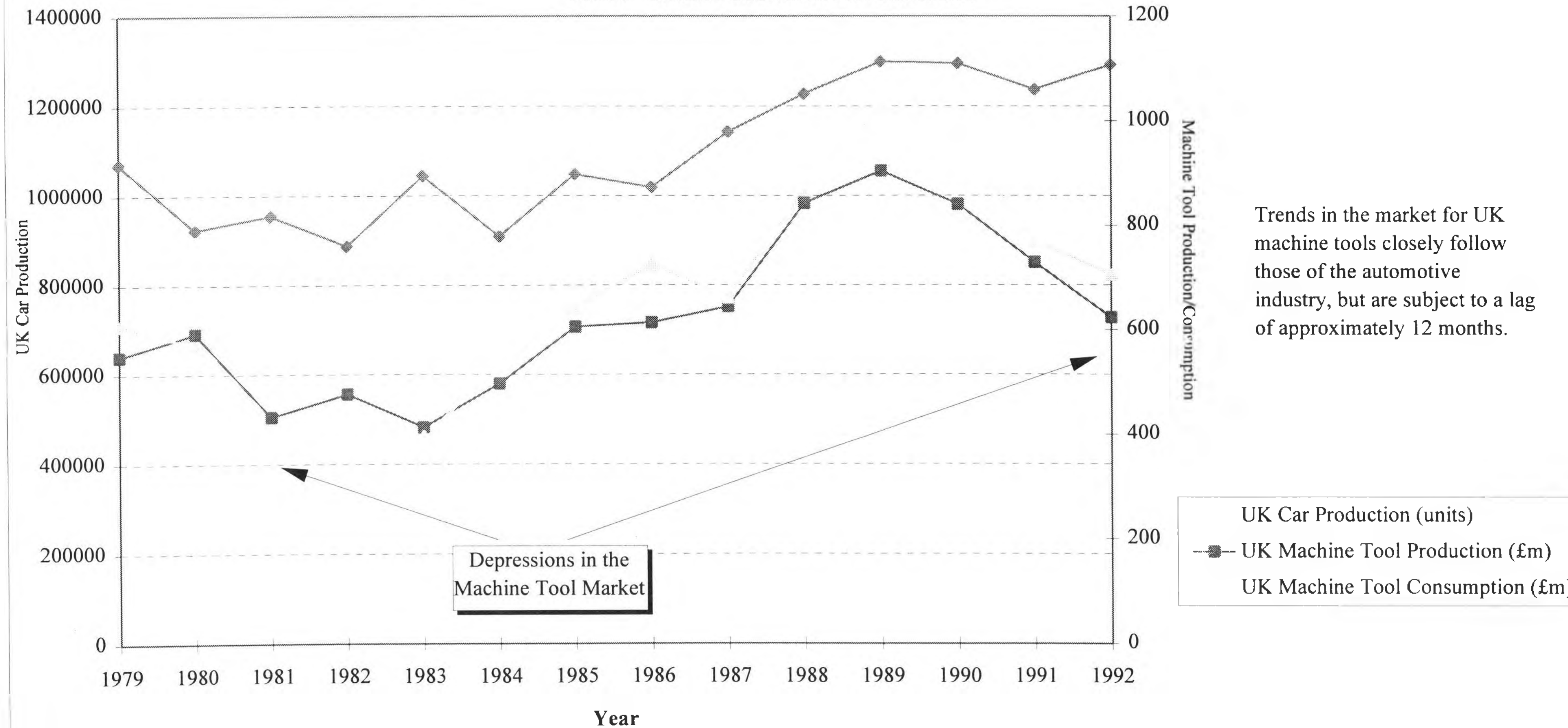
Source - ICC Keynote Report 1992



Appendix A2.5

Trade Trends in UK Car and Machine Tools, 1979-1992

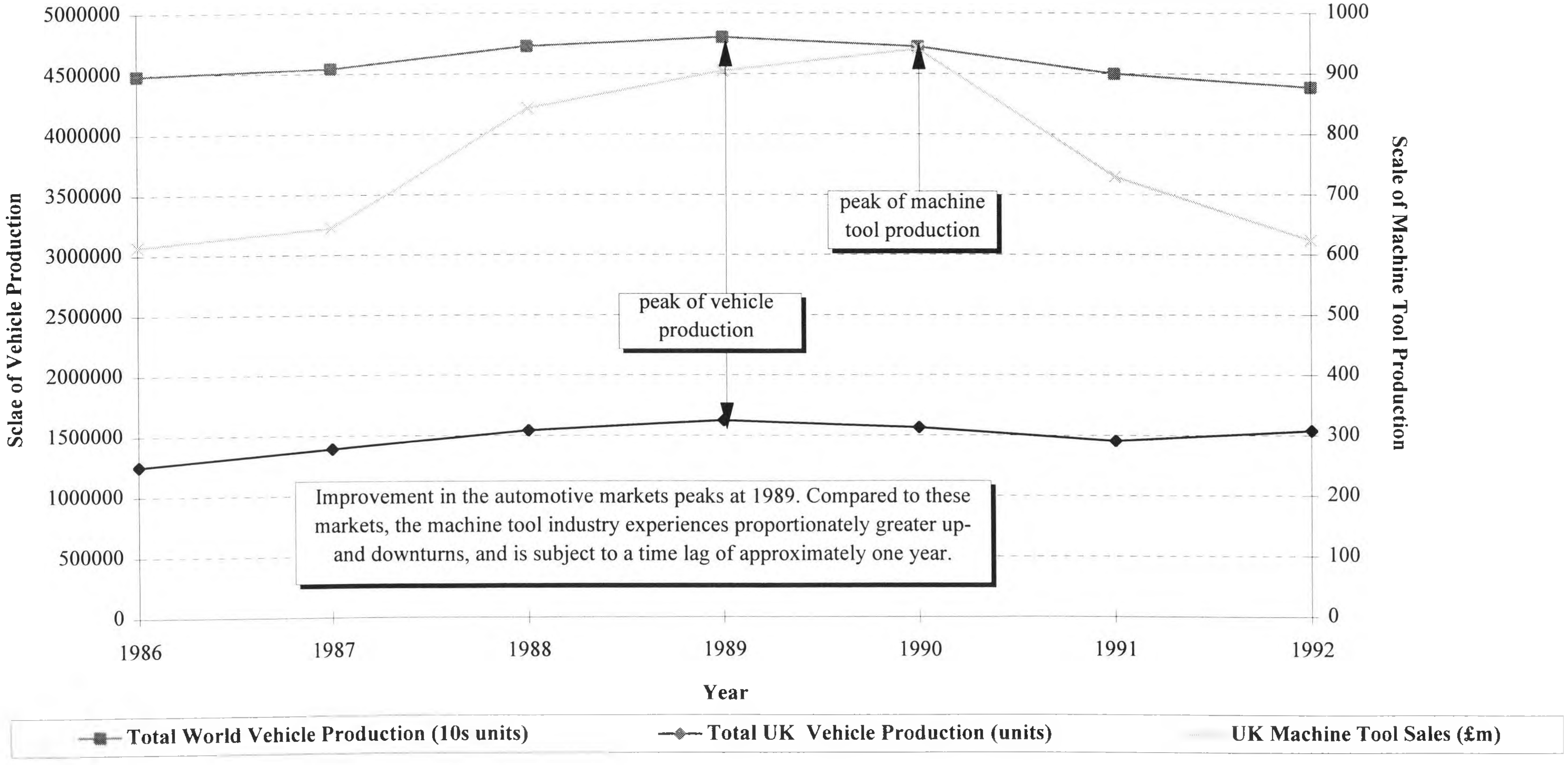
Source - statistics from the MTTA and SMMT



APPENDIX 2.6

Trends in the world and UK automotive markets (car and commercial vehicle) and the UK machine tool market (1986-1992)

Source - MTTA and SMMT



APPENDIX A2.7
'Over-the-Walls' Engineering
as explained by one machine tool builder

APPENDIX A4.1 - The CATWOE Analysis

Customer - (C)
All those elements in the system - ie the upstream, immediate and downstream organisations including the final consumer and the source of natural resources. It is important to stress that this means company-internal as well as company-external. As well as this there are environmental customers such as the financial system, the government, the education system and the literal environment.

Actor - (A)
The activities of a system are performed by 'actors', who in this case are those employed by the systemic elements of (C) above.

Transformation - (T)
Physical inputs are transformed through mechanical, administrative, or creative processes into products whose perceived value will, through the process, have increased. This transformation is matched by flows of information and feedback which can either aid the process of value addition or hinder it. These information flows are on an informal mouth to mouth basis, or a more formal, proceduralised basis.

Weltanschauung - (W)
The Weltanschauung (world view) will depend upon the part of the supply system with which one is concerned. An OEM would regard the system to exist to supply quality machines in order to offer solutions to its manufacturing process requirements designed to satisfy its own consumers' demand. The supplier of the machine tool company or the machine tool company itself would, hopefully say the same about its components, assemblies, machines or services. At the same time it must be said that the system also exists not only to supply product but also to assist in the supply of this product. This latter aspect would introduce a purpose which guides the flow of information feedback - each stage uses the system to promote the development of the prior stages in order eventually to help itself.

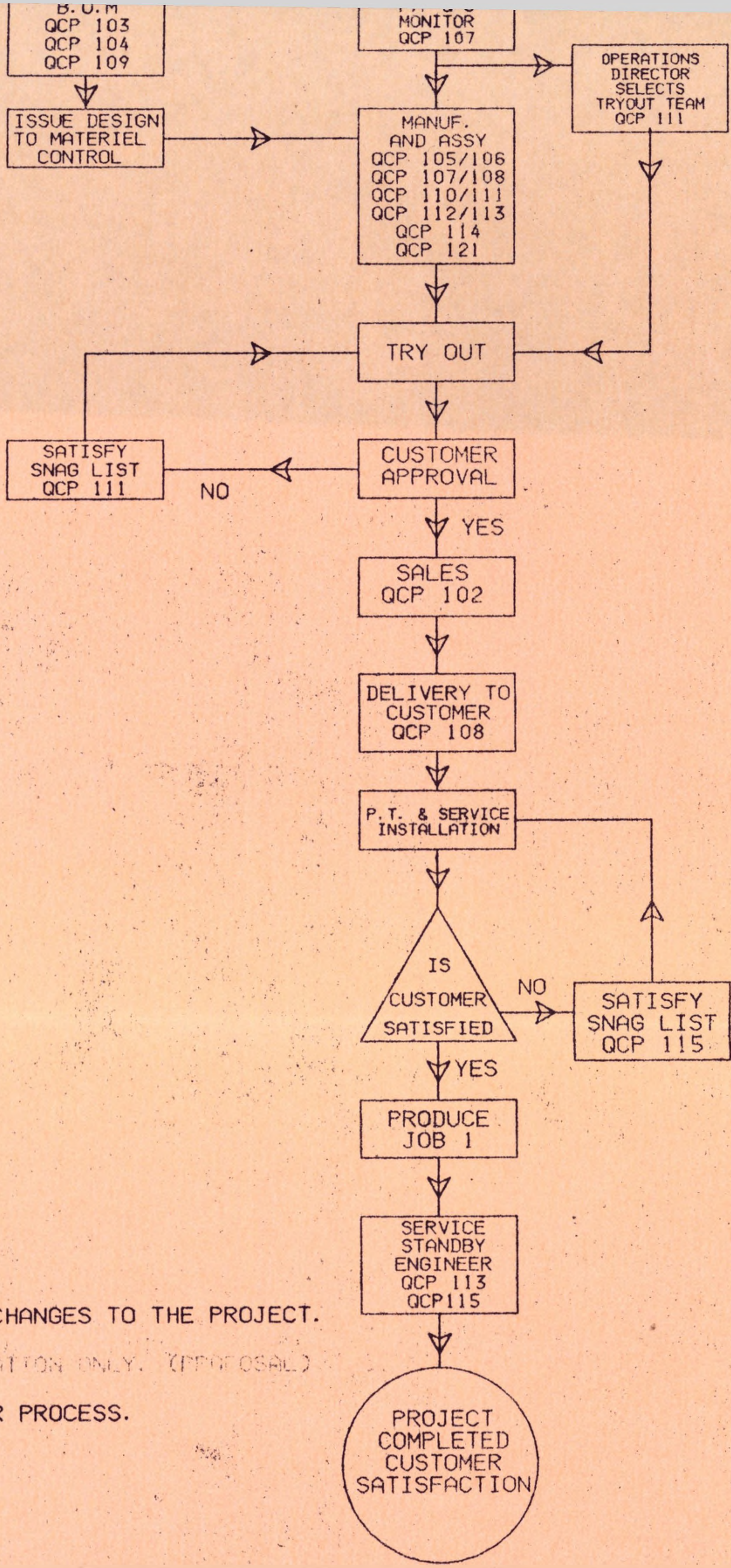
In addition to these product related 'Anschauungen', the system must also be there to support and motivate those who are employed by the system.

A concise version of this is then perhaps "*the satisfaction of the needs of all internal and external customers - regardless of the process direction.*"

Owner - (O)
To varying extents the answer here must equate to a combination of both (C) & (A)

Environment (E)
The constraints placed upon the system by the environment are those of finance, international trading restrictions, derived demand and thus subjection to the economic cycle.

APPENDIX A4.2
A Process Flow Chart from the Field Research Illustrating the Complexities and Feedback Involved in Quality Control of the Supply Process



RED = ALL CHANGES TO THE PROJECT.

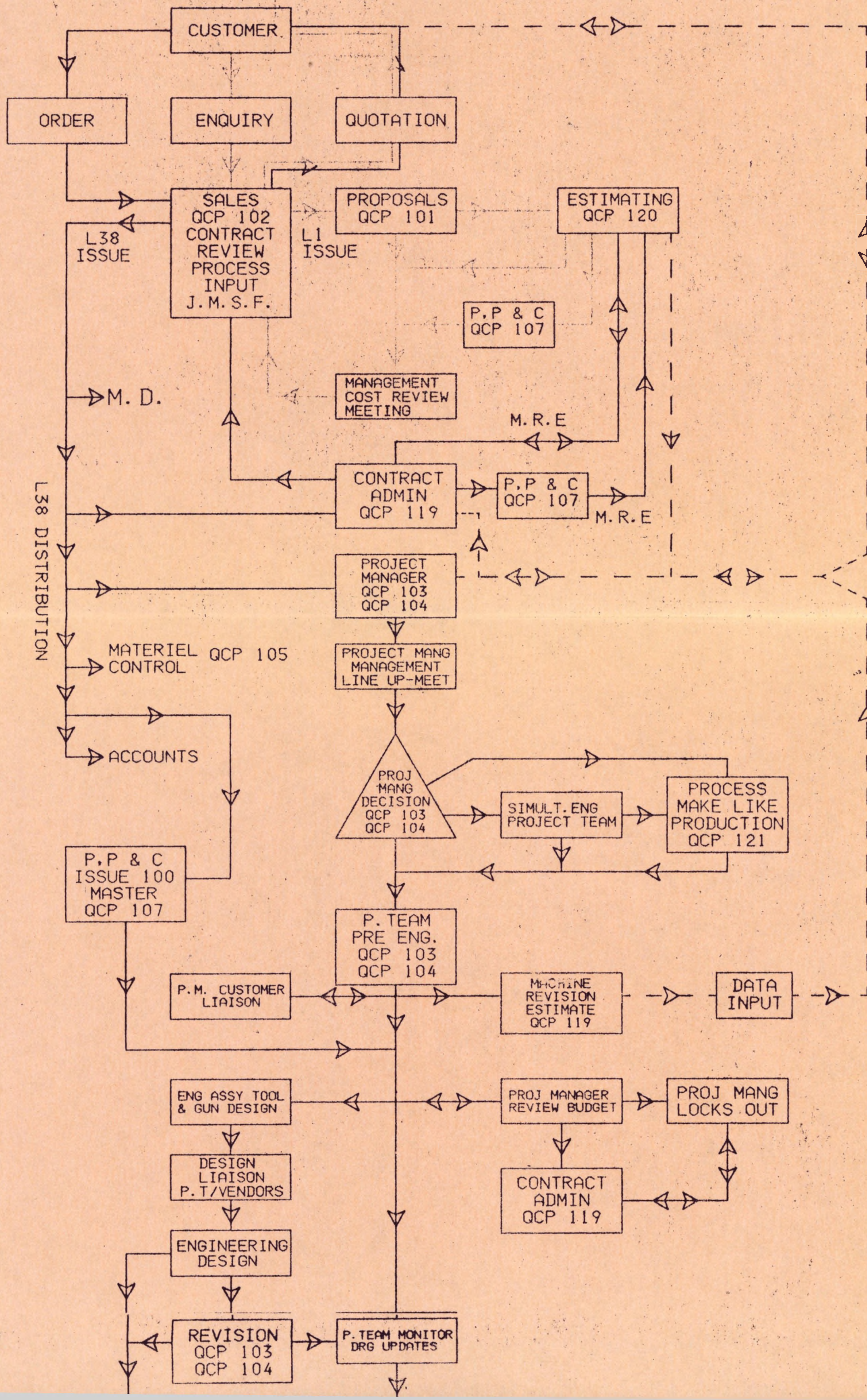
BLUE = QUOTATION ONLY. (PROPOSAL)

GREEN = ORDER PROCESS.

LEGEND

PROCEDURE NO.	TITLE
Q.C.P. 101	PROPOSALS PROCEDURE
Q.C.P. 102	SALES DEPARTMENT
Q.C.P. 103	ENGINEERING DESIGN PROCEDURES
Q.C.P. 104	CONTROLS ENGINEERING PROCEDURES
Q.C.P. 105	MATERIEL CONTROL PURCHASING
Q.C.P. 106	MATERIEL CONTROL THE ESTABLISHMENT OF APPROVED SUPPLIERS
Q.C.P. 107	MATERIEL CONTROL-PRODUCTION, PLANNING & CONTROL AND QA/FOLLOW UP PROCEDURE
Q.C.P. 108	MATERIEL CONTROL STORES PROCEDURE AND DESPATCH
Q.C.P. 109	MANAGEMENT INFORMATION SYSTEMS PROCEDURE
Q.C.P. 110	MANUFACTURING PROCEDURES
Q.C.P. 111	ASSEMBLY PROCEDURES
Q.C.P. 112	INSPECTION PROCEDURE
Q.C.P. 113	NON CONFORMING PRODUCT AND CORRECTIVE ACTION
Q.C.P. 114	CALIBRATION PROCEDURE
Q.C.P. 115	INSTALLATION/SERVICE AND WARRANTY
Q.C.P. 116	TRAINING AND DEVELOPMENT
Q.C.P. 117	QUALITY SYSTEM AUDIT PROCEDURE
Q.C.P. 118	DOCUMENT CONTROL AND QUALITY RECORDS
Q.C.P. 119	CONTRACT ADMINISTRATION
Q.C.P. 120	ESTIMATING PROCEDURE
Q.C.P. 121	PROTOTYPE PROCEDURE

QUALITY PLAN



APPENDIX A4.3 - EXAMPLES OF QUESTIONS USED DURING SEMI-STRUCTURED QUESTIONNAIRE

The chosen interview method was an informal one, using audio tape to record the discussion. Confidentiality was ensured, and where requested a hard copy of the translation of the tape was forwarded to the interviewee.
It was always attempted to answer all of the questions below, but not necessarily in the order shown.
Certain questions were given more time than other depending upon the experience of the interviewee and the company in question.

Q1 NAME OF COMPANY

Q2 NATURE OF BUSINESS / PRODUCT PORTFOLIO / CUSTOMER SEGMENTS AS % OF TURNOVER

Q3 AGE OF BUSINESS

Q4 NATURE OF FOUNDATION OF BUSINESS / COMPANY HISTORY

Q5 NUMBER OF EMPLOYEES / % 'BLUE' & % 'WHITE' COLLAR (IF DISTINCTION POSSIBLE)

Q6 EXPORT MARKET ORIENTATION / % UK/EU/R.o.W. BUSINESS

Q7 COMPANY FINANCING / - SELF/BANK/plc

Q8 ATTITUDES TOWARDS / EXPERIENCE OF CHANGES IN MAJOR CUSTOMER PROCUREMENT POLICIES

Q9 IN LIGHT OF WHICH....IS THERE ONE GUIDING POLICY THAT HAS CONTRIBUTED TO X'S SUCCESS? WHY HAS X SURVIVED THE UK MKT' S DEMISE?

Q10 WHAT ARE X'S CURRENT INTERNAL POLICY DRIVES/FOCUS?

Q11 HR POLICIES?

Q12 ATTITUDES TOWARDS / EXPERIENCES OF CONCURRENT ENGINEERING?

Q13 DIFFERING APPROACHES TOWARD SUPPLIER RELATIONS BETWEEN CUSTOMERS / INDUSTRIES / NATIONALITIES?

Q14 PREDICTIONS FOR THE FUTURE A) OF X, B) OF CONCURRENT ENGINEERING & C) OF MAJOR CUSTOMER'S AND THEIR PROCUREMENT POLICIES.

APPENDIX A6.1 - SUPPLY PORTFOLIOS

To treat 'supply', 'purchasing' or 'procurement' as generic activities is to exhibit incomplete understanding of the products and processes involved. The matrices below show examples of how externally purchased products may be sub-divided into various categories. Each category, in turn, requires particular management, concentration and investment.

APPENDIX 6.1 (a)

Purchasing Portfolio Analysis
Source - Kraljic, 1977 (author's translation)

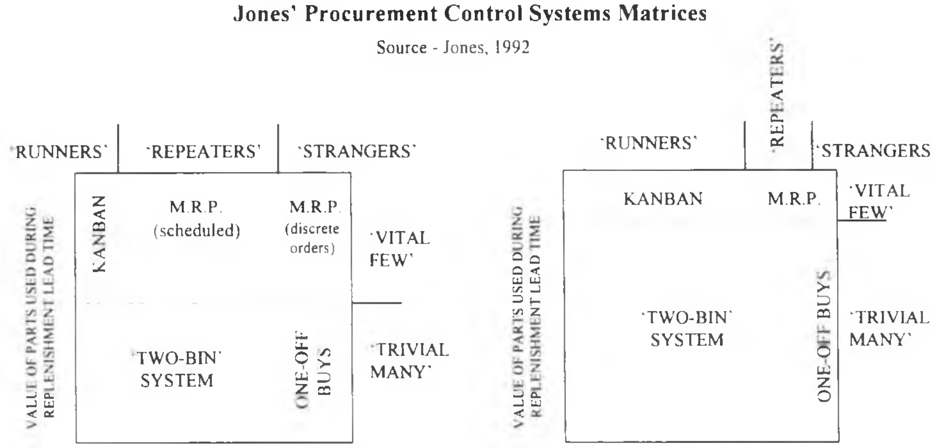
PRODUCT	RISK OPERATIONS	RISK COST	ACTIONS	INFORMATION	METHOD	RESPONSIBILITY/ TIMESCALE
STRATEGIC Benzol Cyclohexan	H	H	Precise requirements Detailed market research Long-term relationships Identify risks	Detailed market knowledge Long-term needs	Market Analysis Risk Analysis Simulation Price forecasts Long-term	Purchasing manager Long-term
BOTTLENECK Catalysts Metals	H	L	Volume guarantee (price premiums?) Supplier follow-up Safety stocks	Mid-term needs Storage costs Good market knowledge	Negotiated agreements Mid/long-term	Purchaisng agent Mid/long-term
KEY DP Equipment Motors Heating oil	L	H	Bulk buying Alternative products Spot buys?	Good market knowledge Transport costs Maintenance costs	Competitive bidding leading to extended agreement	Senior buyer
NORMAL Stationery Office equipment	L	L	Standardization Groupage	Market overview EOQ	Competitive bidding Short-term agreement (1 year?)	Buyer Short/Mid-term

H = High risk to operations or cost performance
L = Low risk to operations or cost performance

Appendix A6.1(b)

Jones' Procurement Control Systems Matrices

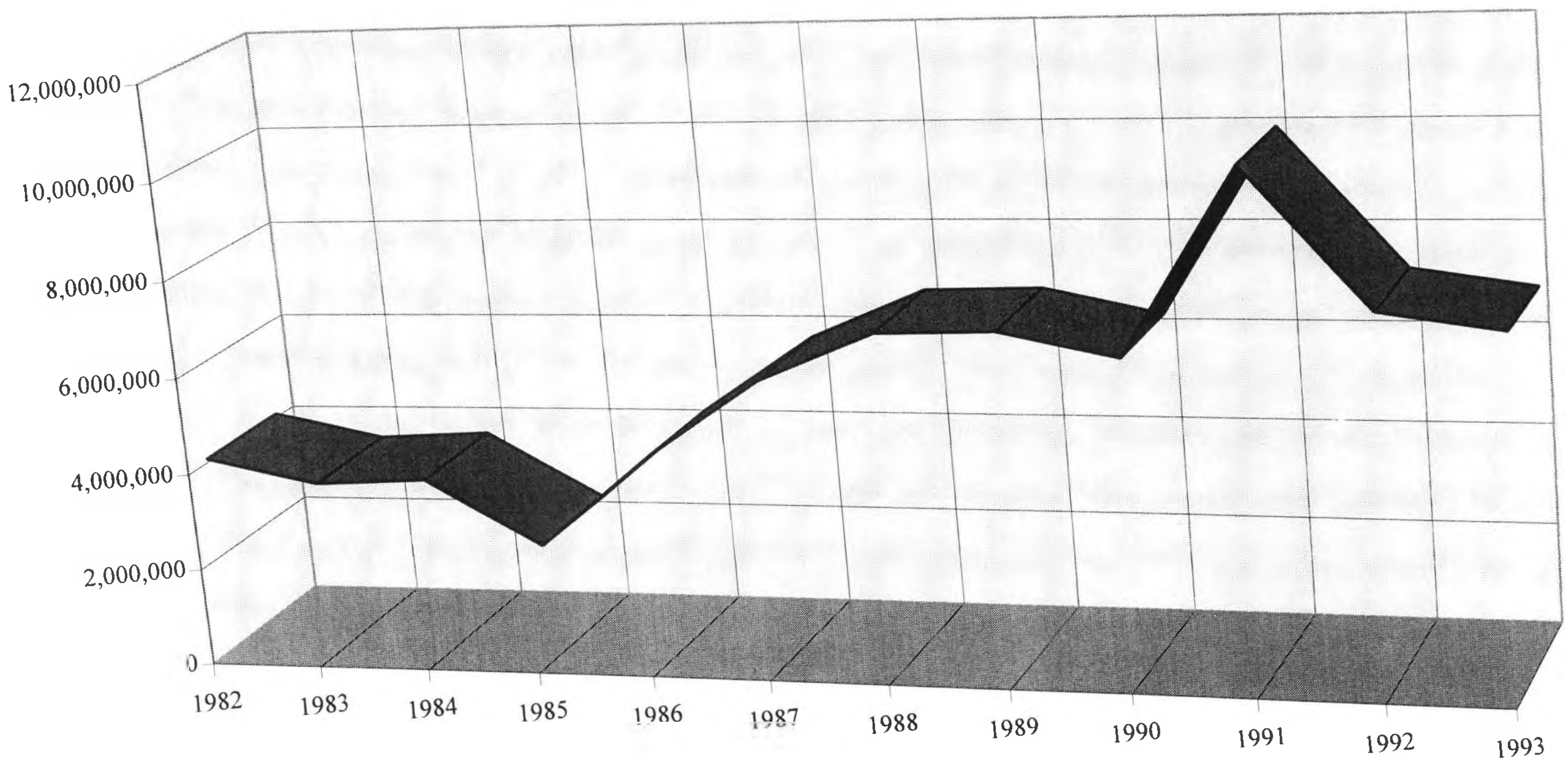
Source - Jones, 1992



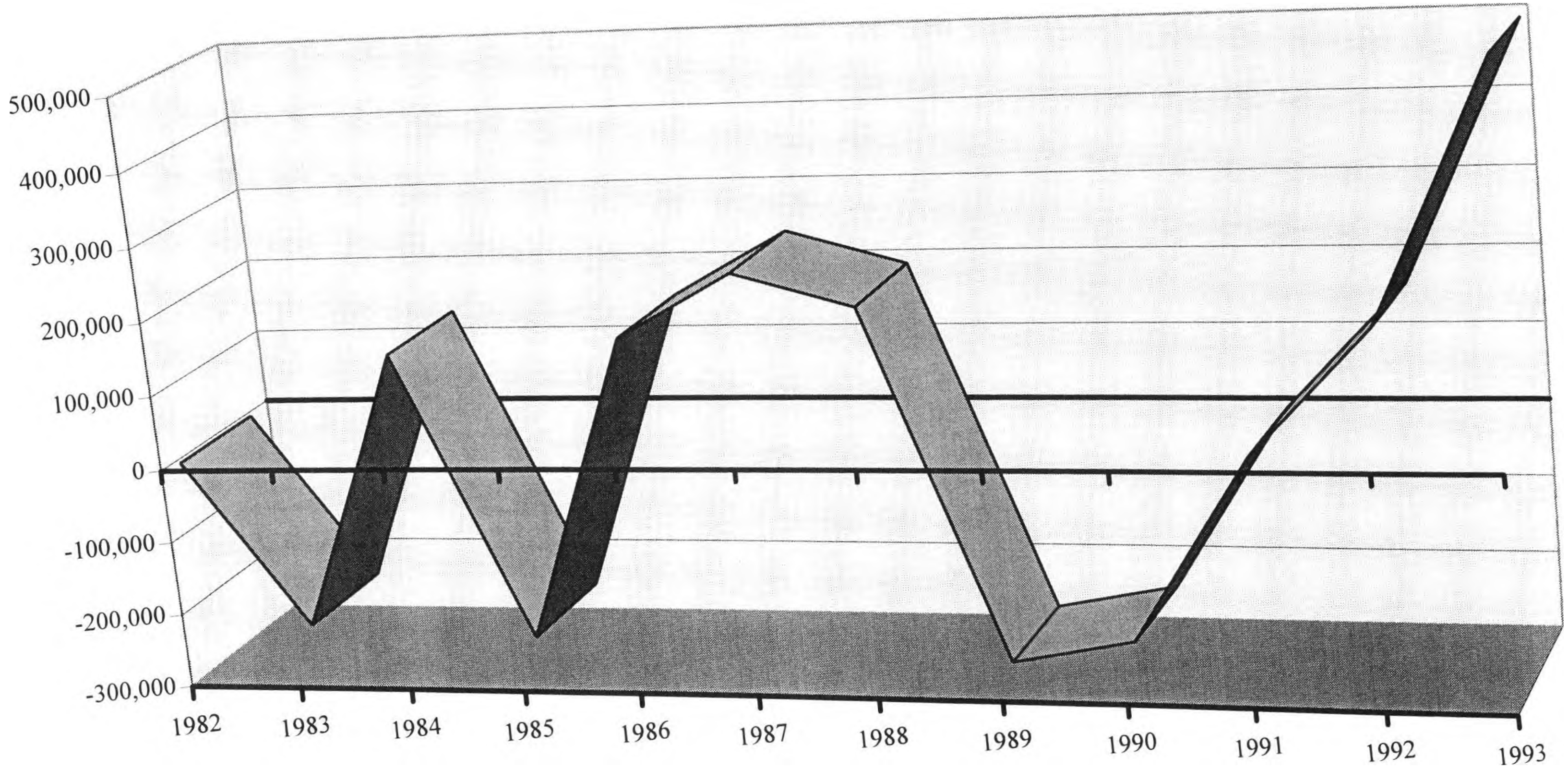
(a) - M.R.P. Dominant

(b) - Two-Bin Dominant

APPENDIX A6.2(a)
Turnover for Group (£) - 1982-1993



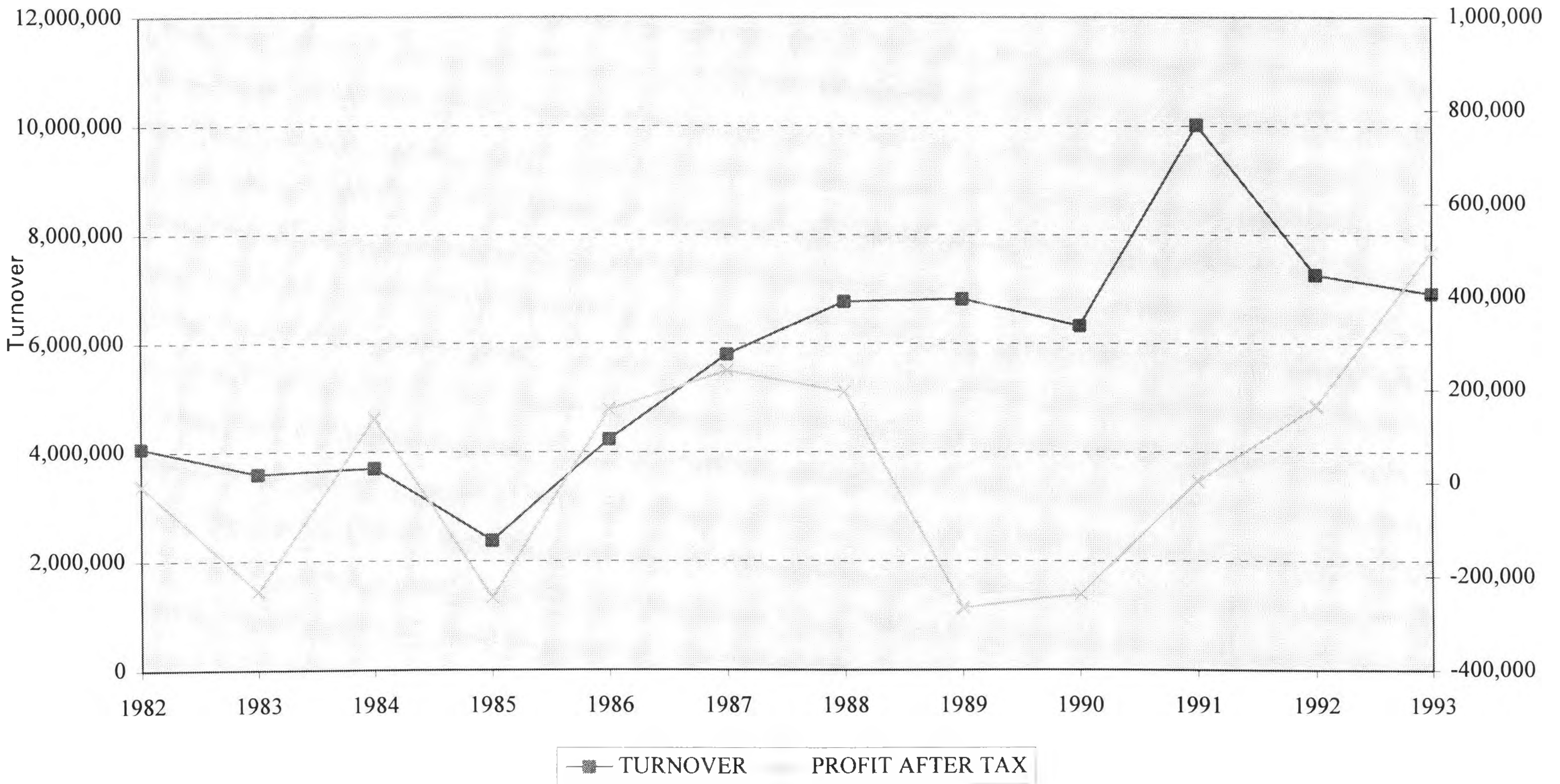
APPENDIX A6.2(b)
Group Profit After Tax (£)



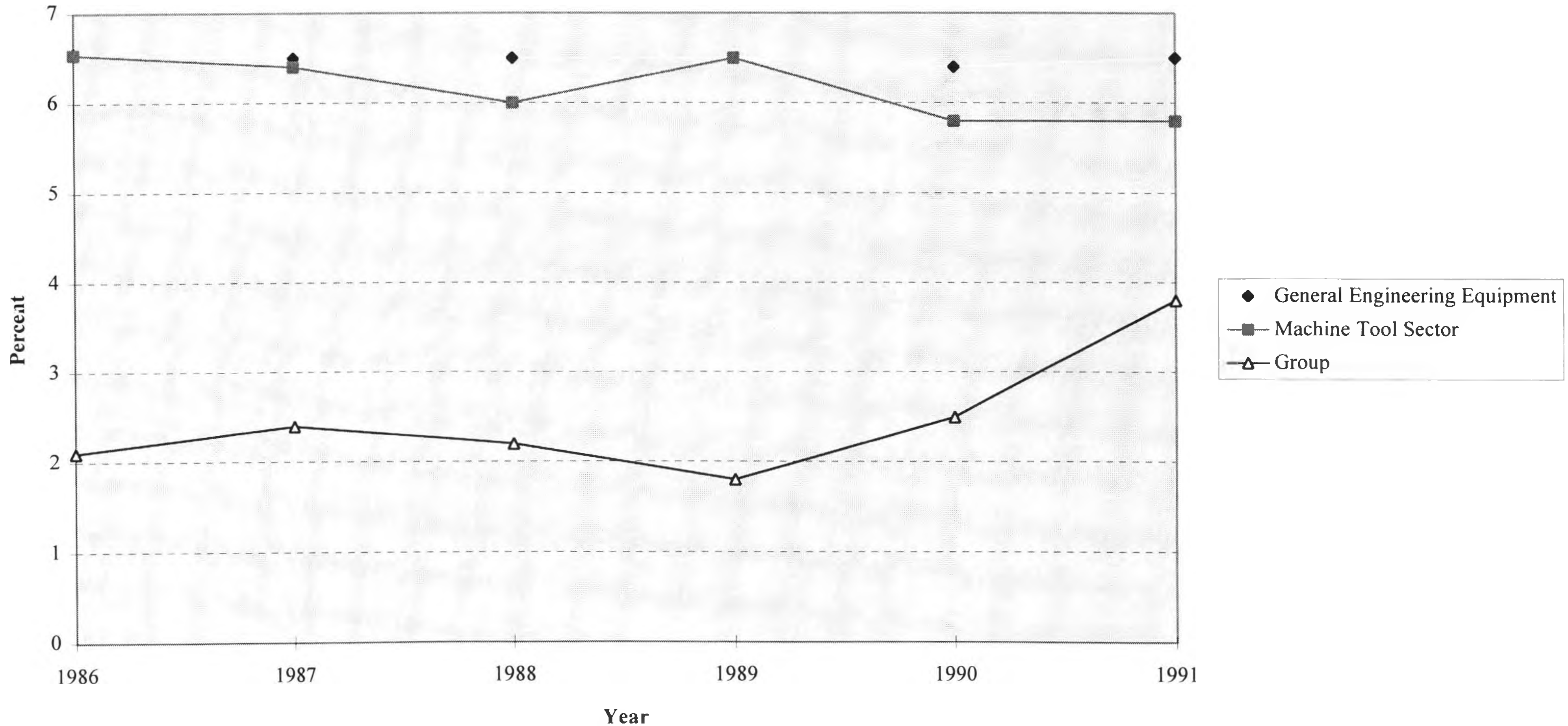
APPENDIX A6.2(c)

Turnover and Profit Figures for the Group (£) - 1982-1993

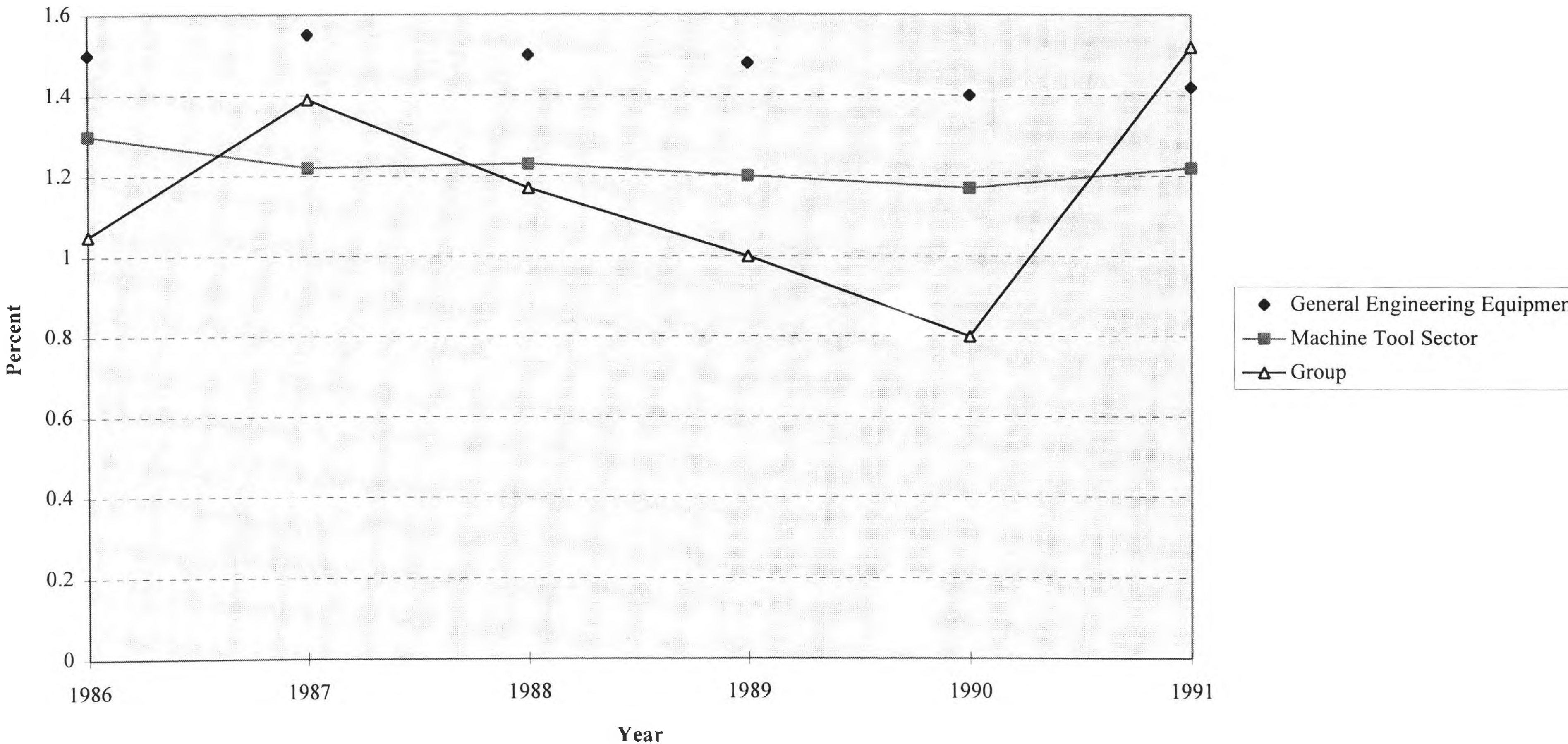
showing convergence after 1989



Appendix A6.2(d)
Comparison of Turnover of Fixed Assets



Appendix A6.2(e)
Comparison of Asset Utilisation 1986-1991



APPENDIX A7.1 - ALDERFER'S CATEGORIES OF NEEDS

Source - Carlisle & Parker, 1989.

Type 1	Type 2	Type 3
Existence Needs	Relatedness Needs	Growth Needs
All forms of psychological and natural desires, including money	Relationships with people and their need for recognition of worth or self-esteem	The desire to be creative and to achieve full potential
As Type 1 needs are met, we begin looking to meet Type 2 needs	As Type 2 needs are met, we begin looking to meet Type 3 needs	

Ford

Attachment 1

Ford of Europe Incorporated

J V Chalsom
Director – Facilities and
General Supplies – Supply

Brentwood Essex CM13 3BW

11 July 1986

Mr P Cantarella
COMAU S.p.A
Via Rivalta 30
10095 Grugliasco
Torino

Dear Paolo,

All the Ford activities working on the 1992 Zeta engine programme are very pleased that Comau are joining us in a new partnership approach to development of the product processes and equipment involved.

The aim is to resolve design and manufacturing concerns before equipment is ordered, and so avoid changes later in the programme with their inherent threats to quality, cost and timing.

Based on our past co-operation, and your expertise in this particular field we believe that Comau will make a major contribution to the success of this innovative business relationship. Recognising this, it is Ford's intention to order from Comau, without competition, the automated assembly equipment for the cylinder head, both within the transfer line and following on from it. We both recognise that there are risks as well as benefits in this enterprise.

There is the possibility of initial disagreement on price but, as in the past, this could probably be resolved by negotiation. Only if this failed would we seek competitive bids, possibly using ideas contributed by Comau. It is also possible that the programme will not be approved, or that after approval it could be postponed or cancelled.

Should these or other events prevent us from completing the expected orders with you, Ford would discuss ways of compensating Comau for the costs incurred through your special involvement over and above your "normal" sales and proposal expenses.

Yours sincerely, Best wishes,
John

Incorporated with Limited Liability in the State of Delaware, U S A

Attachment 2

CONFIDENTIAL

COMAU

Amministratore Delegato
Direttore Generale

Grugliasco, Septembre 15, 1986
034/rm

Dear John,

thank you for your letter on the 1992 Zeta Engine Programme.

We are very proud of having been chosen from FORD for the assembly equipments.

In principle I agree with your proposal as described. I am totally confident on FORD and you personally, so in any event we would find together solutions able to protect Ford and Comau's interests and right.

Best regards

(Paolo Cantarella)

Director – Facilities and
General Supplies – Supply
FORD of EUROPE INCORPORATED
Brentwood Essex CM13 3BW

APPENDIX A7.2

APPENDIX A7.3

INGERSOLL

EDSON I GAYLORD
CHAIRMAN OF THE BOARD

June 2, 1995

8579

Dear John:

Within the last six years, we have been commissioned by General Motors to build machinery for two engine programs. The first one was designed after we had more than a year of simultaneous engineering. The results were good for all concerned.

The second program, which includes two lines, was purchased by Senor Lopez and, as you can imagine, ended up with Ingersoll and General Motors being in complete adversarial roles instead of partners searching for the best investment. This program is not finished but it's far enough along so the results are known and the stark contrast between the first program and the second makes a very good story as to the value of simultaneous engineering as a way for the car companies to buy their production systems.

The lines Senor Lopez bought may well be the most expensive transfer lines ever built!

I know this is a story that you would be interested in and would probably have good ideas as to how it should be reported.

I am going to be away from the office for a week but after that I am here to talk with you when convenient.

I have tentative plans to be in Europe the second week in July; I will give you a call after June 11.

Best regards,

Edson/slh

EIG/slh

THE INGERSOLL MILLING MACHINE COMPANY 707 FULTON AVENUE ROCKFORD, ILLINOIS 61103 TEL. (815) 987-6000 TELEX 257427 FAX (815) 966-7685

APPENDIX A7.4

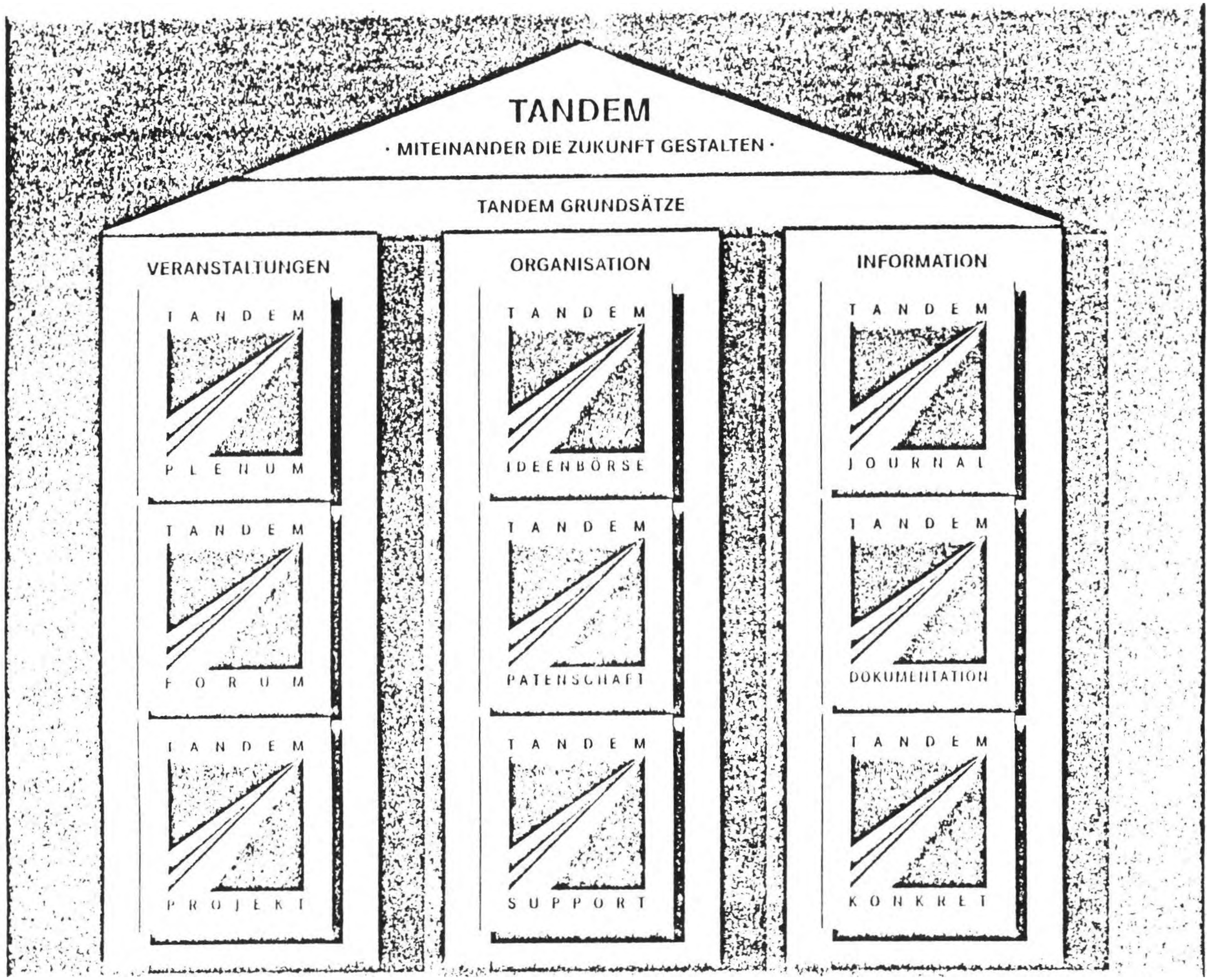
(Issue 3, 2/94)

PROJECT MANAGEMENT SUMMARY

		SCORE MAX	1	2
3.1	PROJECT RESPONSIBILITY			
3.2.1	Contract Feasibility Review			
3.2.2	Project Plan & Review			
3.2.3	Design & Development Programme			
3.2.4	Design FMEA			
3.2.5	Prototype Manufacture & Test			
3.2.6	Planning for Product in Service			
3.2.7	Process Planning			
3.2.8	Control Plan			
3.2.9	Manufacturing Facility Procurement			
3.2.10	Gauge & Test Equipment			
3.2.11	Human Resource Planning			
3.2.12	Sub-Supplier Control			
3.2.13	Review of Quality Systems			
3.2.14	Product Identification, Packaging & Delivery			
3.2.15	Installation, Commissioning & Acceptance			
3.2.16	Formal Certification of Process Capability			
3.2.17	Control of Non-Conforming Product			
3.2.18	Systems & Software			
3.2.19	Project Cost Management			
3.2.20	Quality Cost Analysis & Review			
3.2	PROJECT PLANNING, REVIEW & IMPLEMENTATION			
3.0	PROJECT MANAGEMENT TOTAL			

APPENDIX A7.5

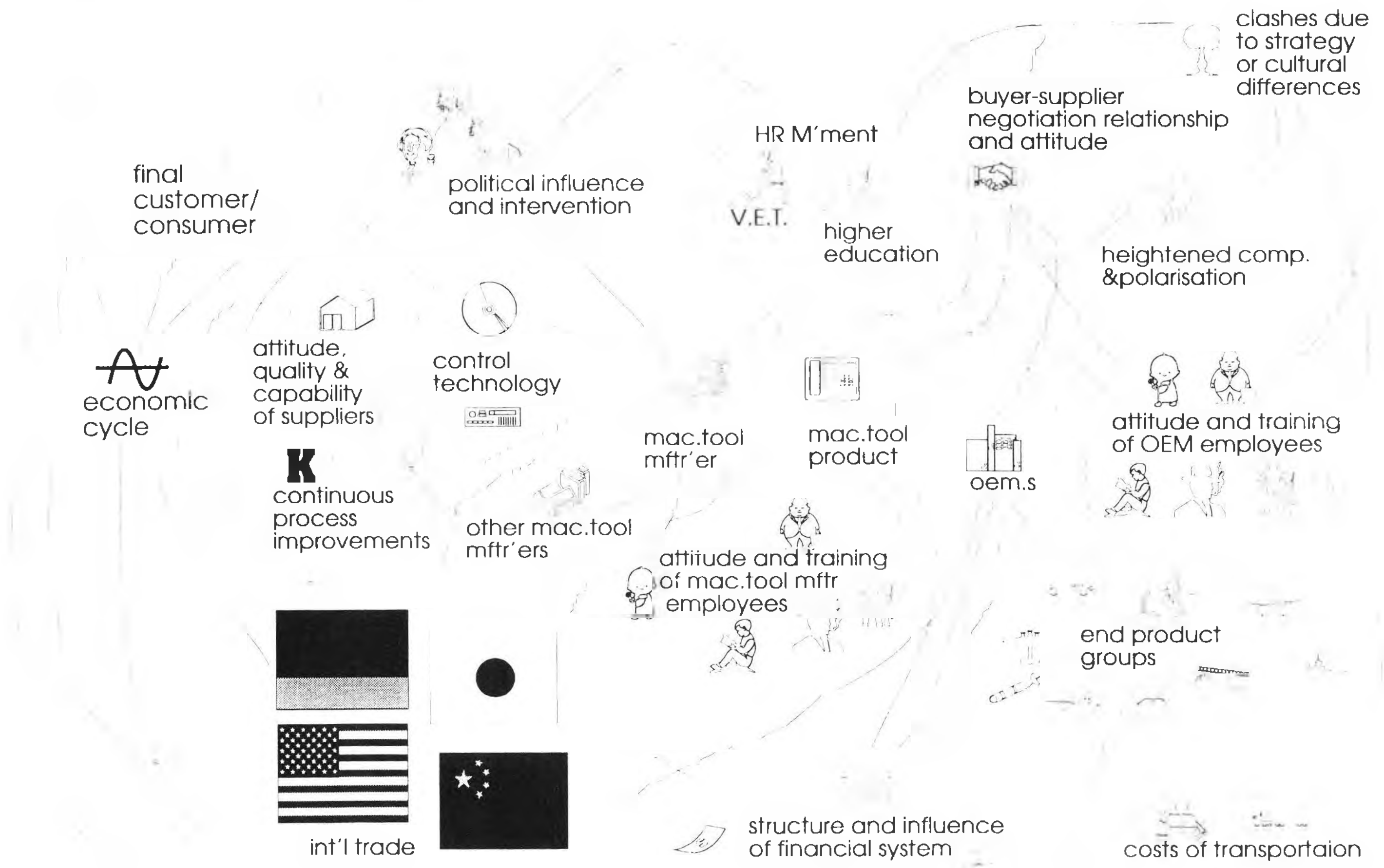
TANDEM
PLENUM



Mercedes Benz

Appendix A8.1

"RICH PICTURE" of the market for machine tools, showing some relationship lines

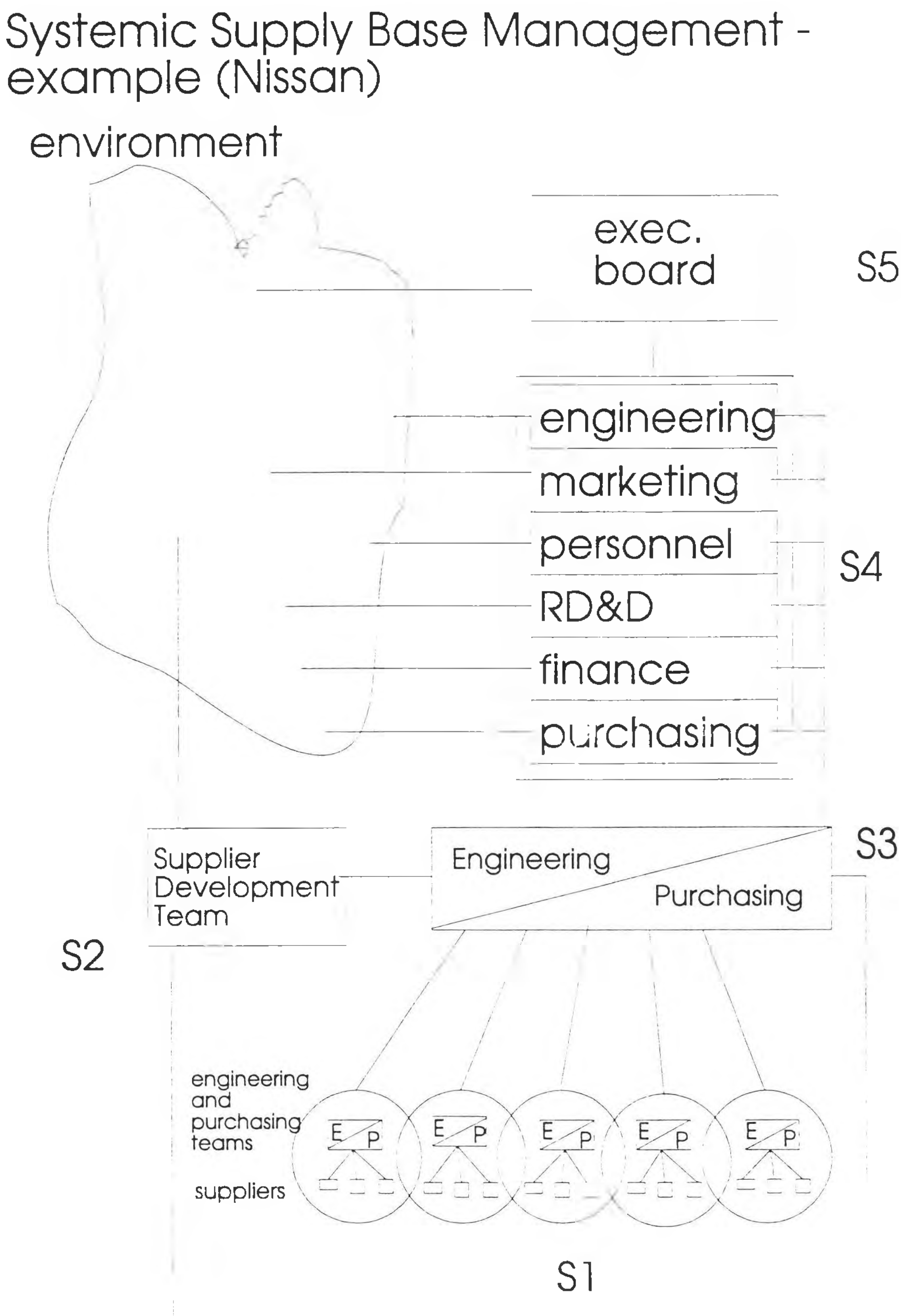


APPENDIX A8.2 - The Root Definition of the Machine Tool Supply System

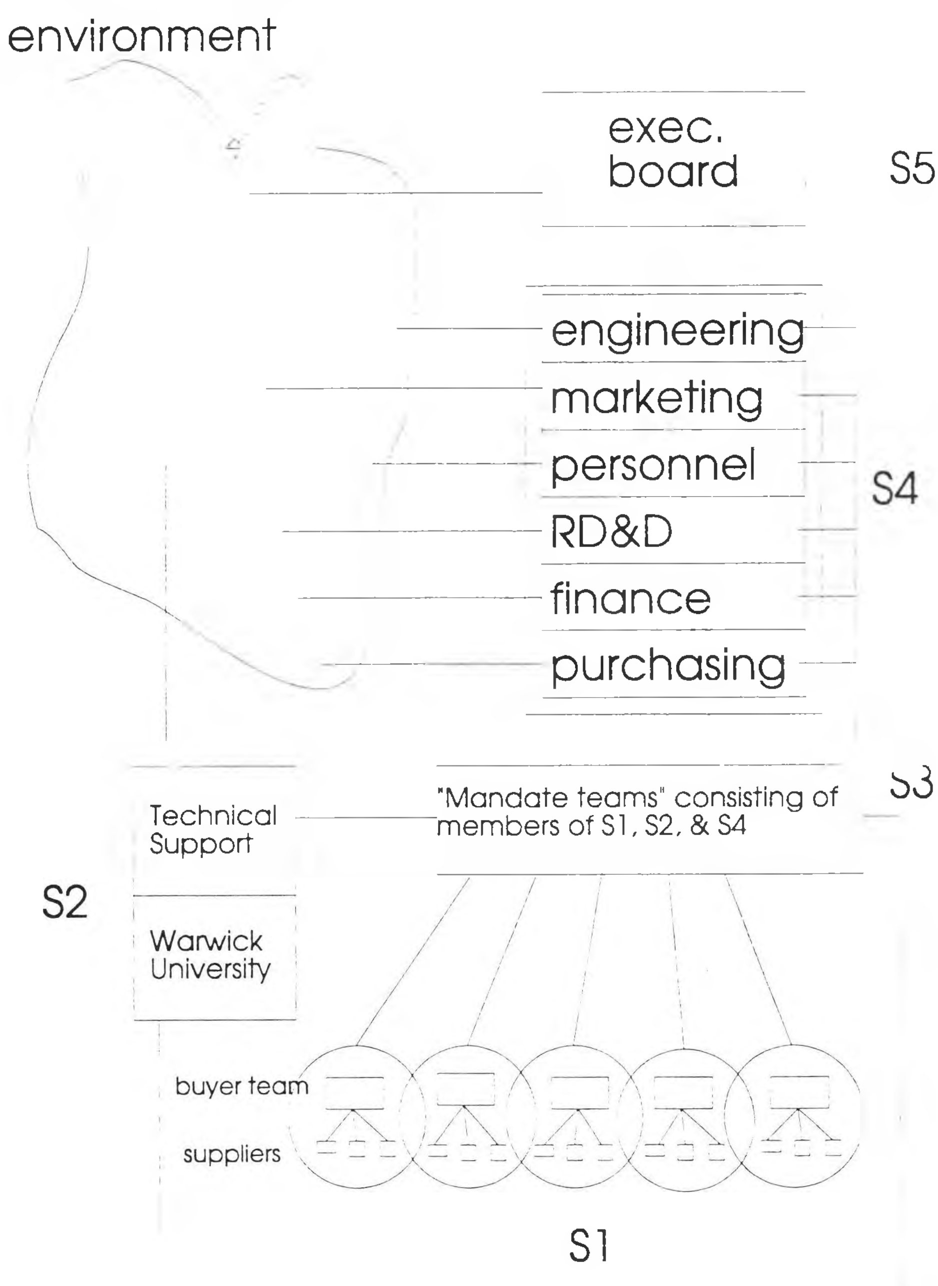
Below is the root definition of the machine tool supply system. First mentioned in chapter four, the definition is referred to as an appendix in chapter eight. The CATWOE analysis from which this definition comes is given in appendix A4.1

> *A system which exists to supply machinery encompassing all organisations or groupings that are involved in physical and non-physical input into the process and the consumption or appropriation of its output. It must recognise the importance and value of all of those directly or indirectly employed or engaged in all of these stages; these being active in the process of satisfying their customers. Ignorance of this could cause any part of the system ultimately to destroy or severely damage the system's performance. The satisfaction of the customers of each element or actor takes place within substantial dynamic environmental constraints.*

APPENDIX A8.3 - Real World Examples of the VSM Structure



Systemic Supply Base Management - example (The Rover Group)



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